AIR Demand Surge Function

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1 Introduction

AIR's Demand Surge Function allows users to assess the impact of demand surge on loss potential.

Demand surge is the increased demand for materials and services required to repair and rebuild property damaged by catastrophic events. It is associated with temporary price inflation for these resources, resulting in increased losses to the insurers.

The following discussion provides background information about the demand surge phenomenon, an explanation of the process by which AIR developed and validated the demand surge function, and an overview of its implementation in the AIR software applications.

Background

Market forces generally ensure that the availability of materials and labor in any particular geographical area are sufficient to accommodate a normal level of demand without affecting price. However, if demand increases sharply and unexpectedly—as after a catastrophe event—the pressure on resources can cause prices to inflate temporarily. The relative scarcity of resources can also result in increases in the time required to repair and rebuild damaged property.

Coupled with other economic, social and infrastructural factors, this can lead to insured losses exceeding “normal” expectations for a particular event and portfolio, which are based on the assumption that sufficient resources are readily available at constant prices. This phenomenon is referred to as demand surge. The greater and more widespread the damage from an event, the greater will be the resulting demand surge and thus the greater will be the insured losses.

AIR engineers and statisticians have developed a mathematical function that relates the amount of demand surge—or the factor by which insured losses increase—to the amount of modeled industry insurable loss. Developing a demand surge function requires a high degree of judgment, as there are few historical data points, with Hurricane Andrew (1992), the Northridge earthquake (1994), and the 2004 and 2005 hurricane seasons being chief among them. The development of the AIR demand surge function was based on an examination of the historical data, statistical analysis, reviews of economic time series, and analysis of construction material and labor cost data. AIR has augmented detailed client claims data, publicly available economic data and findings from post-disaster surveys conducted in the aftermath of the 2004 and 2005 hurricane seasons with high resolution, component level cost data for the 2004 and 2005 hurricanes from Xactware, an ISO subsidiary. During the course of validating the AIR hurricane and earthquake models for the United States, demand surge is included in the modeled losses for historical events.[1] The modeled losses compare well with reported losses, validating both the AIR models and the AIR demand surge function.

[1] As of this writing, there have been no historical losses from winter storms, severe thunderstorms or wildfire large enough to trigger the AIR demand surge function.

Note that the current default AIR demand surge function was developed using economic principles and validated based on U.S. loss levels and component cost analyses, as described in this document. Because demand surge is a phenomenon seen only with especially large catastrophes, there are relatively few events with which to validate demand surge functions outside of the U.S. This scarcity of data is further complicated by the relative paucity of cost indices and detailed data.

Nevertheless, development of country/region demand surge functions is currently underway at AIR. These will depend on, among other things, the size of local and national labor markets and thus their ability to accommodate excess demand, and augmented by other labor, material, and construction indices as available. The functions will reflect the interaction between supply and demand of rebuilding resources and will be scalable to suit local economies.

In the meantime, for countries other than the U.S., clients may choose to apply the U.S. demand surge function or a user-defined demand surge function, at their discretion. Clients are also encouraged to perform sensitivity testing to better understand the scale of impact and uncertainty inherent in applying demand surge to non-U.S. models and perils.

2 Understanding demand surge

A demand surge function is derived from a variety of factors (e.g. catastrophe type, geography, demand, business type, regional capacity) and a collection of prices and indices.

Factors affecting demand surge

A significant hurricane, earthquake or other catastrophe event can cause widespread damage to property, which can in turn lead to a sharp increase in the need for building materials and labor. Demand also increases sharply for related services and resources such as transportation, equipment and storage in the affected area. Resource availability in any regional economy is usually sufficient to accommodate normal demand; an unexpected and sudden increase in demand can lead to shortages and, ultimately, to price increases. This inflationary effect will serve to increase Coverage A and B losses to insurers.

In addition, low regional capacity to meet the increased demand can result in longer-than-normal repair times. This, in turn, results in greater business interruption losses and additional living expenses (Coverage D). Infrastructure damage, delayed building permit processes and a shortage of available building inspectors are also factors in increasing time element loss.

Should a second event occur in close geographical and temporal proximity to the first —before rebuilding from the first event has been completed—the demand for materials and labor will have a bigger impact on the regional economy than the occurrence of a single event. Thus, for purposes of modeling demand surge, it is necessary to consider the aggregation of damage and loss from events both preceding and succeeding a particular event. In 2004, for example, Florida experienced four hurricanes—three of them major—within a span of 45 days. Each hurricane generated losses of around $6 billion (in 2004 dollars), but the region suffered a total loss exceeding $20 billion. The pressure on resources was much larger than had the same four events occurred over a longer time period and greater geographical distance.

AIR's demand surge function reflects economic inflation only. It does not account for other factors that may increase insured losses in the aftermath of a catastrophe, such as hazardous waste clean-up or insurance-to-value issues. These factors may cause higher losses than expected, but do not constitute demand surge. In addition, it is not correct to use a single factor to adjust for insurance-to-value or hazardous waste clean-up, as the correct adjustment for these issues is heavily dependent on the type of business a company writes. If further adjustments to loss estimates are required due to such issues, AIR clients have the option to manually modify the demand surge function, as well as the application of other loss adjustment factors. To resolve insurance-to-value issues, clients also have the option of using Verisk 360Value™ to obtain more accurate replacement values for insured residential and commercial properties.

Quantifying demand surge

Insight into the inflationary effects of catastrophes can be gained by tracking material and labor price changes in affected regions in the immediate aftermath of an event. AIR utilized construction cost time series data from XactAnalysis™, a reporting tool created by Xactware, a subsidiary of Insurance Services Office (ISO). XactAnalysis offers Industry Trend Reporting, which provides construction labor and material cost information over time. As illustrated by the figures in the sections that follow, data from recent events indicate that increased labor costs, as opposed to building materials prices, are the driving force behind demand surge.

Impact on material prices

Material prices were tracked following the unusually active 2004 and 2005 hurricane seasons. The data indicate that the impact of catastrophe events on building material prices may not be very significant. This may be the result of:

- Large chain stores keeping the prices of building materials constant following large events
- Government regulation and policy changes to control prices following large events
- Delays in rebuilding due to limited labor, thus spreading the rebuilding work over an extended period of time

Figure 1 below shows the lumber price index at both the national level and in Florida from 2003 through 2006. While there was a sharp increase in third quarter of 2003, the 2004 and 2005 hurricane seasons do not appear to have had a significant impact on the price of lumber.

