Validating Large-Scale Simulations of Socio-Political Phenomena

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Agenda

- Project Overview.
  - Research goal.
  - Technical Approach.
  - Application to linear equations.
- Prototype Development.
- Illustration of Tool Functionality.
- Opportunities and Challenges.

The Challenge for HSCB Simulations

- Potential for significant contributions to the development of policy, strategy, and operational plans.
- Often large and complex.
  - Prohibits complete validation over space of possible situations.
  - Makes transparency into causes of outcome for specific situations very difficult.
- Resulting lack of credibility can lead to user avoidance.

Need scientifically based methods and tools that improve transparency and help users and developers manage risks.

Research Goal

- Create an automated capability to help a *user* assess the applicability of a simulation for a specific use without having to be familiar with model algorithms.
  - Supports systematic variation of input variables and examination of output variables.
  - Identifies the subset of chosen input variables and interactions that most influence chosen output.
- User defines his/her problem, configures the simulation, and frames experiment.
  - Specifies cases to be explored and questions to be answered.
  - Identifies a set of relevant input variables.
  - Establishes hypotheses about expected outcomes.
- Improve transparency of complex simulations.
- Help sponsors, end users, and developers manage the risk associated with application of complex simulations.

Technical Approach

Innovative Use of Modified Box-Meyer Algorithm

- Employ Box-Meyer algorithm for finding active factors in fractionated screening experiments.
  - Uses Bayesian algorithm with 2-level experimental designs to compute the probability a set of variables is active given outcomes.
  - Overcomes limitations of traditional visual inspection methods in dealing with interactions.
  - Analyzes factors simultaneously verses sequential factor-by-factor sensitivity analysis.
- Use method to help users rapidly identify important factors that may be acting individually or in concert with others.
- Develop user friendly automated tool.
  - Control of experimental designs, key parameters, simulation runs.

Technical Approach

Major Focus of Research

- Minimize errors (false positives/negatives) in the presence of computational constraints.
  - Selection of algorithm parameters.
  - Impact of including factor interactions in analysis.
  - Partitioning input factors to reduce computationally intractable models to computable ones.
- Use scientific measurable approach:
  - Develop and explore hypotheses regarding errors.
  - Evolve application methods and guidelines.
  - Use systematic experiments & progressively more complex models.
    - Sets of tailored & known linear equations.
    - Simulations with well understood behavior.

Highlights of Equation Based Research for Identifying Active Factors in Linear Models

- Reviewed, streamlined, improved, and verified the code that instantiates the B-M algorithm.
  - Reduced tool run time by order of magnitude.
- Developed automation to rapidly generate equations with interactions and noise, run tool, and analyze results.
  - Developed computable quantitative metrics to serve as indicators of the degree to which variables in an equation are active.
- Developed hypotheses regarding tool behavior and application strategies for 6-10 variables.
  - Explored impact of parameter values, including interactions in analyses and partial designs.
- Developed and evolved partitioning approach for equations with 12-50 variables.
  - Varied size of partitions, completeness of designs, etc.

Identifying Active Factors in Equations with Many Input Variables: Partitioning

- The general partitioning approach: Use a set of partitions that satisfy the following condition:
  - Each combination of factors to at least the maximum order of interactions to be analyzed in the equations (MAXINT) is represented in at least one partition.
- The method for constructing partitions: divide the factors into groups and use each combination of MAXINT groups as a partition.
- The design for applying tool: Fractional factorial with resolution matched to MAXINT.

Supporting Exploratory Experiment

- Research issues:
  - The larger the group, the more runs required. What is the optimal group size?
  - The more complete the design, the more runs required. What is the minimum resolution of the design?
- Key parameters
  - Variables in equations: 20, 30, 40, 50.
  - Number of equations: 100 (50 for 50 variables).
  - Order of equations: 2.
  - Order of interactions included in analysis: 2.
  - Group sizes: 3, 4, 5, 6.
  - Designs: Full design and 2^{10-1}, 2^{10-2}, and 2^{10-3} for group size 5.
  - Noise levels: 1, 3 (σ = noise level * range / 20).

Summary of Accomplishments For Equation Research

- Recommendations for how to do partitioning when identifying active factors in linear equations with large number of factors and noise.
  - Partitioning method is matched to the order of interactions included in analysis.
  - Size of groups and design resolution of partitions were determined.
- Methods to help detect presence of systemic errors when MAXINT setting is too low.
- Confirmation of parameter selections recommended by Box.
- Additional method of ranking active factors and models.

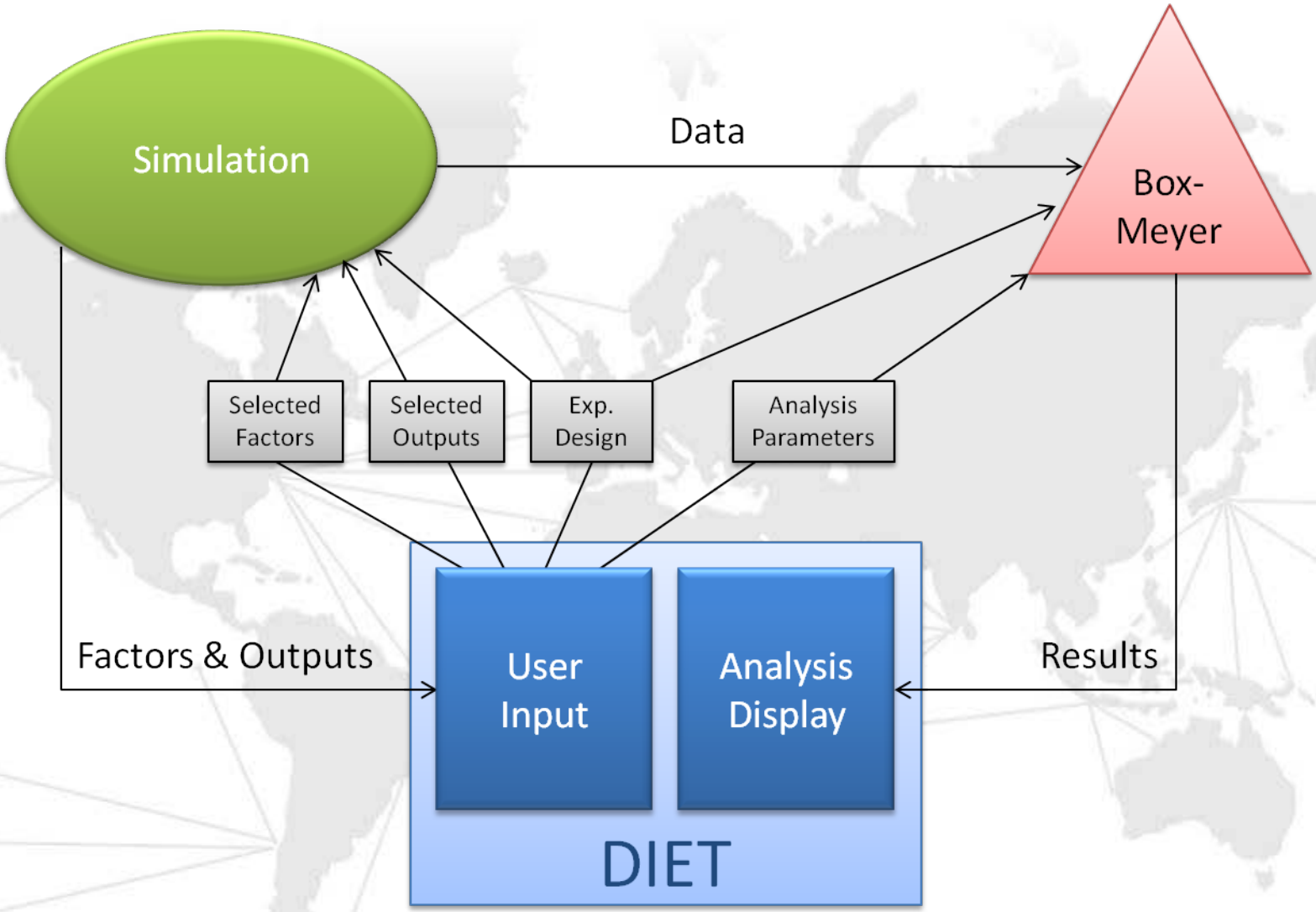
Minimizes Error Under Computational Constraints.

