

Frequently Asked Questions of NCDEX
Rainfall based Weather Derivative
Futures Contract

NCDEX

NCDEX – Mumbai Rainfall-Based Weather Derivative – Frequently Asked Questions

1. Summary

This note outlines the understanding on weather and Weather based derivative products including basic understanding on weather, rainfall, methodology used for weather derivatives, data sources, spot-price construction process, and contract mechanics for the proposed Mumbai rainfall-based weather derivative. The contract settles on the monthly cumulative deviation from the Long Period Average (LPA), calculated using daily rainfall observations from IMD's Colaba and Santacruz stations, obtained through an authenticated API feed.

The product is designed as a cash-settled futures contract, where settlement is based on the spot value - cumulative deviation for the relevant month - arrived from actual rainfall value provided by IMD. The contract expires on the last calendar day of each month, while the last trading day is the business day immediately preceding the expiry, ensuring alignment with spot-data availability and operational transparency.

In addition to this note, one should refer other pertinent documents/information provided on NCDEX website such as Product Note, Contract Specification, Spot Methodology, external links for deeper understanding on trading parameters, contract size, tick structure, daily price limits, position limits, and other regulatory and operational aspects of the document. Together, these documents provide market participants with a comprehensive understanding of how the contract functions, the data sources it relies upon, and the rules governing trading and settlement.

2. What is Weather

- Weather refers to day-to-day atmospheric conditions defined by weather parameter such as rainfall, temperature, humidity, and wind.

3. What is Weather Derivative

- Weather derivatives are financial instruments that can be used by organizations or individuals as part of a risk management strategy to reduce risk associated with adverse or unexpected weather conditions. A weather derivative has an underlying measure such as rainfall, temperature, humidity, or snowfall.

4. What is rainfall-based derivative

- It is a type of weather derivative and financial instrument whose payoff depends on actual rainfall recorded at a defined location during a specific period.

5. Why weather derivatives are needed in India

- The southwest monsoon is a critical determinant of India's macroeconomic performance, accounting for nearly 75–80% of annual rainfall between June and September. Monsoon outcomes significantly influence economic planning, policy decisions, and business expectations. Increasing weather variability—especially in rainfall—has emerged as a key risk factor affecting multiple sectors such as agriculture, power, construction, logistics, tourism, and insurance.
- Currently, weather risk mitigation in India primarily relies on insurance products (e.g., crop and motor insurance) and government support mechanisms. However, these solutions have limited coverage, involve complex procedures, and often require administrative intervention to assess losses. Insurance payouts are triggered only when predefined thresholds are breached, while government relief is largely confined to catastrophic events and to the agricultural sector. As a result, most corporates and non-farm participants remain inadequately protected against weather-related financial risks.
- Weather derivatives can address these gaps by offering a market-driven, transparent, and faster risk management solution. Based on objective and verified weather data, they enable farmers, businesses, and institutions to freely hedge weather risks without the need for loss assessment or government intervention, making them a complementary and more effective financial instrument for India's evolving climate risk landscape.

6. How Weather Derivatives different from other derivatives

- Weather derivatives differ fundamentally from traditional derivatives as their payouts are linked to objective weather data (such as rainfall, temperature, or humidity etc.) rather than prices of tradable assets like commodities, equities, currencies, or interest rates.

- Unlike other derivatives, there is no underlying asset ownership, delivery, or price discovery involved in case of weather derivatives.

7. What are the benefits of weather derivatives?

- **Effective Hedging** - Weather derivatives help businesses hedge against financial losses caused by adverse or unexpected weather conditions (e.g., drought, excess rainfall, extreme temperatures). This stabilizes earnings and reduces weather-related risk exposure.
- **Improved Earnings and Cost Stability** - By offsetting weather-driven revenue shortfalls or cost overruns, weather derivatives reduce volatility in cash flows, supporting more predictable financial performance.
- **Better Budgeting and Forecasting** - They enable firms to plan budgets more accurately by transferring weather uncertainty to the market, improving financial planning and liquidity management.
- **Enhanced Risk Management** - Weather derivatives form part of an integrated risk management framework, helping organizations identify, quantify, and mitigate weather-related operational and financial risks.
- **Price and Market Stability** - By reducing uncertainty for weather-dependent sectors (such as agriculture, energy, and utilities), they contribute to more stable commodity prices and supply planning.
- **Encouragement of Investment** - Lower exposure to weather variability makes weather-sensitive sectors more attractive to investors, supporting long-term investment and growth.
- **Improved Decision-Making and Resource Allocation** - Market-based pricing of weather risk provides valuable signals for operational decisions, such as crop selection, planting schedules, inventory planning, and capacity utilization.