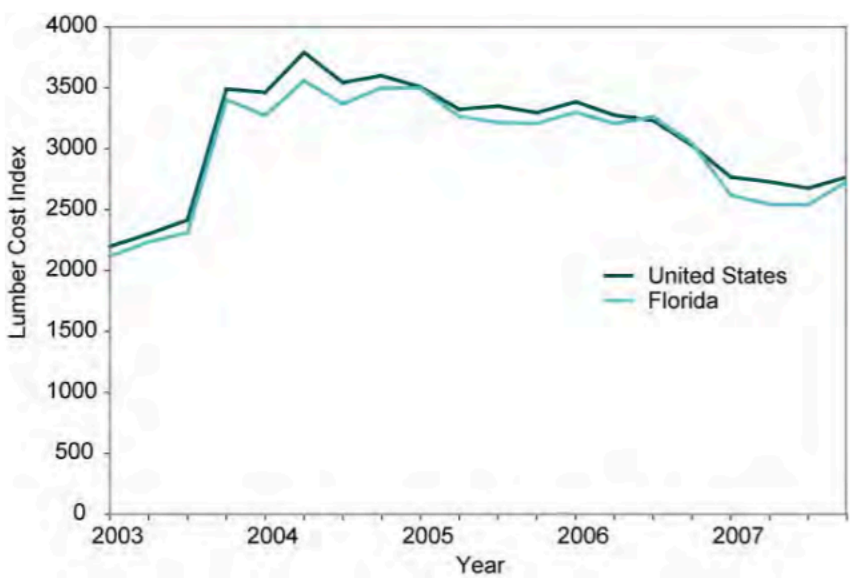

Figure 1. Lumber price indices, 2003-2007 (source: Xactware)

This next figure tracks a composite price index of building materials (lumber, roofing materials, drywall and carpet) over the same time period, again both at the national level and in Florida alone. While the cost of building materials has been steadily increasing since the start of 2003, there is no evidence of any significant impact from the hurricanes—even in

Florida, which in 2004 felt the brunt of four hurricanes in relatively close geographical and temporal proximity.

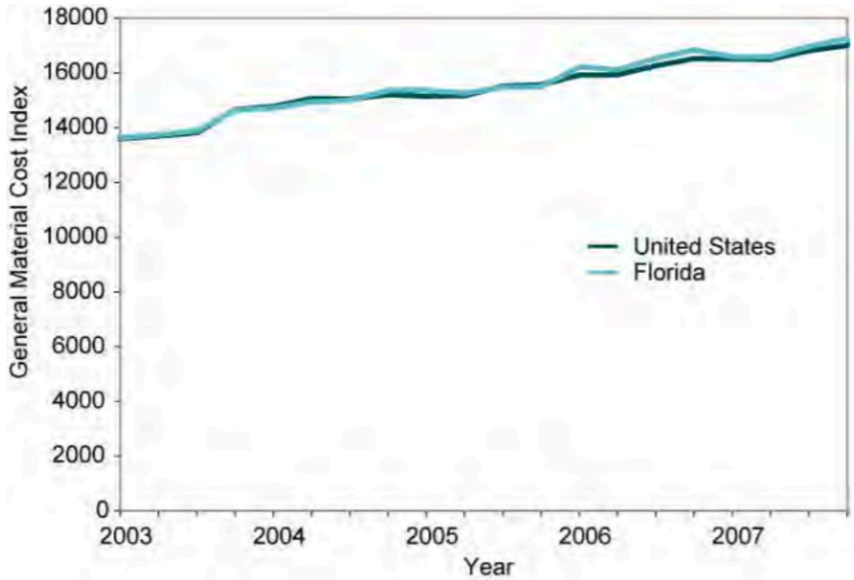

Figure 2. Composite building material indices, 2003-2007 (source: Xactware)

Impact on labor prices

Another component of construction costs is labor. Unlike the relatively stable prices for building materials seen in the aftermath of the 2004 and 2005 hurricane seasons, labor costs rose significantly. This may be the result of several factors, including:

- Increased demand for available labor given the scope of rebuilding
- Costs associated with importing labor from outside the affected areas
- Per diems paid to workers who are brought into the affected areas during reconstruction

The next figure tracks a composite labor price index from 2003 through 2007 for the U.S. as a whole and for Florida only. The impact of the 2004 hurricane season on overall labor costs in Florida is clearly illustrated by the sharp increase in the third and fourth quarters of that year. [2] The effect on labor prices at the national level is much less pronounced. Labor markets tend to be strongly regional; building materials can be transported to the affected region with relative ease—bringing in additional labor resources is more problematic.

[2] The Florida labor price index has continued to outpace the national average, indicating that labor prices are generally sticky.

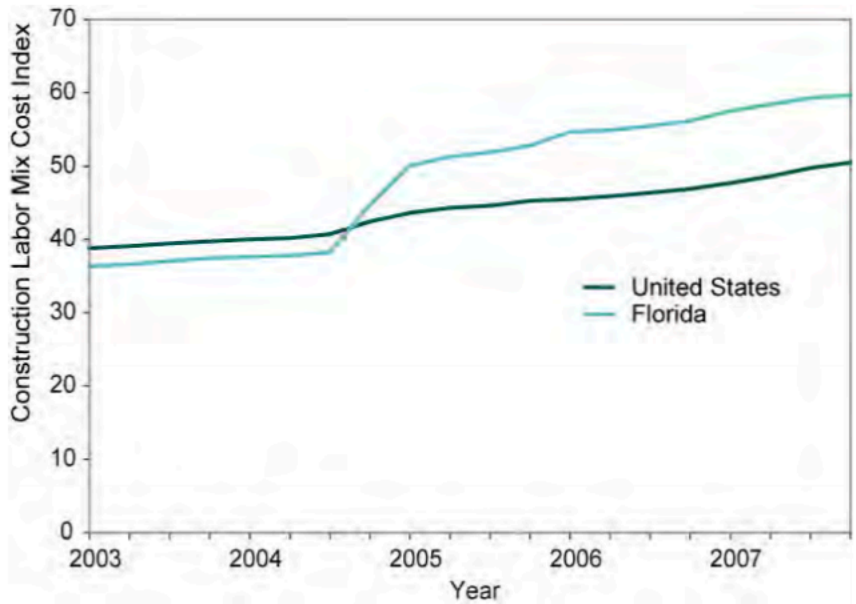

Figure 3. Composite labor price indices, 2003-2007 (source: Xactware)