Development of Prototype

Driver Identification Exploration Tool (DIET)

- Objective: Develop a software prototype that instantiates the algorithm and application methods resulting from earlier research.
  - Functional architecture.
  - Interfaces with simulation.
- Key Challenge: Develop a DIET "Dashboard" that provides:
  - Integrated presentation of results, performance indicators, and needed actions.
  - Easy access to supporting details or controls for running and comparing additional cases.
- Base presentation framework on types of problems faced by user and questions that arise in applying DIET.
  - Define classes of problems & questions.
  - Identify critical displays, indicators, and controls.
  - Organize and present for ease of use.

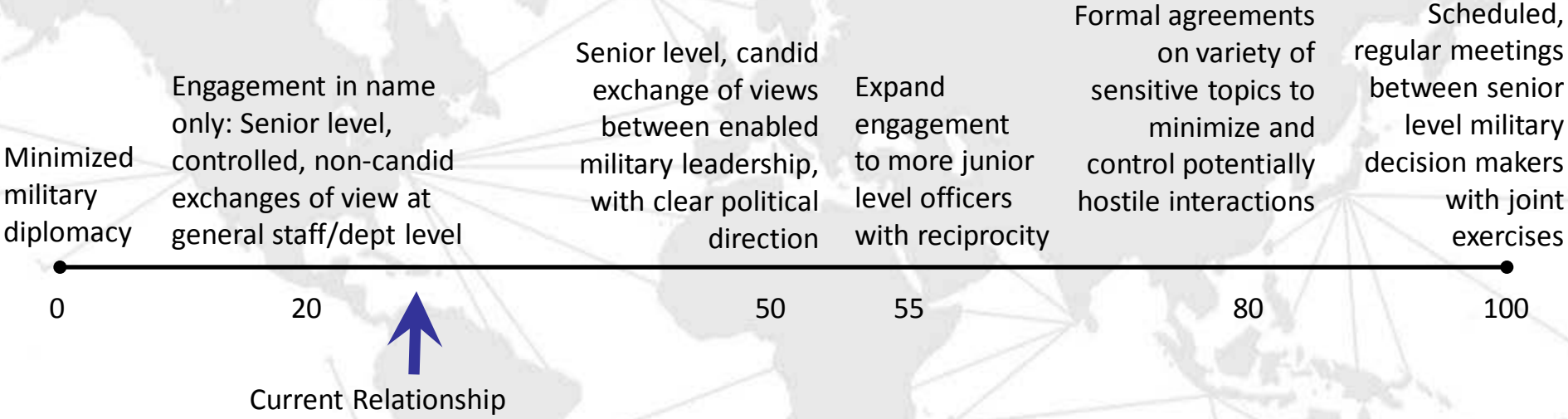
Top Level Architecture



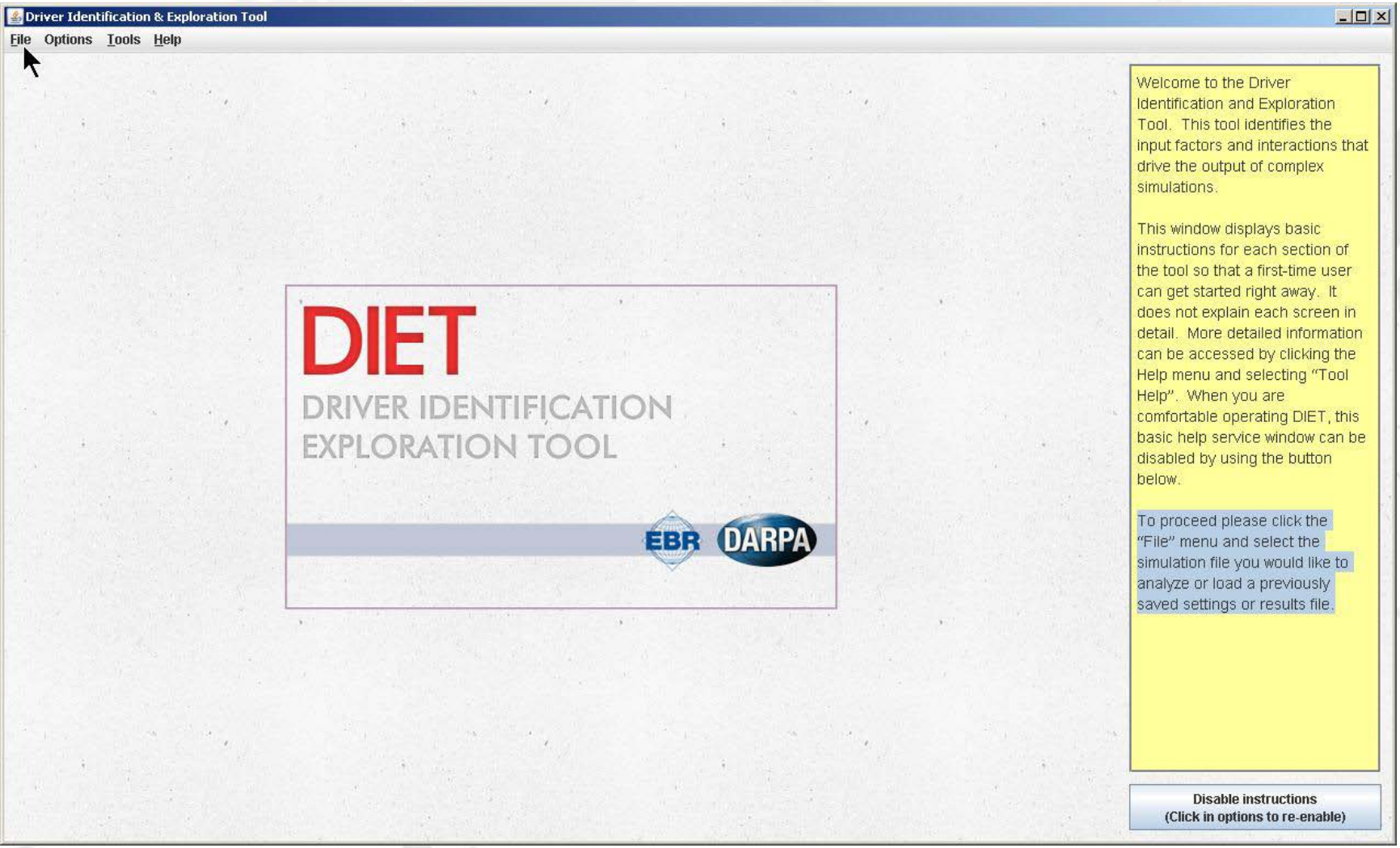
Application to Senturion Simulation

- DIET utilized stored results from runs of Senturion application to US-Chinese negotiations.
  - Earlier in the project, NDU ran the Senturion simulation using the min and max positions for 24 Chinese actors.
    - The set of inputs was the opening position of each actor on a US-PRC Military Diplomacy Issue Scale.
    - The set of outcomes was the final position of each of the 43 actors.
    - The 24 Chinese actors were partitioned into 5 groups.
- Application illustrates:
  - Typical choices of outputs, inputs, and design.
  - Initial results.
  - Iteration and refinement.