8. What type of events do Rainfall Derivatives cover?

- Rainfall derivatives are primarily designed to address frequent, non-catastrophic rainfall variability, such as moderate excess or deficit rainfall relative to the Long Period Average (LPA). These outcomes occur with relatively high probability and can materially impact revenues, costs, and operations of weather-sensitive businesses. By using rainfall derivatives as part of their risk management strategy, participants can mitigate the financial impact of such recurring weather variations.

- At the same time, extreme weather events (such as floods or cyclonic rainfall episodes) also contribute to the actual rainfall recorded during the measurement period. Since the contract settles purely on objectively measured cumulative rainfall deviation, any excess or deficit rainfall—regardless of whether it arises from normal weather patterns or extreme events—automatically gets reflected in the final settlement price.
- The contract, does not distinguish between types or causes of rainfall events. Settlement is based solely on the measured rainfall deviation from LPA, without any separate classification, weighting, or special treatment for catastrophic events.

9. Can weather derivatives be combined with commodity for hedging

- Yes, weather derivatives can be combined with commodity hedging. Commodity specific derivatives hedge mainly price risk (e.g., futures/options on agri, electricity etc.). Weather derivatives envisaged to hedge volume/yield or demand risk driven by weather vagaries (excess/deficit rainfall). Used together, they provide a more complete hedge against profit volatility.
- Commodity prices often move because of weather, but price hedges alone don't protect output or demand shocks. Weather derivatives cover losses when weather reduces production or demand even if prices are hedged.
- Example - Farmer/Agri processor can use Rainfall derivative for monsoon failure i.e. yield risk and can use commodity futures to hedge adverse price movements i.e price risk.

10. Which weather parameter used for proposed pilot product of NCDEX?

- The proposed weather parameter for the contract is Rainfall and it is a futures contract.

11. What type of exchange based contracts NCDEX has proposed for launch under Weather Derivatives?

- NCDEX has proposed to launch rainfall based futures contract settled on final spot price observed at expiry day of the contract

12. Who Can Use this product and for what purpose?

- The rainfall-based derivative can be used by a wide range of stakeholders whose revenues, costs, or operational outcomes are sensitive to rainfall variability.
- It enables users across sectors such as agriculture, power, construction, mining, logistics, airline industry tourism, and public administration to hedge financial risks arising from deficient or excess rainfall in a transparent and market-driven manner. Settlement is based on objectively measured and verified rainfall data, allowing efficient risk transfer without loss assessment or administrative intervention.
- Additionally, it can be used by hedge funds, retail participants, trading desks, algo users and others interested in capitalizing volatility in the markets.

13. Are weather derivatives traded anywhere else?

- Yes, Weather derivatives are already traded and widely used in several international markets, through both regulated exchanges and over-the-counter (OTC) markets. They are most prominently traded on the Chicago Mercantile Exchange (CME Group) where they offers standardized futures and options contracts based mainly on temperature based indices (Heating Degree Days and Cooling Degree Days), for multiple cities across the U.S., Europe, Japan and parts of Asia.

14. How rainfall is defined on any particular day

- Rainfall is measured using rain gauges or automatic weather stations (AWS) installed at specific locations; therefore, rainfall represents the precipitation recorded at that exact location. For example, “rainfall at Colaba Station or rainfall over Colaba Station” refers to the measurement captured by the Colaba rain gauge installed at Colaba station of Indian meteorological department (IMD) or any other exchange specified agency.
- The standard unit of rainfall measurement is millimeters (mm), which basically represents the depth of water collected in the gauge.
- Rainfall for any given day is defined as the total cumulative rainfall measured during the 24-hour period ending at 8:30 am on that day. For instance, the rainfall for June 5, 2025 is the accumulated rainfall recorded from 8:30 am on June 4, 2025 up to 8:30 am on June 5, 2025.
- Note: Even if a portion of the 24-hour period falls on the previous calendar day, the entire 8:30 am–to–8:30 am measurement is attributed to the current day’s rainfall value as per IMD standards.