Note that in Figure 3, the Florida labor market barely recognizes the 2005 losses from Hurricanes Katrina, Rita and Wilma, again pointing to the regional nature of labor markets, at least in the short term.[3]

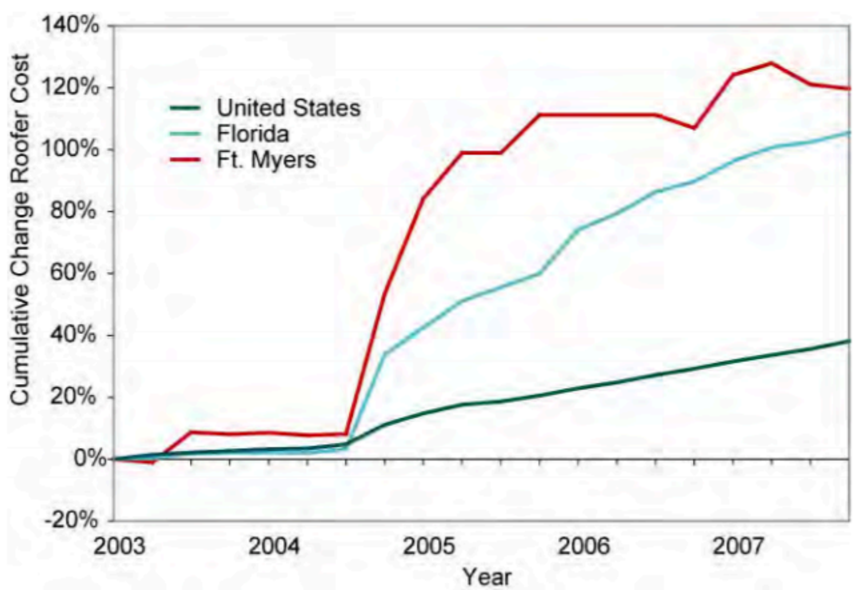

Figure 4. Roofing labor price indices, 2003-2007 (source: Xactware)

[3] The labor price index time series for the third and fourth quarters of 2005 in Louisiana and Mississippi did not show the large increases that might have been expected from the record-breaking losses of Hurricane Katrina. AIR's research indicates that a major factor in the relatively small price increases following Katrina was the slow pace (or lack) of rebuilding in Louisiana, particularly in Orleans parish where the majority of the losses were incurred. Because of the flooding and the displacement of so many, and because of impending litigation over what would be covered, there was not the rush to rebuild, and therefore the demand on labor resources was spread out over a much longer period of time than might otherwise be expected from such a large event.

Figure 4 shows the impact of the 2004 and 2005 hurricane seasons on roofing labor costs in the U.S., Florida and, finally, Fort Myers, FL, which was impacted by Hurricane Charley and, to a lesser extent, Hurricanes Frances and Jeanne during the 2004 season. Note again the significant jump beginning in the third quarter of 2004.

3 The AIR demand surge function

The demand surge analysis feature, available in AIR's software applications, allows users to adjust model results to reflect the impact of demand surge. The demand surge modification increases estimated losses according to a function that varies with the amount of modeled insurable industry loss. [4]

Software feature

The demand surge analysis feature, available in AIR's software applications, allows users to adjust model results to reflect the impact of demand surge. The demand surge modification increases estimated losses according to a function that varies with the amount of modeled insurable industry loss. [5]

The AIR demand surge function, first introduced in 1992, has been reviewed and refined as additional data have become available for analysis. The current version is triggered at an industry occurrence insurable loss of $5 billion in the 48 contiguous states and $2 billion in Alaska and Hawaii. That is, for losses below $5 (or $2) billion, the function assumes— and evidence suggests— that the available labor and materials resources are sufficient to execute repairs without significant inflationary ramifications. Limited damage also limits business interruption (BI) and additional living expenses (ALE).

Once the threshold of $5 billion is reached, the demand surge function increases rapidly. At this level of loss, it may not be cost effective to import labor to the affected region. With little increase in the supply of labor regionally, the increased demand will manifest itself in higher prices.

For larger losses, the function increases at a slower rate as the search for available resources broadens and laborers begin to migrate into the region, attracted by the higher wages. For very large events, demand surge increases at a constant rate and ultimately levels off. During these stages, product substitutions flow in from neighboring regions, restricting increases in materials prices, while the expanded labor pool begins to experience diminishing returns.

Demand surge is also capped by insurance policy limits, which typically allow for a maximum replacement cost of between 25 and 50 percent in excess of insured value.

[4] Insurable industry loss is used rather than insured since factors which drive demand surge are not limited to the size of insured industry losses

[5] Insurable industry loss is used rather than insured since factors which drive demand surge are not limited to the size of insured industry losses

Aggregation of industry losses from multiple events

If a second large event hits the same region before rebuilding from the first has been completed, demand surge will be exacerbated. Therefore, in addition to the industry loss from any given event, the AIR demand surge function considers industry losses from other events that occur in close geographic and temporal proximity

Regional aggregation

Data suggest that the sudden increase in reconstruction costs following a catastrophe event is driven primarily by the cost of labor; labor is relatively immobile and labor markets tend to be regional—at least in the short term. Therefore, the pressure on labor resources caused by the increase in demand may not be felt in regions not immediately affected by the catastrophe event.

The notion of "geographic proximity," as used by the AIR demand surge function, is defined based on 12 U.S. regions. These divisions take into consideration factors such as distance, population concentrations, economic interdependencies and hazard concentrations. Consideration has also been given to differences in construction regulations and other insurance laws and policies followed by the various states.

Figure 5. Regional divisions for U.S. aggregate demand surge

Temporal aggregation

The effect on prices of a sudden, one-time increase in demand decreases with time. Therefore, what drives the aggregation of industry losses from events within a specific region is the length of time between the two events. If two events occur in very close succession, there will have been little or no time to begin rebuilding before the second event occurs. In such cases, the AIR demand surge function treats them as a single large event under the assumption that building materials were purchased, and labor contracted only after both events occurred. As the time between events increases, more of the rebuilding from the first event will have taken place; thus, the total effect on the economy would reflect whatever rebuilding remains from the first event, plus the additional demand from the second event, as illustrated schematically below.