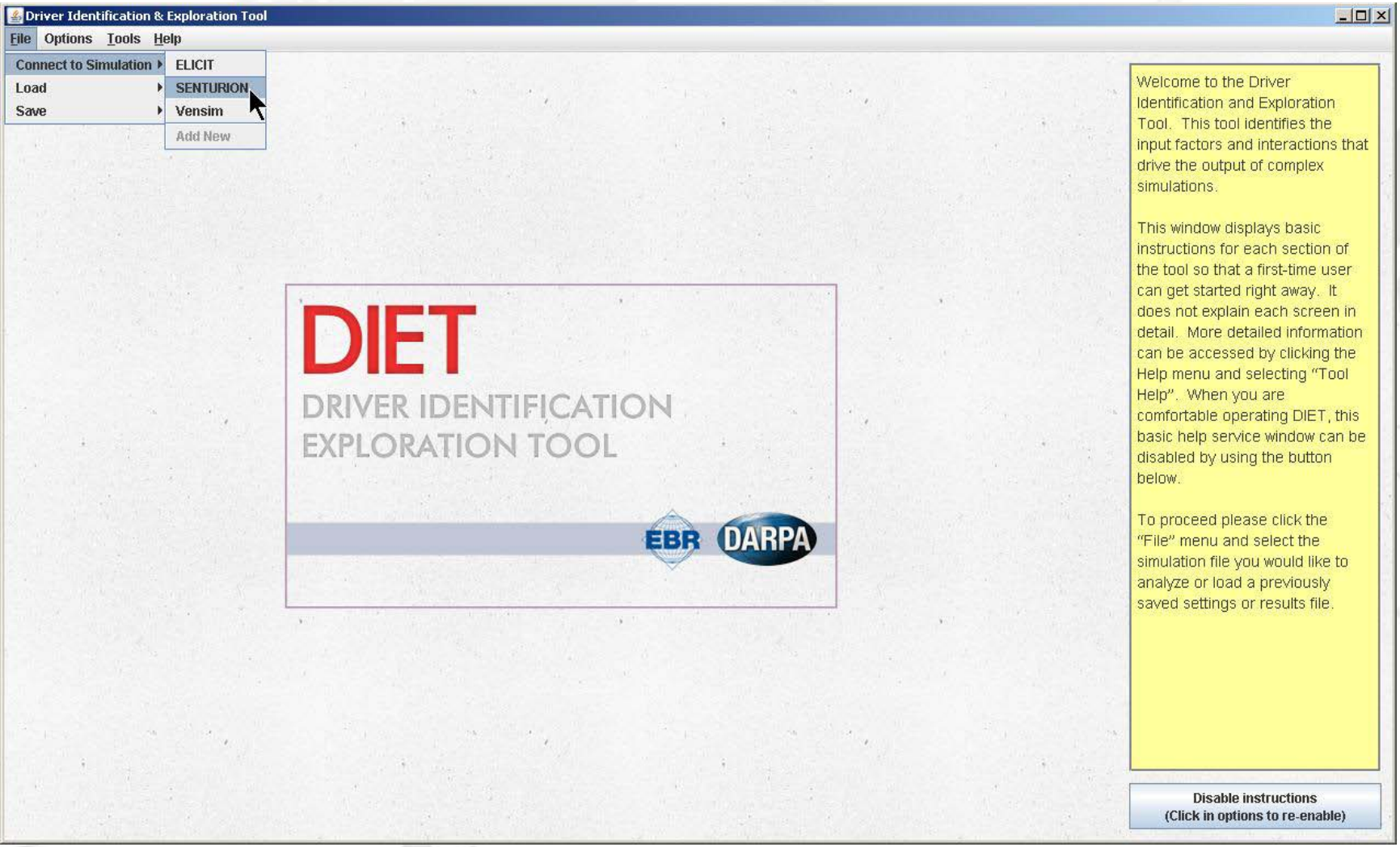
US-PRC Military Diplomacy Issue Scale



Welcome to DIET



Selection of Simulation



Selection of Outputs

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design

4 Outputs Selected | Select Visible | Clear Visible | Clear All | Show Selected | Show All

Selection	Name	Position	Country	Type
- No Filter -			- No Filter -	- No Filter -
☐	Final Forecast			
☑	Hu Jintao	President	China	Final Position
☑	Wen Jiabao	Premier	China	Final Position
☐	Zeng Qinghong	Vice President	China	Final Position
☐	Luo Gan	Politburo	China	Final Position
☐	Guo Boxiong	CMC	China	Final Position
☐	Liang Guanglie	Chief of Genereal Staff Dept - CMC	China	Final Position
☐	Zhang Qinsheng	Deputy Chief of Staff - resp for int re...	China	Final Position
☐	Wu Bangguo	Politburo	China	Final Position
☐	Wu Yi	Vice Premier	China	Final Position
☐	Zeng Peiyan	Vice Premier	China	Final Position
☐	Li Zhaoxing	Ministry of Foreign Affairs	China	Final Position
☐	Dai Bing Guo	Vice Min Foreign Affairs	China	Final Position
☐	Cao Gangchuan	Ministry of National Defence	China	Final Position
☐	Xu Caihou	CMC	China	Final Position
☐	National Development and Reform ...		China	Final Position
☐	Jin Renqing	Ministry of Finance	China	Final Position
☐	Chen Bingde	Head of Armaments Dept - CMC	China	Final Position
☐	Jing Zhiyuan	Commander of the Second Artillery ...	China	Final Position
☐	Costind		China	Final Position
☐	Jiang Zemin		China	Final Position
☐	Xiong Guang Kai	President of China Instit for Intl Stu...	China	Final Position
☐	Chinese Inst for Strategic Studies		China	Final Position
☐	Found for Intl Strategic Studies		China	Final Position
☐	Retired Former High-Level Generals		China	Final Position
☐	George Bush	President	US	Final Position
☐	Dick Cheney	Vice President	US	Final Position

Select the simulation outputs you wish to understand by either:

- Clicking on the checkbox(es) in the first column or
- Filtering on the basis of desired characteristics of the output factor(s) of interest by using the drop down menus under the column headings and then clicking "Select Visible."

You can also filter on the basis of undesired characteristics by clicking "Select All" then filtering on the undesired characteristics and clicking "Clear Visible."

To make it easier to narrow your search, outputs can be sorted by any of their properties by clicking on the appropriate column title.

After you have selected which outputs to use, select the factors tab.

Disable instructions
(Click in options to re-enable)

Selection of Input Factors

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design

24 Factors Selected | Select Visible | Clear Visible | Clear All | Show Selected | Show All

Selection	Name	Position	Country	Type	Default Value	Strict Min	Strict Max	Value	Min	Max
Selected	- No Filter -	- No Filter -	- No Filter -	- No Filter -						
☑	Hu Jintao	President	China	Position	20	0	100		0	50
☑	Wen Jiabao	Premier	China	Position	35	0	100		5	65
☑	Zeng Qinghong	Vice President	China	Position	30	0	100		0	60
☑	Luo Gan	Politburo	China	Position	7	0	100		0	37
☑	Guo Boxiong	CMC	China	Position	25	0	100		0	55
☑	Liang Guanglie	Chief of Genereal Staff...	China	Position	30	0	100		0	60
☑	Zhang Qinsheng	Deputy Chief of Staff - ...	China	Position	25	0	100		0	55
☑	Wu Bangguo	Politburo	China	Position	35	0	100		5	65
☑	Wu Yi	Vice Premier	China	Position	35	0	100		5	65
☑	Zeng Peiyan	Vice Premier	China	Position	40	0	100		10	70
☑	Li Zhaoxing	Ministry of Foreign Affa...	China	Position	30	0	100		0	60
☑	Dai Bing Guo	Vice Min Foreign Affairs	China	Position	36	0	100		6	66
☑	Cao Gangchuan	Ministry of National De...	China	Position	30	0	100		0	60
☑	Xu Caihou	CMC	China	Position	20	0	100		0	50
☑	National Development...		China	Position	50	0	100		20	80
☑	Jin Renqing	Ministry of Finance	China	Position	50	0	100		20	80
☑	Chen Bingde	Head of Armaments D...	China	Position	35	0	100		5	65
☑	Jing Zhiyuan	Commander of the Se...	China	Position	10	0	100		0	40
☑	Costind		China	Position	25	0	100		0	55
☑	Jiang Zemin		China	Position	40	0	100		10	70
☑	Xiong Guang Kai	President of China Ins...	China	Position	20	0	100		0	50
☑	Chinese Inst for Strate...		China	Position	22	0	100		0	52
☑	Found for Intl Strategic...		China	Position	60	0	100		30	90
☑	Retired Former High-L...		China	Position	25	0	100		0	55

- Clicking on the checkbox(es) in the first column or

- Filtering on the basis of desired characteristics by using the drop down boxes under the column headings and then clicking either "Select Visible."