15. What are the basis centres of RAINMUMBAI futures contract?

| |
|---|
| <ul style="list-style-type: none">• Basis Centre – Mumbai |
| <ul style="list-style-type: none">• Stations used for Spot calculation – Colaba and Santacruz |

16. What are the different rainfall data IMD provides and which data types used by NCDEX for spot and contract settlement?

- **Surface Rainfall Observation:** Rainfall is measured following World Meteorological Organization (WMO) standards and recorded manually by IMD officials using calibrated, standardized instruments. Observations are taken every three hours during the synoptic hours between 08:30 AM and 08:30 AM of the next day (total of eight observations), which are then aggregated to arrive at the daily rainfall total as defined earlier.
- **Automatic Weather Stations (AWS) Observations:** Rainfall intensity is captured automatically through AWS instruments. Measurements are recorded at 15-minute

intervals (96 observations per day) and subsequently cumulated to derive the daily rainfall amount.

- **Data Used for Contract Settlement and Spot Construction:** For both contract settlement and daily spot-value updation, NCDEX will use Surface Rainfall Observation data, given its higher reliability, longer historical availability, and recognized acceptance in meteorological and research standards.
- **Use of AWS Observations:** AWS rainfall data will be displayed on the NCDEX website as part of the real-time information dissemination process, helping participants track intra-day rainfall trends. This data shown on website is retrieved from Automatic Weather Stations of IMD and displayed on an “as – is” basis, only for reference purposes. NCDEX does not undertake liability and responsibility for any inaccuracy in the said data. Also, NCDEX does not use this data for RAINMUMBAI spot calculation. Market Participants are requested to make any trading/ investment decisions at their sole discretion.
- **Fallback Mechanism:** AWS data will serve as a fallback input in situations where Surface data is delayed, temporarily unavailable, shows discrepancies or requiring validation. Exchange may also onboard additional agency/ agencies for rainfall data to be used as additional fallback mechanism in case both surface and AWS data is delayed, temporarily unavailable, shows discrepancies or requiring validation. Exchange will inform the trade participants regarding onboarding of any such additional agency/ agencies for obtaining rainfall related data.
- **Data Acquisition and Frequency:** Both Surface and AWS observations will be fetched through API feeds from the IMD data server. Surface data will be accessed once daily, whereas AWS data will be fetched at 15-minute intervals or higher frequency in line with its measurement frequency.

17. Long Period Average (LPA) or Normal

- **Long Period Average (LPA)** refers to IMD’s climatological normal computed over a **30-year reference period (currently 1991–2020)**. LPA is calculated **separately for each station/location** and also for each day which denotes the **expected or climatologically normal rainfall for each calendar day at that location**, expressed in millimeters.
- **For example**, the **LPA for 1 June at IMD Colaba** is derived by averaging the rainfall recorded on **1 June for each year from 1991, 1992, ... up to 2020**. This approach ensures consistency in long-term climate comparison.

18. How the spot Mumbai Rainfall Spot is calculated?

- Mumbai rainfall spot is calculated using the following inputs:
 - Daily Long period average (LPA) rainfall for Mumbai location

- Daily actual rainfall for Mumbai location during current year
- Calculation of daily Rainfall deviation during Monsoon season (1 June to 30 September)

a. Calculation of Mumbai Daily Long period Average (LPA_Mumbai_Date1)