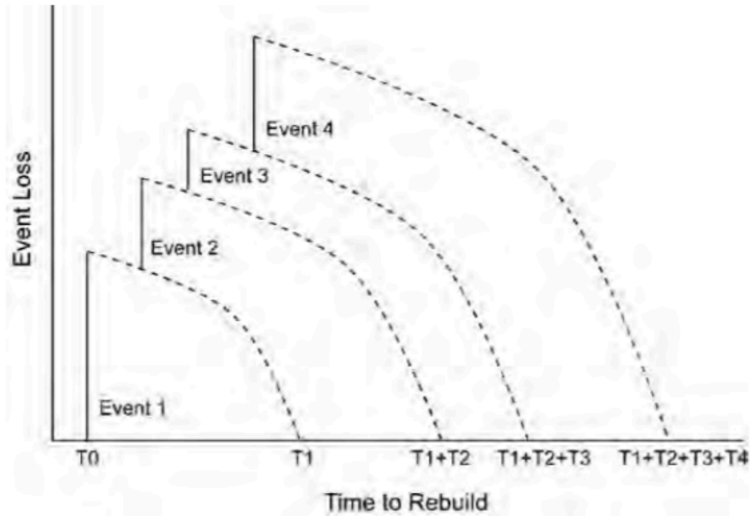

Figure 6. Cumulative effect on demand caused by events that occur in close geographic and temporal proximity

As events occur farther apart, their aggregate impact diminishes. This next figure shows the decay function used to aggregate the losses of events that occur in close proximity both temporally and geographically:

- Within 30 days of T0 = 100% of the losses aggregated
- 30 to 60 days of T0 = 75% of the losses aggregated
- 60 to 120 days of T0 = 50% of the losses aggregated
- 120 to 180 days of T0= 25% of the losses aggregated

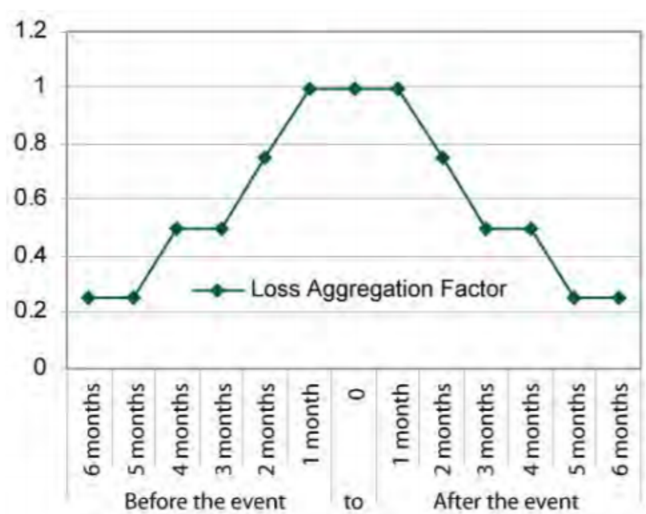

Figure 7. Decay function for aggregation of U.S. demand surge

Demand surge by coverage

The AIR demand surge function varies by coverage, as illustrated below. AIR's research and analysis indicates, for example, that as industry loss increases, time element losses increase at a rate exponentially higher than the demand surge function for Coverages A and B. The replacement cost of contents, on the other hand, has been shown to be virtually unaffected by demand surge.

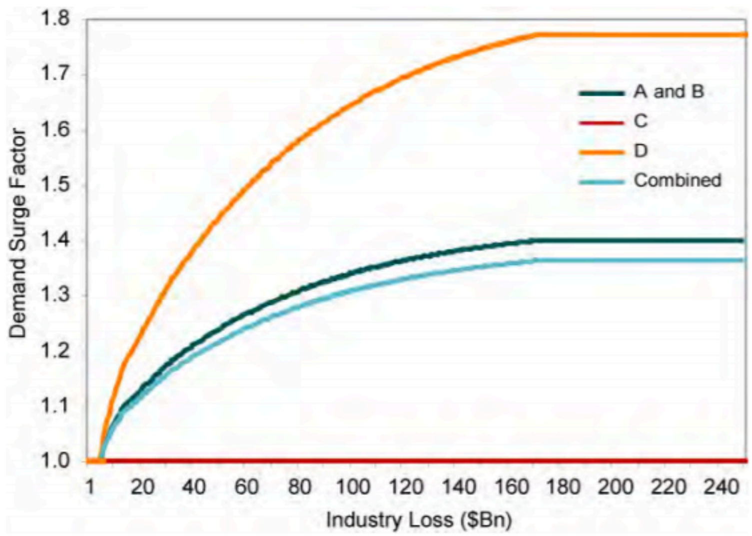

Figure 8. AIR demand surge functions by coverage

Coverage A (building) and B (appurtenant structures)

The demand surge function for coverages A and B relates industry losses to a corresponding demand surge factor. Events with an industry loss of $5 billion or less have a demand surge factor of one (no increase). Once the $5 billion threshold is met, the demand surge factor increases rapidly for reasons discussed above. However, for larger loss amounts, the rate of increase slows and ultimately becomes constant as diminishing returns to labor set in.

Coverage C (contents)

AIR's analysis of claims data from the 2004 and 2004 hurricane seasons indicates that items insured under contents coverages do not see significant price increases following catastrophes. Therefore, AIR's demand surge function for Coverage C is set to a factor of one at all levels of loss.

Coverage D (time element)

Time element losses can be particularly sensitive to demand surge. When there is widespread damage to property, low regional capacity to meet the increased demand can result in longer-than-normal repair times. This, in turn, results in greater business interruption losses and additional living expenses. Infrastructure damage, delayed building permit processes and a shortage of available building inspectors are also factors in increasing time element losses.

AIR's analysis indicates that as industry losses increase, Coverage D losses increase at a significantly higher rate than for Coverages A and B. Therefore, the demand surge factor applied to coverage D for all levels of loss above $5 billion is an exponential of the demand surge factor for Coverages A and B.

All coverages combined

Since Touchstone Re is an aggregate loss analysis application, it uses a single combined demand surge function. This curve was developed by first applying the relevant demand surge factors to AIR modeled industry losses by coverage. Aggregating the losses across all coverage types with demand surge included and dividing the sum by the losses without demand surge yielded an estimate of the demand surge factor for each event. These factors by event were then matched with their respective modeled industry loss and smoothed to achieve a final curve that encompasses all coverage types. This function is implemented in Touchstone Re. While the combined function does not provide resolution by coverage type, the results are reasonably stable between the two methodologies.