You can also filter on the basis of undesired characteristics (one per column), clicking "Clear Visible" and then "Select Visible."

The default value for each factor as well as the strict minimum and maximum, as controlled by the simulation, are shown. If any of these values are modified in your actual simulation runs you should change them here by double clicking the appropriate box, and entering the correct values. If nothing is entered, the defaults will be used.

After you have selected which factors to use, select the design tab.

Disable instructions
(Click in options to re-enable)

Input of Computational Constraints

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design

4 Outputs
24 Factors

Estimated Time for Single Simulation Run:

Maximum Time for All Simulation Runs:

Show All Designs

Number of Runs Required	Estimated Run Time	Level of Interaction

Enter the estimated time for a single simulation run and the maximum amount of time you wish to allocate for all runs. Enter using s, m, h, and d for seconds, minutes, hours, and days. For example, a single simulation run might take 1s, and you may want to generate designs that will take a maximum of 1d 2h.

Hit enter and the tool will generate the designs that can be used within your preferred time frame. If you do not know or do not wish to enter the run time information, you can show the entire set of design options by clicking on the "Show All Designs" button.

Disable instructions
(Click in options to re-enable)

Selection of Design

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design

4 Outputs
24 Factors

Estimated Time for Single Simulation Run: 1s
Maximum Time for All Simulation Runs: 16h

Show All Designs

Number of Runs Required	Estimated Run Time	Level of Interaction
40960	11h 22m	3
28672	7h 57m	3
24576	6h 49m	2
20480	5h 41m	3
16384	4h 33m	3
14336	3h 58m	3
12288	3h 24m	2
10240	2h 50m	3
8192	2h 16m	3
6144	1h 42m	2
5120	1h 25m	2
3840	1h 4m	2
3584	59m 44s	2
3072	51m 12s	2
2560	42m 40s	2
1920	32m 0s	2
1792	29m 52s	2
1536	25m 36s	2
1280	21m 20s	2
960	16m 0s	2
768	12m 48s	2

This screen lists the designs that can be used without introducing spurious relationships between the input and output variables (typically called confounding). A higher level of interaction produces better results, but the higher the level of interaction, the more combinations that must be analyzed, and therefore the more time needed.

Double click on the row for the design you wish to use.

Disable instructions
(Click in options to re-enable)

Dashboard: Activeness Ranking for Total Effects

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (16 Active Factors)

Relative Level of Activeness

Active Factors

- Hu Jintao
- Liang Guanglie
- Zhang Qinsheng
- Guo Boxiong
- Jiang Zemin
- Jin Renqing
- Cao Gangchuan
- Found for Intl Strategic Studies
- Xu Caihou
- Wen Jiabao

Total Effect | Main Effect | Interaction Effect

Distribution of Factors by Relative Level of Activeness

Relative Level

Main

Inactive Factors

Error Indicators

Domain

Perform Another Run?

Interactions

Perform Another Run?

Advanced View

The top chart shows the relative level of activeness of each factor. By default, only the total effect of the active factors is shown. Click on the legend entry to enable (or disable) the corresponding bar for the other options. Notice that for a given variable, the total effect is not generally the sum of the main effect and the interaction effect.

Click on the "#" button above the scrollbar to change the number of factors you wish to see displayed in the window. The maximum number allowed is sixteen.

Click on a factor's blue bar to see the interaction strength of that factor with other factors. Click on a factor's red bar to see the interaction strength compared with the main effect.

The bottom chart shows the distribution of relative level of activeness of the factors in decreasing order of their relative level. Hovering over a bar indicates which factor is represented by that bar.

Disable instructions (Click in options to re-enable)

Dash Board: Activeness Ranking for Main Effects and Interactions

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (16 Active Factors)

Relative Level of Activeness

Active Factors: Hu Jintao, Liang Guanglie, Zhang Qinsheng, Guo Boxiong, Jiang Zemin, Jin Renqing, Cao Gangchuan, Found for Intl Strategic Studies, Xu Caihou, Wen Jiabao

Total Effect | Main Effect | Interaction Effect

Distribution of Factors by Relative Level of Activeness

Relative Level

Main: Inactive Factors

Error Indicators

Domain: Perform Another Run?

Interactions: Perform Another Run?

Advanced View

The top chart shows the relative level of activeness of each factor. By default, only the total effect of the active factors is shown. Click on the legend entry to enable (or disable) the corresponding bar for the other options. Notice that for a given variable, the total effect is not generally the sum of the main effect and the interaction effect.

Click on the "#" button above the scrollbar to change the number of factors you wish to see displayed in the window. The maximum number allowed is sixteen.

Click on a factor's blue bar to see the interaction strength of that factor with other factors. Click on a factor's red bar to see the interaction strength compared with the main effect.

The bottom chart shows the distribution of relative level of activeness of the factors in decreasing order of their relative level. Hovering over a bar indicates which factor is represented by that bar.

Disable instructions (Click in options to re-enable)

Dash Board: Interaction Strengths for Factor

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (16 Active Factors)

Interaction Strength for Actor Hu Jintao

Interaction Strength for "Hu Jintao"

(Ordered by Absolute Strength)

Strength

Active Factors

Terms

Liang Guanglie
Zhang Qinsheng
Jiang Zemin
Guo Boxiong
Cao Gangchuan
National Development and Reform Commission
Wen Jiabao
Li Zhaoxing
Jin Renqing
Zeng Qinghong

Relative Level

Main

Inactive Factors

Error Indicators

Domain

Perform Another Run?

Interactions

Perform Another Run?

Advanced View

Click on the "#" button above the scrollbar to change the number of factors you wish to see displayed in the window. The maximum value allowed is sixteen.

Each bar on this chart represents the interaction effect of one factor's value on the current factor. The main factor is listed first (if visible) followed by each interaction in decreasing order by absolute interaction effect.

Disable instructions (Click in options to re-enable)

Dash Board: Distribution of Factors by Strength

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (16 Active Factors)

Relative Level of Activeness

Active Factors

Hu Jintao
Liang Guangli
Zhang Qinshen
Guo Boxion
Jiang Zemi
Jin Renqin
Cao Gangchua
Found for Intl Strategic Studie
Xu Caiho
Wen Jiaba

Active Factors

Active Factors At/Above (5 Factors)

Hu Jintao
Liang Guanglie
Zhang Qinsheng
Guo Boxiong
Jiang Zemin

Active Factors Below (11 Factors)

Jin Renqing
Cao Gangchuan
Found for Intl Strategic Studies
Xu Caihou
Wen Jiabao
Li Zhaoxing
Zeng Qinghong
National Development and Reform Commission

teraction Effect

Main

Inactive Factors

Error Indicators

Domain

Perform Another Run?

Interactions

Perform Another Run?

Distribution Activeness

Relative Level

Jiang Zemin

Advanced View

Click on the "#" button above the scrollbar to change the number of factors you wish to see displayed in the window. The maximum number allowed is sixteen.

Click on a factor's blue bar to see the interaction strength of that factor with other factors. Click on a factor's red bar to see the interaction strength compared with the main effect.

The bottom chart shows the distribution of relative level of activeness of the factors in decreasing order of their relative level. Hovering over a bar indicates which factor is represented by that bar. Clicking on a bar shows which factors' relative levels of activeness are at/above and below the relative level of the factor represented.