- For Mumbai rainfall daily spot calculation, Long Period Average (LPA) of both Colaba and Santacruz Stations will be used.
- Mumbai Daily LPA (LPA_Mumbai_Date1) for particular date (say Date1) = $(LPA_Colaba_date1 + LPA_Santacruz_date1) / 2$ i.e average LPA of these two stations. The Mumbai daily LPA will be used for defining normal rainfall/ LPA on particular date for Mumbai location spot calculation.
- Mumbai Monthly LPA = Sum of Mumbai daily LPA for that month. For example: Monthly LPA for June month will be sum of Daily LPA from 1 June to 30 June.
- Mumbai Monsoon Season LPA = Sum of Mumbai daily LPA from 1 June to 30 September.
- Based on IMD data, Mumbai Monsoon Season LPA is **2206.7 mm**.
- The monthly LPA of Mumbai rainfall is mentioned below

| Month | LPA Rainfall (mm) – Mumbai – Month wise |
|---------------------------|---|
| June | 539.7 |
| July | 794.9 |
| August | 524.3 |
| September | 347.8 |
| Total (also seasonal LPA) | 2206.7 |

b. Calculation of Mumbai Daily Rainfall (Rain_Mumbai_Date1)

- Mumbai Daily Rainfall (Rain_Mumbai_Date1) for a particular date (say Date1) = $(Rain_Colaba_date1 + Rain_Santacruz_date1) / 2$ i.e average Rainfall of these two stations.

c. Mumbai Daily Deviation calculation (Deviation_Mumbai_Date1)

- Mumbai Daily Deviation (Deviation_Mumbai_Date1) = $Rain_Mumbai_Date1 - LPA_Mumbai_Date1$
- Positive deviation = excess rainfall then LPA on that day; Negative deviation= deficit rainfall than LPA on that day)

d. Spot Calculation – Daily Deviation Model

- Mumbai rainfall Spot will measure the deviation of actual rainfall on a given day with the LPA rainfall on that day. The deviation will be calculated starting from June 01 every year.
- The starting point (also known as anchor point) on day zero for Mumbai rainfall spot will be the Mumbai Monsoon Season LPA (i.e 2206.7)**

- ***This anchor point will remain unchanged in case the last trading day futures contract of September month is immediate preceding to the last calendar day in a particular year. In case, last trading day is not immediate preceding to the last calendar day, then LPA (anchor point) will be revised based on LPA values from June 01 till calendar day immediately following the last trading day of the September month futures contract.*
- *Example*

| | 30-Sep | 29-Sep | 28-Sep | 27-Sep | Last Trading Day | Due Day / Expiry Day | LPA Period |
|--------|-------------|-------------|-------------|-------------|------------------|----------------------|----------------|
| Case 1 | Holiday | Trading Day | Trading Day | Trading Day | 29-Sep | 30-Sep | 1 Jun - 30 Sep |
| Case 2 | Trading Day | Holiday | Trading Day | Trading Day | 28-Sep | 29-Sep | 1 Jun - 29 Sep |
| Case 3 | Trading Day | Trading Day | Holiday | Trading Day | 29-Sep | 30-Sep | 1 Jun - 30 Sep |
| Case 4 | Holiday | Holiday | Trading Day | Trading Day | 28-Sep | 29-Sep | 1 Jun - 29 Sep |
| Case 5 | Trading Day | Holiday | Holiday | Trading Day | 27-Sep | 28-Sep | 1 Jun - 28 Sep |
| Case 6 | Trading Day | Trading Day | Holiday | Holiday | 29-Sep | 30-Sep | 1 Jun - 30 Sep |
| Case 7 | Holiday | Holiday | Holiday | Trading Day | 27-Sep | 28-Sep | 1 Jun - 28 Sep |

- From June 01, daily spot will be calculated by adding the Mumbai daily rainfall deviation to the starting point. Subsequently, each day's deviation will be added to the previous days value.