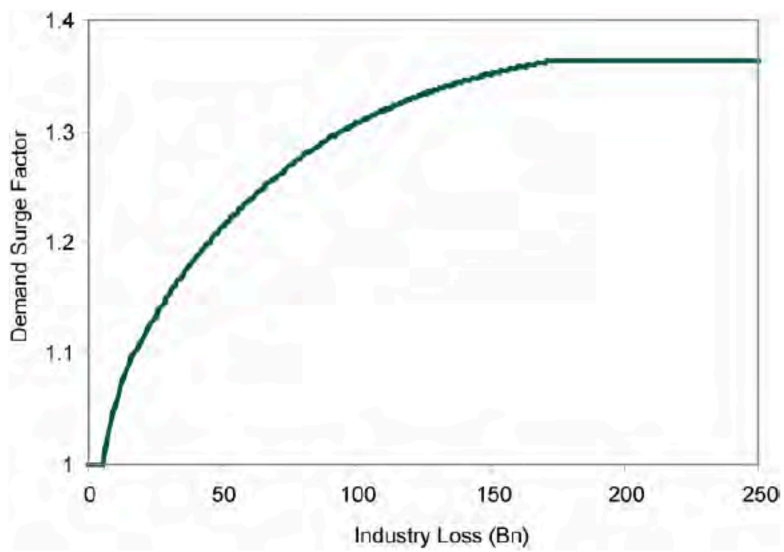

Figure 9. Touchstone Re Industry Demand Surge Curve

Uncertainty in demand surge modeling

As noted previously, there are few historical data points with which to develop and validate a demand surge function; for extreme events that make up the tail of the distribution there are none. The data that is available presents challenges due to differences in reporting practices and timeliness. Also, because much of the available data is reported quarterly, it can be difficult to distinguish the effects of events that occur in close geographic and temporal proximity, or from other inflationary pressures not related to the events themselves.

There are additional challenges to modeling Coverage D, as losses are rarely reported separately for this coverage and the available cost time series data tends to focus solely on the effects on building materials and labor. Information regarding delays in reconstruction is sparse and chiefly anecdotal. However, these challenges can be addressed in a number of ways. AIR has performed original research and analysis based on information available in academic, construction, insurance, business, and actuarial trade publications. In addition, AIR utilizes the opinions of their construction experts, who have 25 years of industry experience, as well as experts in economics, statistics, and actuarial science.

The AIR demand surge function currently implemented in the AIR software systems is the result of 15 years of research and refinement. That research is still ongoing, and as new data becomes available, AIR will make additional refinements as appropriate.

Sensitivity studies

Although there is uncertainty in modeling demand surge, stress tests performed on the demand surge function do not produce radically different results. AIR conducted a series of tests to quantify the effects of altering the curves by various amounts. This was done by increasing or decreasing the curves one at a time by the factors indicated in the table below, while holding the curves for the other coverages constant. The impact of the altered functions on estimated industry average annual loss (AAL) and 1% probability of exceedance losses (100-year return period) are also summarized in the table.

Table 1. Effects of stress tests performed on the AIR demand surge function

Coverage	Stress	% Change in AAL	% Change in 1% Loss	% Change in 0.4% Loss
A/B (Buildings/Other Structures)	Increase 25%	2.7	4.8	5.1
A/B (Buildings/Other Structures)	Decrease 25%	-2.4	-3.8	-4.1
C (Contents)	Increase 5%	-0.5	0.5	0.7
C (Contents)	Increase 10%	0.9	1.1	1.5
D (Time Element)	Square Root (A/B Curve)	-0.8	-1.4	-2.3
D (Time Element)	Equal to A/B Curve	-0.5	0.9	-1.4
D (Time Element)	(A/B Curve) Cubed	1.2	2.1	3.7

4 Validate the demand surge

This section describes analyses conducted by AIR to validate the demand surge function.

Validation

In addition to internal peer review and analyses such as those presented here, the AIR demand surge function has been reviewed and meets the Demand Surge Standard of the Florida Commission on Hurricane Loss Projection Methodology It has also been reviewed by rating agencies as part of the due diligence they perform with respect to insurance-linked securitizations, or catastrophe bonds.

Construction cost time series data available following the U.S. hurricanes of 2004 and 2005 have been used to validate the demand surge function. The fact that there have been no major damaging earthquakes in the U.S. in recent years and thus no recent data on associated changes in local labor and materials costs makes explicit calibration of the demand surge function to the earthquake peril challenging. There is anecdotal evidence, however, that would suggest the reasonability of the AIR demand surge function for use with the AIR Earthquake Model for the United States. Following the Northridge earthquake of 1994, the California Earthquake Authority testified that insurers had reported price inflation of 20% in the wake of that event. [6]

If the Northridge earthquake event were to recur today, AIR's estimate of insurable industry losses would be $49 billion, which corresponds to a demand surge factor of roughly 21% using the current function. Indeed, there is no evidence to suggest that the demand surge function is peril specific. Demand surge is fundamentally an economic phenomenon; while there may be some differences in the types of materials and labor required for repair and rebuilding, these should have a relatively small impact on overall price inflation in the aftermath of a catastrophe.

Validate demand surge for coverage A and B

The construction cost time series data from the 2004 and 2005 U.S. hurricane seasons allowed AIR to isolate the changes in the costs of individual building components due to each storm and, subsequently, to determine how each component contributed to the demand surge as it relates to Coverage A and B losses.

The construction cost data came from XactAnalysis™, a reporting tool created by Xactware. XactAnalysis offers Industry Trend Reporting, which provides construction labor and material cost information over time. AIR-obtained quarterly data for the labor and material breakdowns shown below. The data were used to analyze the effects of the 2004 Hurricanes Charley, Jeanne, Frances, Ivan, and the 2005 Hurricanes Katrina, Rita and Wilma.

[6] Catastrophe Modeling: A New Approach to Managing Risk (Kunreuther et al, Springer Publishing, 2005)

Table 2. XactAnalysis data series used for validation

Labor	Material
Roofer	Roofing Material
Carpenter	Lumber
Drywall Installer	Drywall Materials
Flooring Installer	Carpet
Demolition Laborer	
Electrician	
Plumber	

Material and labor cost changes

Trend data on material and labor costs is monitored on an ongoing basis. After an event, the change in cost for each material and labor category in each geographic area was calculated for:

- the quarter in which the storm made landfall
- the following three quarters

In an attempt to isolate the effect of the storms on construction costs from other effects, the change in U.S. average cost for each data category for the corresponding time period was subtracted from the cost change for the storm-affected region.