On the right, there are two error indicators that specify the extent to which the domains of the factors and level of interaction used have impacted the quality of the analysis. Clicking on the

Disable instructions
(Click in options to re-enable)

Dash Board: Inactive Factors

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (16 Active Factors)

Relative Level of Activeness

Active Factors: Hu Jintao, Liang Guanglie, Zhang Qinsheng, Guo Boxiong, Jiang Zemin, Jin Renqing, Cao Gangchuan, Found for Intl Strategic Studies, Xu Caihou, Wen Jiabao

Total Effect | Main Effect | Interaction Effect

Inactive Factors

Inactive Factors (8 Factors)

- Luo Gan
- Wu Bangguo
- Wu Yi
- Zeng Peiyan
- Dai Bing Guo
- Chen Bingde
- Chinese Inst for Strategic Studies
- Retired Former High-Level Generals

Distribution of Factors by Relative Level of Activeness

Relative Level

Main

Inactive Factors

Error Indicators

Domain

Perform Another Run?

Interactions

Perform Another Run?

Advanced View

The bottom chart shows the distribution of relative level of activeness of the factors in decreasing order of their relative level. Hovering over a bar indicates which factor is represented by that bar. Clicking on a bar shows which factors' relative levels of activeness are at/above and below the relative level of the factor represented.

On the right, there are two error indicators that specify the extent to which the domains of the factors and level of interaction used have impacted the quality of the analysis. Clicking on the "Perform Another Run?" button will take you back to either the "Factors" or "Designs" tab with instructions on how to improve the results.

The inactive factors button brings up a list of factors not found to be active in the model.

The "View All Outputs" button leads to a chart where one can view the relative level of activeness of all factors across

Disable instructions (Click in options to re-enable)

Dash Board: Getting to Other Views

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (16 Active Factors)

Relative Level of Activeness

Active Factors: Hu Jintao, Liang Guanglie, Zhang Qinsheng, Guo Boxiong, Jiang Zemin, Jin Renqing, Cao Gangchuan, Found for Intl Strategic Studies, Xu Caihou, Wen Jiabao

Total Effect | Main Effect | Interaction Effect

Distribution of Factors by Relative Level of Activeness

Relative Level

Main: Inactive Factors

Error Indicators

Domain: Perform Another Run?

Interactions: Perform Another Run?

Advanced View

Error indicators that specify the extent to which the domains of the factors and level of interaction used have impacted the quality of the analysis. Clicking on the "Perform Another Run?" button will take you back to either the "Factors" or "Designs" tab with instructions on how to improve the results.

The inactive factors button brings up a list of factors not found to be active in the model.

The "View All Outputs" button leads to a chart where one can view the relative level of activeness of all factors across multiple outputs. The "Summary" button shows a summary comparison of the results for all of the outputs. The "Compare Results" button allows you to compare the summary data over result sets in different tabs (which use the same set of input factors but with potentially different analysis settings). The "Close These Results" button removes the current results tab from the tool.

Disable instructions (Click in options to re-enable)

Dashboard: All Outputs View

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (16 Active Factors)

Main

Active Factors

Relative Level

Total Effect Activeness Ranking

Outputs
- Hu Jintao
- Wen Jiabao
- PACOM
- Henry Kissinger

All | Clear

Total Effect Activeness Ranking

Relative Level of Activeness

Active Factors

Hu Jintao

Wen Jiabao

Zeng Qinghong

Guo Boxiong

Hu Jintao ■ Wen Jiabao ■ PACOM ■ Henry Kissinger

Advanced View

This chart shows the relative level of activeness for all factors active for any of the outputs selected. For each bar next to a factor, the legend indicates which output the relative level is associated with. You can also hover over the bar.

To change which outputs' relative levels are shown, use the list on the left. To change the number of factors shown, press the "#" button above the chart.

Disable instructions
(Click in options to re-enable)

Dash Board: Summary of Outputs Graphical View

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Compare Results

Outputs

Results 1

1: Hu Jintao

2: Wen Jiabao

3: PACOM

4: Henry Kissinger

All | Clear

Table View

Add Results

Active Factor Rankings

Factors Top Percent: 0, 3, 6, 9, 12, 15

10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Top Percent

Error Indicators

Value: 0.00, 0.25, 0.50, 0.75, 1.00

1 2 3 4

Run Number

Overall R^2 Average R^2

Percent Active/Inactive

100% 75% 50% 25% 0%

1 2 3 4

Run Number

Percent Active Percent Inactive

Active Factor Distribution

Value: 0.00, 0.25, 0.50, 0.75, 1.00

1 2 3 4

Run Number

Distribution Metric

This screen compares results for analyses done using the same set of input factors. Select the outputs to compare from the list on the left. To add another result set from a file, click on the "Add Results" button.

The upper left chart displays the number of factors that are in the top 10, 20, 30, etc. percentiles of the active factors for each of the selected outputs. The 100 percentile value represents the number of factors that are active for all of the outputs.

The upper right chart displays the Domain and Interaction Indicators for the selected outputs.

The lower left chart displays the active-inactive distribution of factors for each of the outputs.

The lower right chart provides a comparison of the distribution of the active factors by activeness over the

Disable instructions (Click in options to re-enable)

Dash Board: Summary of Outputs Table View

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Compare Results

Outputs

Results 1
1: Hu Jintao
2: Wen Jiabao
3: PACOM
4: Henry Kissinger

All | Clear

Table View

Add Results

Factors Top Percent

100%
75%
50%
25%
0%

Table View

4 Runs Selected | Select Visible | Clear Visible | Clear All | Show Selected | Show All

Selection	Results File	Output	Run #	% Active	% Inactive	Domain Ind.	Interactio Ind.	Activity Level
- No Filter -								
✔	Results 1	Hu Jintao	1	67%	33%	0.467	0.727	0.79
✔	Results 1	Wen Jiabao	2	62%	38%	0.547	0.679	0.798
✔	Results 1	PACOM	3	62%	38%	0.227	0.463	0.471
✔	Results 1	Henry Kissinger	4	58%	42%	0.258	0.6	0.556

This table displays the information for all outputs over all results. Included for each output are the results file, the run number, the percent of active and inactive factors, the domain and interaction error indicator values, and the active factor distribution metric.

Disable instructions
(Click in options to re-enable)

Dashboard: Error Indicators

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (16 Active Factors)

Relative Level of Activeness

Active Factors: Hu Jintao, Liang Guanglie, Zhang Qinsheng, Guo Boxiong, Jiang Zemin, Jin Renqing, Cao Gangchuan, Found for Intl Strategic Studies, Xu Caihou, Wen Jiabao

Total Effect | Main Effect | Interaction Effect

Distribution of Factors by Relative Level of Activeness

Relative Level

Main: Inactive Factors

Error Indicators

Domain: Perform Another Run?

Interactions: Perform Another Run?

Advanced View

The bottom chart shows the distribution of relative level of activeness of the factors in decreasing order of their relative level. Hovering over a bar indicates which factor is represented by that bar. Clicking on a bar shows which factors' relative levels of activeness are at/above and below the relative level of the factor represented.

On the right, there are two error indicators that specify the extent to which the domains of the factors and level of interaction used have impacted the quality of the analysis. Clicking on the "Perform Another Run?" button will take you back to either the "Factors" or "Designs" tab with instructions on how to improve the results.

The inactive factors button brings up a list of factors not found to be active in the model.

The "View All Outputs" button leads to a chart where one can view the relative level of activeness of all factors across

Disable instructions (Click in options to re-enable)

Increasing the Level of Interaction Analyzed

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

4 Outputs
24 Factors

Estimated Time for Single Simulation Run: 1s
Maximum Time for All Simulation Runs: 16h

Show All Designs

Number of Runs Required	Estimated Run Time	Level of Interaction
40960	11h 22m	3
28672	7h 57m	3
20480	5h 41m	3
16384	4h 33m	3
14336	3h 58m	3
10240	2h 50m	3
8192	2h 16m	3

Interaction Level Adjustment

Please select a design with a higher level of interaction to rerun the analysis. The designs have been filtered to only show those with higher levels of interaction. If you would like to see all the designs, click the "Show All Designs" button.