Illustration of Spot updation - daily

| Date | Mumbai Daily LPA (mm) | Mumbai Daily Rainfall (in mm) | Mumbai Daily Deviation (mm) | Spot for the day |
|-------|-----------------------|-------------------------------|-----------------------------|------------------|
| | - | - | - | 2,206.65 |
| 1-Jun | 8.7 | 0.00 | -8.65 | 2,198.00 |
| 2-Jun | 3.7 | 0.00 | -3.70 | 2,194.30 |
| 3-Jun | 6.0 | 0.00 | -6.00 | 2,188.30 |
| 4-Jun | 4.8 | 5.22 | 0.42 | 2,188.72 |
| 5-Jun | 8.9 | 0.47 | -8.43 | 2,180.29 |
| 6-Jun | 5.1 | 0.65 | -4.40 | 2,175.88 |
| 7-Jun | 7.1 | 0.73 | -6.32 | 2,169.56 |
| 8-Jun | 12.7 | 5.87 | -6.78 | 2,162.78 |

| Date | Mumbai Daily LPA (mm) | Mumbai Daily Rainfall (in mm) | Mumbai Daily Deviation (mm) | Spot for the day |
|---------------|-----------------------|-------------------------------|-----------------------------|--|
| 9-Jun | 18.4 | 14.12 | -4.23 | 2,158.54 |
| - | - | - | - | - |
| - | - | - | - | - |
| 28-Jun | 22.8 | 66.66 | 43.91 | 2,119.54 |
| 29-Jun | 24.2 | 53.13 | 28.93 | 2,148.48 |
| 30-Jun | 26.3 | 22.44 | -3.81 | 2,144.67 (Used as final spot for FSP calculation) |
| 1-Jul | 25.6 | 23.59 | -2.01 | 2,142.66 |
| 2-Jul | 37.0 | 36.76 | -0.24 | 2,142.42 |
| 3-Jul | 30.3 | 4.64 | -25.66 | 2,116.76 |
| 4-Jul | 44.3 | 5.66 | -38.64 | 2,078.12 |
| 5-Jul | 38.6 | 16.17 | -22.38 | 2,055.74 |
| 6-Jul | 19.9 | 23.24 | 3.39 | 2,059.14 |

e. What is spot behavior on change of month.

- During the transition from one month to the next (e.g., June to July), the cumulative rainfall deviation up to the last calendar day of the previous month will be carried forward. Accordingly, the closing spot value on 30 June becomes the opening spot value for 1 July, ensuring continuity in the cumulative deviation series. (Refer above illustrative table)

f. What is spot updation cycle under the contract.

- As per IMD and WMO standards, the daily rainfall for any given day is defined as the total precipitation recorded over the preceding 24 hours ending at 08:30 AM. Accordingly, the actual rainfall data for both stations will be made available to the Exchange through the API feed at approximately 09:15 AM each day, prior to the commencement of trading.
- Consequently, the daily spot value will be updated by around 09:45 AM on every trading day, based on the latest rainfall data received through the official API mechanism from IMD.
- The spot value will be updated only once per day on the trading platform, and the same value will remain unchanged for the entire trading session.
- Since the rainfall deviation is calculated for each calendar day of the month, the cumulative deviation for non-trading days will be incorporated into the spot value during the next spot-update cycle. Accordingly, the spot published on the next business day will reflect the aggregated deviation for all intervening non-trading days.

19. What is the contracts launch calendar for weather derivatives?

- NCDEX will launch four futures contract under Mumbai Rainfall with expiry at the end each monsoon season month i.e. June, July, August and September.

20. What are the contract specifications of the Mumbai Rain contract?

✓ **Base price for the contract**

- The base price of the contract is Rs. 2206.7, which is derived from Seasonal LPA value

✓ **Quotation, Lot Size & Tick Value**

- Quotation/Base Value – mm of rainfall (Since rainfall measured in mm)
- Unit of trading – 1 Lot with an effect of multiplier
- Multiplier – Rs. 50 per mm
- Tentative contract value – Rs. 110333 (Base Price*Multiplier - Rs. 2206.7*50 = 110333)
- Tick size – 1 mm
- Tick Value – Rs. 50 (1*50)
- Spot will be conveyed in mm on trading portal and eventually converted to INR using multiplier
- Rainfall (and its deviation) is ascertained till one decimal point, therefore final price will be rounded to nearest tick.

✓ **Daily Settlement Price (DSP) and MTM**

- DSP will be estimated based on weighted volume average of last 30 minutes' future trade price/volumes of the contract as per current practice of the exchange.
- Daily MTM will be calculated based on DSP and open position as per current practice of exchange.