Composition of damage at the county level

To estimate demand surge at the county level (the resolution most closely matching the resolution of the XactAnalysis data), AIR engineers first estimated how physical damage from the storms was distributed across six building components: roof covering, roof sheathing, windows and doors, interiors, exterior walls, other (e.g. plumbing, electrical). The estimated physical damage to each component was then translated into a dollar amount by applying a damage ratio to the replacement cost of the component. Each component's repair cost was then calculated as a share of the total repair cost for the building.

Material and labor breakdown by category

Because demand surge affects materials costs and labor costs differently it was then necessary to determine the breakdown of repair costs between materials and labor for each building component. For example, it is estimated that 29% of the repair cost of replacing roof covering is attributable to materials and 71% is attributable to labor.

Weighted demand surge by county

Based on the information gathered thus far, the change in component costs from XactAnalysis, the share in total repair costs of each component, and the labor/materials breakdown for each component, a weighted demand surge estimate can be determined for each county.

Using the top loss-producing counties, the aggregate demand surge for each storm was calculated as a weighted combination of the county-level demand surge factors, with weights determined by the share of the modeled county loss in total losses. Note that "aggregate demand surge" refers to the inflationary pressure caused by the combined effects of storms that occurred in close temporal and geographical proximity.

For each event, the demand surge for Coverage A and B was calculated for the quarter the storm made landfall, and for the next three quarters (essentially to the beginning of the following hurricane season).

Cumulative demand surge by event

To determine the demand surge for each event, the cumulative demand surge for each quarter was weighted using the percentage of total claims paid during that quarter. The cumulative demand surge function was tested using the major storms of 2004—Charley, Frances, Ivan and Jeanne—which all made landfall in or near Florida within a 45-day period. The demand created by events that occur in such close proximity has a bigger impact on the regional economy than any single event taken independently.

Because of this, and because the XactAnalysis cost data is provided quarterly (therefore making it difficult to isolate the effects of individual storms), AIR took the additional step of calculating a single combined demand surge factor for the four storms together. This factor is simply a weighted combination of the aggregate demand surge of the individual storms, with weights equal to the share of each storm's modeled loss in total losses for the four storms.

The figure [7] below shows the fit of the demand surge factors from recent historical events relative to the AIR demand surge function. Note that the demand surge estimate for Katrina below does not include Louisiana. For a full discussion of the factors affecting the demand surge estimate for Katrina, please see the following section. Overall, given the low number of events, the data approximates the AIR demand surge function reasonably well.

[7] Northridge estimated demand surge is taken from Catastrophe Modeling: A New Approach to Managing Risk (Kunreuther et al, Springer Publishing, 2005)

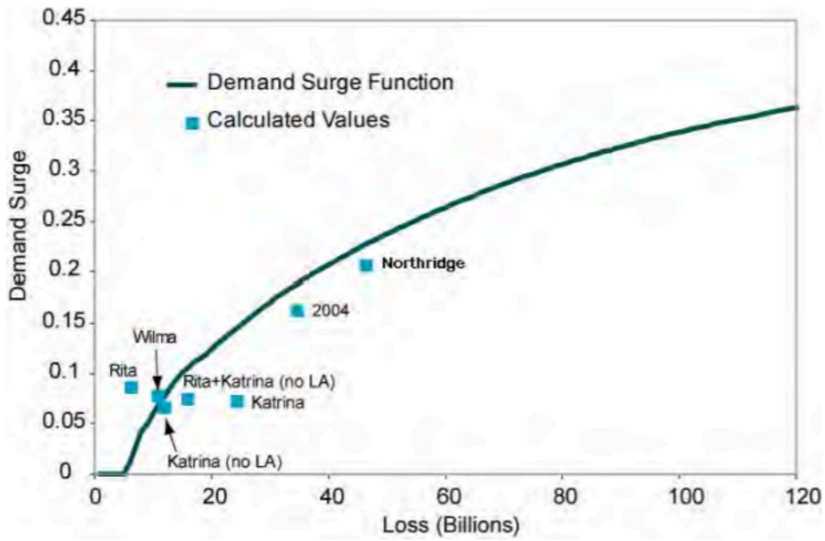

Figure 10. AIR demand surge function for coverage A and B with calculated demand surge for individual events

Hurricane Katrina

Hurricane Katrina was an unprecedented natural disaster in modern U.S. history, both in the scope and nature of the destruction it caused. The floods in New Orleans and its surrounding areas caused significant challenges to rebuilding in the days and weeks following the event. Furthermore, many areas of the city and its surroundings were sparsely or even completely uninhabited for months after the storm hit; some of these neighborhoods are still more or less abandoned today. Because the rebuilding in much of this area has happened gradually rather than being concentrated in a short period, AIR did not observe the same spikes in labor and materials costs that would typically be associated with such events.

Evidence from a wide range of sources points to these factors holding down the demand for rebuilding resources in these areas. For example, on March 19, 2007, the trade publication Engineering NewsRecord ran a story about the delays associated with rebuilding following Katrina:

"[Southeast Louisiana Building and Construction Trades Council President Donald] Denese says many union members and leader had hoped that major reconstruction in the region would be underway by now, but delays in relief funds and insurance hassles have slowed developers plans. "We thought we'd be up and running by now, but it's still crawling," he says. "We're ready to answer the call, but the call hasn't come yet."

In validating the demand surge function, and in particular, the estimates of demand surge for Katrina, AIR has looked at the event from several perspectives. As there is little evidence to show that the rebuilding in Mississippi and Alabama moved at the same abnormally slow pace as the New Orleans area rebuilding, so AIR also estimated demand surge for Katrina by looking at only Mississippi and Alabama losses and the associated changes in labor and materials costs in these areas.

Validate demand surge for coverage D

When a sudden, sharp increase in demand taxes the resources of a catastrophe-affected region, not only do the cost of materials and labor rise, but the time required to repair or rebuild damaged properties also increases. In the case of severe events that cause extensive and widespread damage, construction delays can be significant. The AIR demand surge function accounts for potential delays in reconstruction due to labor shortages—delays that lead to increased time element, or Coverage D, losses.