OK

This screen lists the designs that can be used without introducing spurious relationships between the input and output variables (typically called confounding). A higher level of interaction produces better results, but the higher the level of interaction, the more combinations that must be analyzed, and therefore the more time needed.

Double click on the row for the design you wish to use.

Disable instructions
(Click in options to re-enable)

Selecting Higher Level of Interaction Design

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1

4 Outputs
24 Factors

Estimated Time for Single Simulation Run: 1s
Maximum Time for All Simulation Runs: 16h

Show All Designs

Number of Runs Required	Estimated Run Time	Level of Interaction
40960	11h 22m	3
28672	7h 57m	3
20480	5h 41m	3
16384	4h 33m	3
14336	3h 58m	3
10240	2h 50m	3
8192	2h 16m	3

This screen lists the designs that can be used without introducing spurious relationships between the input and output variables (typically called confounding). A higher level of interaction produces better results, but the higher the level of interaction, the more combinations that must be analyzed, and therefore the more time needed.

Double click on the row for the design you wish to use.

Disable instructions
(Click in options to re-enable)

Higher Level of Interaction Results

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1 | Results 2

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (20 Active Factors)

Relative Level of Activeness

Active Factors: Hu Jintao, Zhang Qinsheng, Liang Guanglie, Cao Gangchuan, Li Zhaoxing, Jin Renqing, Found for Intl Strategic Studies, Guo Boxiong, Xu Caihou, Jiang Zemin

Total Effect | Main Effect | Interaction Effect

Distribution of Factors by Relative Level of Activeness

Relative Level

Main: Inactive Factors

Error Indicators

Domain: Perform Another Run?

Interactions: Perform Another Run?

Advanced View

The top chart shows the relative level of activeness of each factor. By default, only the total effect of the active factors is shown. Click on the legend entry to enable (or disable) the corresponding bar for the other options. Notice that for a given variable, the total effect is not generally the sum of the main effect and the interaction effect.

Click on the "#" button above the scrollbar to change the number of factors you wish to see displayed in the window. The maximum number allowed is sixteen.

Click on a factor's blue bar to see the interaction strength of that factor with other factors. Click on a factor's red bar to see the interaction strength compared with the main effect.

The bottom chart shows the distribution of relative level of activeness of the factors in decreasing order of their relative level. Hovering over a bar indicates which factor is represented by that bar.

Disable instructions (Click in options to re-enable)

Multiple Run Comparison

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1 | Results 2

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Compare Results

Outputs

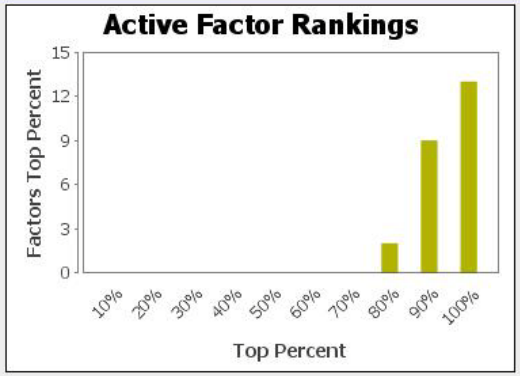
Results 1
1: Hu Jintao
2: Wen Jiabao
3: PACOM
4: Henry Kissinger

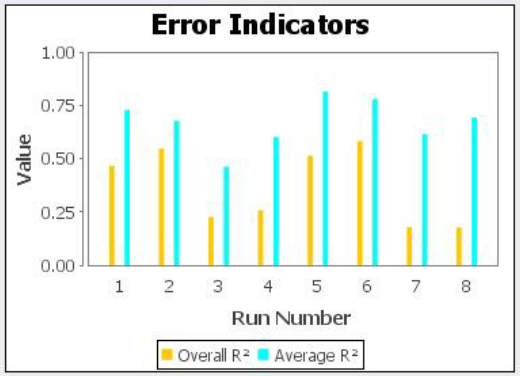
Results 2
5: Hu Jintao
6: Wen Jiabao
7: PACOM
8: Henry Kissinger

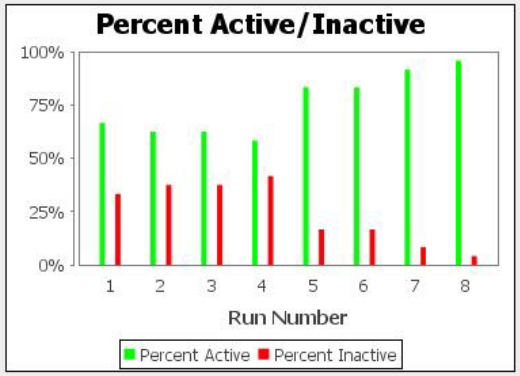
All | Clear

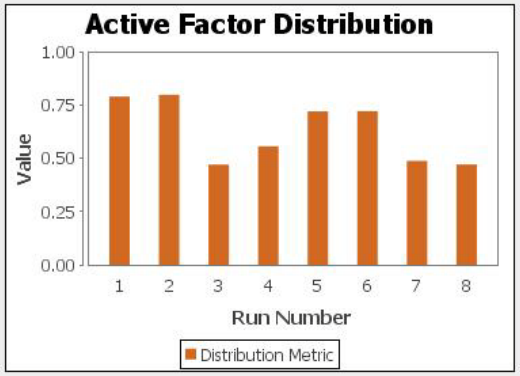
Table View

Add Results









This screen compares results for analyses done using the same set of input factors. Select the outputs to compare from the list on the left. To add another result set from a file, click on the "Add Results" button.

The upper left chart displays the number of factors that are in the top 10, 20, 30, etc. percentiles of the active factors for each of the selected outputs. The 100 percentile value represents the number of factors that are active for all of the outputs.

The upper right chart displays the Domain and Interaction Indicators for the selected outputs.

The lower left chart displays the active-inactive distribution of factors for each of the outputs.

The lower right chart provides a comparison of the distribution of the active factors by activeness over the

Disable instructions
(Click in options to re-enable)

Dashboard: Accessing Advanced View

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1 | Results 2

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (20 Active Factors)

Relative Level of Activeness

Active Factors: Hu Jintao, Zhang Qinsheng, Liang Guanglie, Cao Gangchuan, Li Zhaoxing, Jin Renqing, Found for Intl Strategic Studies, Guo Boxiong, Xu Caihou, Jiang Zemin

Total Effect | Main Effect | Interaction Effect

Distribution of Factors by Relative Level of Activeness

Relative Level

Main: Inactive Factors

Error Indicators

Domain

Perform Another Run?

Interactions

Perform Another Run?

Advanced View

analysis. Clicking on the "Perform Another Run?" button will take you back to either the "Factors" or "Designs" tab with instructions on how to improve the results.

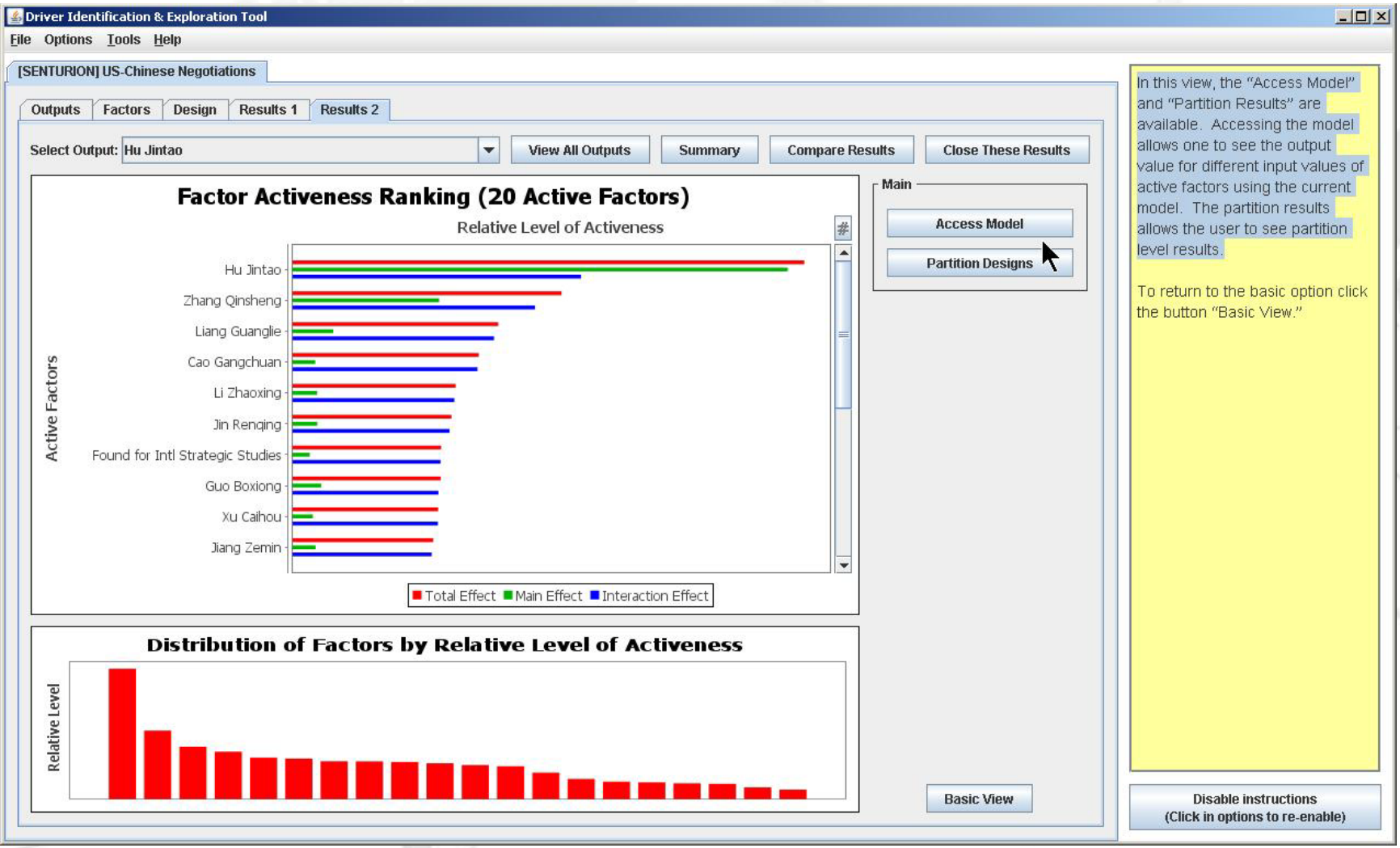
The inactive factors button brings up a list of factors not found to be active in the model.

The "View All Outputs" button leads to a chart where one can view the relative level of activeness of all factors across multiple outputs. The "Summary" button shows a summary comparison of the results for all of the outputs. The "Compare Results" button allows you to compare the summary data over result sets in different tabs (which use the same set of input factors but with potentially different analysis settings). The "Close These Results" button removes the current results tab from the tool.

To view more advanced options click the button "Advanced View."

Disable instructions (Click in options to re-enable)

Dashboard: Advanced View



Advanced Dash Board Views: Accessing Regression Model

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1 | Results 2

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Regression Model Output Calculator

Output: Hu Jintao Value: 27.0

Name	Position	Country (- No Filter -)	Type (- No Filter -)	Input Value	Strict Min	Strict Max
Hu Jintao	President	China	Position	20	0	100
Wen Jiabao	Premier	China	Position	35	0	100
Zeng Qinghong	Vice President	China	Position	30	0	100
Luo Gan	Politburo	China	Position	7	0	100
Guo Boxiong	CMC	China	Position	25	0	100
Liang Guanglie	Chief of Genereal Staff De...	China	Position	30	0	100
Zhang Qinsheng	Deputy Chief of Staff - res...	China	Position	25	0	100
Zeng Peiyan	Vice Premier	China	Position	40	0	100
Li Zhaoxing	Ministry of Foreign Affairs	China	Position	30	0	100
Cao Gangchuan	Ministry of National Defen...	China	Position	30	0	100
Xu Caihou	CMC	China	Position	20	0	100
National Development an...		China	Position	50	0	100
Jin Renqing	Ministry of Finance	China	Position	50	0	100
Chen Bingde	Head of Armaments Dept ...	China	Position	35	0	100
Jing Zhiyuan	Commander of the Secon...	China	Position	10	0	100
Costind		China	Position	25	0	100
Jiang Zemin		China	Position	40	0	100
Xiong Guang Kai	President of China Instit f...	China	Position	20	0	100
Found for Intl Strategic St...		China	Position	60	0	100
Retired Former High-Leve...		China	Position	25	0	100

Main

Access Model

Partition Designs

Basic View

This table uses the active factor regression model to calculate the output value when one or more input values are changed. For reference, the strict minimum and maximum values for each of the inputs are also listed.

Disable instructions (Click in options to re-enable)

Advanced Dash Board Views: Partition Design Table

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1 | Results 2

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (20 Active Factors)

Relative Level of Activeness

Hu Jintao

Main: Access Model | Partition Designs

Partition Designs

Partition	Factors	R²	X²	SD of Y	1	2	3	4	5	6	7	10	11	13	14	15	16	17	18	19	20	21	23	24
1	1 2 3 7 8 9 19 20...	.98	16,779.4	24.35																				
2	1 2 3 7 8 9 22 23...	.90	598.2	10.51																				
3	1 2 3 10 11 12 1...	.80	659.5	10.79																				
4	1 2 3 10 11 12 1...	.89	478.2	5.04																				
5	1 2 3 10 11 12 1...	.96	1,670.8	5.04																				
6	1 2 3 10 11 12 2...	.85	494.3	5.06																				
7	1 2 3 13 14 15 1...	.80	290.3	8.48																				
8	1 2 3 13 14 15 1...	.79	586.4	9.74																				
9	1 2 3 13 14 15 2...	.82	569.3	9.78																				
10	1 2 3 16 17 18 1...	.90	699.3	4.44																				
11	1 2 3 4 5 6 7 8 9	.97	7,826.3	22.22																				
12	1 2 3 16 17 18 2...	.89	559.5	4.23																				
13	1 2 3 19 20 21 2...	.93	512.2	5.42																				
14	4 5 6 7 8 9 10 11...	.92	703.6	8.37																				
15	4 5 6 7 8 9 13 14...	.70	345.8	7.43																				
16	4 5 6 7 8 9 16 17...	.78	242.7	6.29																				
17	4 5 6 7 8 9 19 20...	.86	324.3	7.68																				
18	4 5 6 7 8 9 22 23...	.89	617.7	7.68																				
19	4 5 6 10 11 12 1...	.43	450.1	3.62																				
20	4 5 6 10 11 12 1...	.88	1,151.7	2.42																				
21	4 5 6 10 11 12 1...	.81	834.1	2.27																				
22	1 2 3 4 5 6 10 11...	.81	1,125.1	11.81																				
23	4 5 6 10 11 12 2...	.88	895.4	2.18																				
24	4 5 6 13 14 15 1...	.49	607.9	2.23																				
25	4 5 6 13 14 15 1...	.39	416.5	2.28																				
26	4 5 6 13 14 15 2...	.54	357.9	2.89																				
27	4 5 6 16 17 18 1...	.81	1,148.5	3.00																				

Basic View

In complex simulations, the data must be partitioned into computationally tractable pieces. This table lists the partitions used for this analysis. The factors present in each partition are listed in the second column, and the active factors for a partition are marked with green cells in the factor columns on the right. Inactive factors are marked in red, and factors not included in a partition are marked in white.