In order to measure the effect of large events on time element losses, AIR undertook an analysis of claims data for the major events of the 2004 season and 2005 seasons. The analysis utilized data from a number of sources, including the Insurance Information Institute, ISO Property Claims Services, and the Bureau of Labor Statistics.

Based on estimates of damage ratios to individual buildings and estimates of available labor in the affected areas, AIR construction engineers first calculated the average number of days required to complete repairs to a building to the point where additional living expenses or business interruption would no longer be paid out. These estimates were then combined with information on the total number of property claims to calculate the expected period of time it would take to make all repairs to all damaged buildings. This yielded an estimate of total time element losses that took into account the potential stresses on the labor market following a large catastrophe.

Finally, these figures were compared to the modeled time element losses for these storms. AIR estimated that coverage D demand surge was approximately 21% for the 2004 season and 63% for Katrina. These estimates, point estimates of coverage D demand surge for these events, were used to measure and validate the relationship between coverage A and coverage D demand surge

5 Example of demand surge validation

Construction cost data obtained from XactAnalysis following the U.S. hurricanes of 2004 and 2005 was used by AIR to validate the demand surge function. In particular, AIR first determined the change in cost of individual building components due to each storm, and then how each component contributed to aggregate demand surge. The following discussion walks the user through a sample demand surge calculation, with a focus on 2004's Hurricane Charley.

Calculate changes in material and labor costs

For each of the 2004 and 2005 hurricanes, and for each geographical area affected by the storms, the change in cost for the materials and labor categories shown in Table 3 was calculated.

Table 3. XactAnalysis Data Series

Materials	Labor
Roofing Material	Roofer
Lumber	Carpenter
Drywall Materials	Drywall Installer
Carpet	Flooring Installer
	Demolition Laborer
	Electrician
	Plumber

The percentage change was calculated separately for the quarter before the storm occurred, the quarter in which the storm occurred, and the quarter following the storm. To isolate the cost changes due to the storm from other economic factors, the change in U.S. average costs was subtracted from the cost change reported for the storm-affected region.

For example, the following table shows that the cost of roofing labor in Lee County, Florida increased by 35.9% (42% minus 6.1%) between the third and fourth quarters of 2004 as a result, primarily, of Hurricane Charley.

Table 4. Change in Roofing Labor Cost Change from Q3 to Q4 2004, Lee County

Geographic Area	Mapped County	Cost in $ Per hour Q3 2	Cost in $ per hour Q4 2004	Percent Change from Q3 to Q4
Lee County, FL	Lee	50.74	72.05	42.0%
United States (average)		51.0	54.09	6.1%
Percent change due to hurricanes (42% less 6%)				35.9%

Calculate component contributions to total repair costs

To estimate demand surge at the county level (the resolution most closely matching the resolution of the XactAnalysis data), AIR engineers first estimated how physical damage from the storms was distributed across six building components: roof covering, roof sheathing, windows and doors, interiors, exterior walls, other (e.g. plumbing, electrical). The estimated physical damage to each component was then translated into a dollar amount by applying a damage ratio to the replacement cost of the component, according to the data below.

Table 5. Conversion of mean damage ratio to component damage ratio

Building MDR	Roof Cover	Roof Sheath	Windows/ Doors	Interior	Ext. Walls	Misc.
0.20%	0.10%	0.00%	0.00%	0.00%	0.00%	0.30%
1.50%	3.00%	0.00%	1.00%	0.00%	0.00%	1.00%
5.40%	15.00%	0.10%	5.00%	0.50%	0.00%	5.00%
20.20%	37.50%	2.50%	20.00%	5.00%	3.80%	18.80%
72.50%	100.00%	50.00%	60.00%	25.00%	35.00%	50.00%
97.60%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Component damage ratios for values between the mean damage ratios provided above were calculated by linear interpolation. This step was done at a ZIP Code level.

As an example, ZIP Code 33921 had a mean damage ratio of 17.36% from Charley. In order to get the component damage ratios for this ZIP Code, values for each component were interpolated between the 5.40% and 20.20% mean damage ratio data shown in the table. Thus, the Roof Cover component damage ratio was 32.47%, Roof Sheathing 1.96%, and so forth.

This calculation was made at the ZIP Code level and aggregated by county by weighting each ZIP within a county by its modeled loss for a given event. Each component's repair cost was then calculated as a share of the total repair cost for the building. Table 6 illustrates this calculation for a typical home in Lee County, Florida, in the aftermath of Hurricane Charley. The top row provides the average replacement cost for each building component as estimated by AIR construction engineers. For example, the average replacement cost of a roof covering in Lee County is estimated at $5,899.

Table 6. Damage percentages from Hurricane Charley for Lee County

	Roof Covering	Roof Sheathing	Windows and Doors	Interiors	Exterior Walls	Misc	Foundation/ Other	Total
Replacement Cost	$5,899	$3,595	$9,364	$45,486	$12,551	$15,206	$28,000*	$120,000[8]
Damage Ratio	0.200	0.034	0.098	0.043	0.028	0.078	----	----
Repair Cost	$1,180	$122	$918	$1,956	$351	$1,186	----	----
Component Contribution to Total Repair Cost	20.6%	2.1%	16.0%	34.4%	6.1%	20.8%	0.0%	100.0%

The second row shows AIR's estimate of the component damage ratio, or the percentage of each building component damaged by Hurricane Charley in Lee County. For example, it is estimated that 20% of the roof covering will be damaged. The product of the replacement cost and damage ratio is calculated for each component to achieve the repair cost for that component (e.g. $5,899 * 0.20 = $1,180). The sum of all the products (the sum across row three) is the total cost to repair the property ($5,713). The final row gives the percentage contribution of each component repair to the total repair cost.

Calculate the contribution of material and labor to repair costs

Because demand surge affects materials costs and labor costs differently, it is necessary to determine the breakdown of repair costs between materials and labor for each building component. Results as estimated by AIR construction engineers are summarized in the table below.

For example, it is estimated that 29% of the cost of repairing roof coverings is attributable to materials and 71% is attributable to labor. The column labeled Materials indicates the type and composition of materials need for the repair. The Labor column indicates the type and composition of labor need to execute the repairs. Where the materials needed do not match the most common material types, the repair costs are attributed entirely to labor since, in any case, the demand surge effect on materials prices is minimal.