For each partition both an R^2 and X^2 value are given along with the standard deviation of the partition outputs (SD of Y).

The R^2 value measures how well the model composed only of the active factors explains the partition outputs, while the X^2 value measures how well the residuals from the mean (intercept residuals) fit a normal distribution with standard deviation equal to the SD of Y.

A low X^2 value means that the intercept residuals are close to

Disable instructions (Click in options to re-enable)

Advanced Dash Board Views: Accessing Partition Residuals Graphs

Driver Identification & Exploration Tool

File Options Tools Help

[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1 | Results 2

Select Output: Hu Jintao

View All Outputs | Summary | Compare Results | Close These Results

Factor Activeness Ranking (20 Active Factors)

Relative Level of Activeness

Hu Jintao

Main

Access Model

Partition Designs

Partition Designs

Partition	Factors	R^2	X^2	SD of Y	1	2	3	4	5	6	7	10	11	13	14	15	16	17	18	19	20	21	23	24
1	1 2 3 7 8 9 19 20...	.98	16,779.4	24.35																				
2	1 2 3 7 8 9 22 23...	.90	598.2	10.51																				
3	1 2 3 10 11 12 1...	.80	659.5	10.79																				
4	1 2 3 10 11 12 1...	.89	478.2	5.04																				
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7	1 2 3 13 14 15 1...	.80	290.3	8.48																				
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10	1 2 3 16 17 18 1...	.90	699.3	4.44																				
11	1 2 3 4 5 6 7 8 9	.97	7,826.3	22.22																				
12	1 2 3 16 17 18 2...	.89	559.5	4.23																				
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16	4 5 6 7 8 9 16 17...	.78	242.7	6.29																				
17	4 5 6 7 8 9 19 20...	.86	324.3	7.68																				
18	4 5 6 7 8 9 22 23...	.89	617.7	7.68																				
19	4 5 6 10 11 12 1...	.43	450.1	3.62																				
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22	1 2 3 4 5 6 10 11...	.81	1,125.1	11.81																				
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24	4 5 6 13 14 15 1...	.49	607.9	2.23																				
25	4 5 6 13 14 15 1...	.39	416.5	2.28																				
26	4 5 6 13 14 15 2...	.54	357.9	2.89																				
27	4 5 6 16 17 18 1...	.81	1,148.5	3.00																				

Basic View

X^2 value measures how well the residuals from the mean (intercept residuals) fit a normal distribution with standard deviation equal to the SD of Y.

A low X^2 value means that the intercept residuals are close to normal, in which case, the variation in partition outputs can be treated as noise, and a low R^2 becomes less important. Of course, if the standard deviation is high, this might not be the best interpretation.

A high X^2 value, on the other hand, indicates that the partition behavior is non-normal or "interesting." Partitions with a high X^2 value and low R^2 value may indicate an inadequate analysis.

Click on a column to sort the partitions by one of the criteria.

Double click on a partition row to open a scatter plot of residuals for that partition, including the residuals for the model as identified by the tool for that partition.

Disable instructions (Click in options to re-enable)

Advanced Dash Board Views: Partition Residuals Graphs

Driver Identification & Exploration Tool

File Options Tools Help

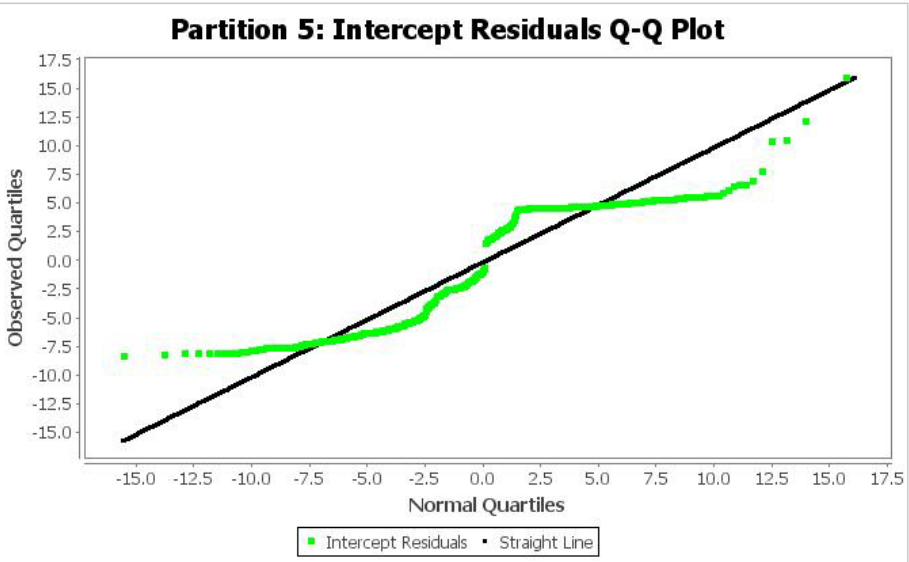
[SENTURION] US-Chinese Negotiations

Outputs | Factors | Design | Results 1 | Results 2

Select Output: Hu Jintao | View All Outputs | Summary | Compare Results | Close These Results

Partition 5 Residuals

Intercept Q-Q Plot | Intercept vs Partition Model | Partition Model Q-Q Plot | Partition Model vs Overall Model



$X^2(97) = 1670.8$ and $N(0, 5.04)$

Main: Access Model | Partition Designs

Basic View

The graphs on this screen describe the distribution of partition residuals.

This graph is a Quartile-Quartile plot of the intercept residuals (residuals from the mean output) against the normal distribution with standard deviations equal to the standard deviation of the residuals. This allows a visual analysis of how close these residuals are to a normal distribution.

Disable instructions (Click in options to re-enable)

Interpretation of Findings

- These are both interesting results that the simulation itself would not have revealed.
- In the case of Kissinger, while Renqing does not change his position directly, when Renqing's max position is used at the outset, it affects the simulation in such a way that other actors are in a position to move Kissinger.
- In the case of Jintao, when Qinsheng is at his max, Wilder (NSC) is able to move Jintao to 28. When Qinsheng is at his min, PACOM is able to move Jintao to 25.
- These are results that the user would not have known without using the tool.

Key Accomplishments

- Variable partitioning method that promises a useful level of scalability while controlling errors.
- Means of ranking factors in terms of the degree of activeness.
- Guidelines for application of the algorithm to simulations.
  - Algorithm Parameters.
  - Level of interaction analyzed.
  - Variable domain end points.
  - Experimental design.
- Indicators of the potential sources of error.

Enabled definition of requirements for development of prototype tool

Next Steps: Applications

- Tool is ready for application to simulations.
  - Will allow continuing development of the tool's analysis capability.
  - Will refine understanding of each simulation.
- Will help users and developers rapidly identify important factors that may be acting individually or in concert with others.
- Application will help improve transparency of complex simulations and help sponsors, end users, and developers manage the risk associated with their application.
- Interaction with model developers will be necessary to either build an interface or produce the runs needed.

Next Steps: Research Opportunities

- Determine better metrics than R2 for measuring model fit; e.g. the distribution of the residuals.
- Develop algorithms for automatic identification of anomalous behavior in the model.
- Include basic testing for non-linearity in the model (within specified factor ranges).
- Develop means of automatically identifying the factors whose ranges contribute the most to the non-linearity.
- Illuminate causal chain within simulation.
- Given some level of non-linearity, explore the effect of using different partitionings.
- Develop means of combining the results of multiple partitionings.
- Develop potentially more efficient partition construction methods that reuse the partitions from those associated with the analysis of lower levels of interaction.

Closing Thoughts

- Research produced application strategy that addresses key scalability and performance issues.
- Seeking partners interested in:
  - Further research to refine understanding.
  - Applying prototype tool to simulations.
  - Continuing development of analysis capability.
  - Commercialization of services or tool.