[8] Approximate estimate

Table 7. Estimated labor/materials repair cost breakdown by building component, Lee County

	Breakdown	Materials	Labor
Roof Covering	29% Material 71% Labor	100% Roofing Material	100% Roofer
Roof Sheathing	39% Material 61% Labor	100% Lumber	100% Carpenter
Windows and Doors	66% Material 34% Labor	No Match	100% Carpenter
Interiors	43% Material 57% Labor	33% Drywall Materials 67% Carpet	33.3% Drywall Installer 33.3% Carpet Installer 33.3% Demolition Laborer
Exterior Walls	54% Material 46% Labor	100% Lumber	100% Carpenter
Other	41% Material 59% Labor	No Match	33% Electrician 67% Plumber

Calculate the effect on demand surge of individual components

Continuing with the example of the cost of roof covering, we know from the previous table that the repair cost breakdown between materials and labor is 29% and 71%, respectively. From the analysis of the XactAnalysis cost time series data for Lee County, we know that labor costs experienced a 35.9% increase as a result of the storm (from Table 4). A similar analysis (not shown here) shows a decrease of 0.3% in the cost of roofing materials between Q3 and Q4—that is, virtually no change.

Table 8. Calculation of demand surge effect on the cost of roof covering in Lee County due to Hurricane Charley

Cost Series	% Contribution to Repair Costs	Cost Change Due to Hurricane Charley (Q3 - Q4, 2004)	Demand Surge Effect
Roofing Material	29	-0.3%	-0.1%
Roofer Labor	71	35.9%	25.6%
Total	100%		25.4%

As shown in the table above, the total demand surge effect on roof covering repair costs from Hurricane Charley in Lee County is estimated at 25.4% for the third quarter (the quarter in which the storm made landfall). From Table 9 , we know that repairs to roof covering account for 20.6% of the total building repair cost. If we multiply the demand surge effect on the component cost by that component's contribution to total repair costs, we arrive at the component's contribution to total demand surge. This process is illustrated in the first column of the table.

These steps are repeated for each of the six modeled building components and the results summed. As the table shows, the total demand surge effect from Hurricane Charley in Lee County is estimated at 15.81% for the third quarter.

Table 9. Contribution of building components to total demand surge in Lee Country

Building Component	Roof Covering	Roof Sheathing	Windows and Doors	Interiors	Exterior Walls	Other	Total
Component Contribution to Total Repair Cost	20.6%	2.1%	16.0%	34.4%	6.1%	20.8%	100.0%
Est. Demand Surge by Component	25.4%	23.9%	12.5%	14.6%	19.0%	9.1%	
Est. Demand Surge Weighted by Component	5.23%	0.50%	2.00%	5.02%	1.16%	1.89%	15.81%

Calculate demand surge across the affected region

The process described above is repeated for each of the counties significantly affected by each storm. The aggregate demand surge for the storm during the quarter is calculated as a weighted combination of the county-level demand surge factors, with weights determined by the share of the modeled county loss in total losses.

The table below shows the results for Hurricane Charley for the first quarter following landfall. Total demand surge for this quarter is calculated at 14.79%.

Table 10. Demand surge by county (Hurricane Charley)

County	Gross Loss (Coverages A and B)	Weighted Loss Percentage	Demand Surge (%)
Lee	2,805,299,238	72.31	15.81
Charlotte	466,621,525	12.03	14.48
Collier	196,702,714	5.07	15.93
Orange	133,371,186	3.44	4.10
Sarasota	86,657,899	2.23	10.57
Volusia	61,724,517	1.59	12.25
Osceola	45,696,118	1.18	7.23
Polk	43,521,229	1.12	5.96
Seminole	40,012,575	1.03	8.16
Total	$ 3,879,607,002	100.00%	14.79%

For each event, demand surge is calculated for the quarter in which the storm made landfall (capturing essentially the change in cost before the storm to after the storm) and for the next three quarters (essentially to beginning of the next hurricane season). The example for Hurricane Charley is shown below.

Table 11. Demand surge by quarter (Hurricane Charley)

	Q3 2004 (Landfall)	Q4 2004	Q1 2005	Q2 2005
Quarter-specific Demand Surge	14.79	7.16	1.25	0.53

Calculate cumulative demand surge by event

To determine the total demand surge factor for each event, the cumulative demand surge for each quarter was weighted using the percentage of total claims paid during that quarter. An example, using Hurricane Charley, is provided below.

Table 12. Demand surge percentages for Hurricane Charley

	Q3 2004	Q4 2004	Q1 2005	Q2 2005	Total
Percent of Claims Paid in Quarter	48.00	37.00	11.00	4.00	
Cumulative Percent of Claims Paid	48.00	85.00	96.00	100.00	
Quarter-Specific Demand Surge	14.79	7.16	1.25	0.53	
Cumulative Demand Surge	14.79	23.01	24.55	25.21	19.32%

The aggregated demand surge for each of the storms analyzed is provided in Table 13. Hurricane Charley has the highest demand surge despite the losses being lower than those from some of the other events. This is because post-Charley damage surge includes the incremental inflationary pressures of Hurricanes Frances, Jeanne and Ivan. Similarly, demand surge for Hurricane Jeanne, which caused lower losses than either Charley or Frances, is quite high because it followed a path very similar to Frances less than three weeks after Frances made landfall, putting maximum pressure on local resources.

Table 13. Demand surge percentage by event

Event	Aggregate Demand Surge (%)
Charley	19.32
Frances	15.69
Ivan	11.79
Jeanne	18.92
Wilma	7.72
Katrina	7.22
Rita	8.61

Aggregation of 2004 losses

The major storms of 2004—Charley, Frances, Ivan and Jeanne—all made landfall in or near Florida within a 45-day period. The demand created by events that occur in such close proximity has a bigger impact on the regional economy than any single event taken independently. Because of this and because the XactAnalysis cost data is provided quarterly (therefore making it difficult to isolate the effects of individual storms), AIR took the additional step of calculating a single combined demand surge factor for the four storms together (Table 14). This factor is simply a weighted combination of the aggregate demand surge of the individual storms, with weights equal to the share of each storm's modeled loss in total losses for the four storms.

Table 14. 2004 aggregate demand surge

Storm	Charley	Jeanne	Frances	Ivan	Weighted Average Demand Surge
Loss (billions)	8.906	9.845	6.47	9.592	16.14
Demand Surge	19.32	18.92	15.69	11.79	

About AIR Worldwide

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