✓ **Final Settlement Price (FSP)**

- Final Settlement Price (FSP) will be estimated based on cumulated monthly deviation above/below the normal i.e underlying spot values arrived on expiry day of the contract
- Example: Referring to illustrative table mentioned above the Spot on 30th June is **2,144.67 mm and therefore FSP for June expiry contract will be Rs. 2144.67.**

✓ **Trading Schedule**

| Parameter | Details |
|-------------------------|--|
| Last Trading Day | Business day immediately preceding the last calendar day of the contract expiry month. |
| Contract Expiry day | Calendar Day following the last trading day |
| Settlement/Maturity Day | As per existing rules of NCDEX |

- **Other detailed contract specifications for the product can be seen on NCDEX official website under product category page.**

21. What are the costs applicable for trading in this contract?

| Particulars | Amount |
|---------------------------|--|
| Exchange delivery charges | Not Applicable |
| Other delivery charges | Not Applicable |
| CTT | Applicable |
| Transaction charges | The transaction charges will be applicable at flat rate of Rs. 5.80 per lakh of trade as per the NCDEX Circular No. NCDEX/TRADING-042/2024 dated September 27, 2024. |
| RMF | As per circular no. NCCL/FINANCE-003/2021, dated March 09 2021, Risk Management Fee at Rs. 5 per lakh on the value of every fresh overnight open interest position created in contracts shall be applicable. |
| Delivery default penalty | Not Applicable, Cash Settled Contract. |

22. What factors are considered to take positions in this contract

- **Rainfall Forecast versus Normal (LPA)**

Positions (long or short) are taken based on expectations of **actual rainfall deviating above or below the Long Period Average (LPA)**, using forecasts issued by credible meteorological agencies such as **IMD, Skymet, AccuWeather**, etc.

- **Long position:** Expected rainfall above LPA
- **Short position:** Expected rainfall below LPA
- *Example:* If IMD forecasts excess rainfall for a season or month, participants may take a long position, and vice versa.

- **Understanding Month-wise LPA and Expected Deviation**

Before taking a position in a monthly contract, participants should:

- Refer to the **normal (LPA) rainfall for that specific month**
- Estimate the **expected deviation** from the monthly LPA
- Add the expected deviation to the **monsoon season LPA** to determine the indicative contract level (pricing)
- *Illustrative example:*
If June's LPA is **539.7 mm** and participants expect **10% excess rainfall**, the deviation would be **~53.9 mm**.
If monsoon LPA is **2206.7 mm**, the indicative level becomes:
2206.7 + 53.9 = 2260.6, around which positions may be considered.

- **Impact of Cumulative and Continuous Spot Calculation**

Since the spot rainfall index is **cumulative and continuous**, participants should consider the following while positioning:

- **June exposure only:** Buy June futures

- **July-only incremental exposure:** Buy July futures and sell June futures
- **July futures position:** Reflects cumulative deviation up to July (June + July)
- **Seasonal exposure (entire monsoon):** Take position only in the September expiry contract
- This structure allows precise positioning based on **monthly, incremental, or full-season rainfall expectations.**
- **Exposure Sizing and Risk Quantification**
Participants should:
 - Assess the **financial impact of excess or deficient rainfall** on their underlying business or portfolio
 - Quantify the risk in monetary terms
 - Determine the **number of lots** based on contract value (approximately **₹1,10,000 per lot**) to align hedge size with exposure

23. What determines the futures price during the trading period?

- The futures price reflects:
 - Market expectations of rainfall deviation from LPA
 - Updated weather forecasts from meteorological agencies
 - Progress of actual rainfall during the contract month
 - Demand and supply of risk among market participants
- Prices are discovered through normal exchange-based trading mechanisms.

24. Is daily rainfall volatility expected to impact futures prices?

- Yes. - As new rainfall data and updated forecasts become available, market participants may reassess expectations, which can lead to price movements in futures contracts. However, settlement depends only on the final cumulative deviation at expiry, not on intraday spot changes.

25. What happens if rainfall exactly matches the Long Period Average (LPA)?

- If actual rainfall matches the LPA exactly, the net deviation becomes zero. In such a scenario, the spot value remains unchanged from the applicable anchor level, and gains or losses on the contract depend on the participant's entry price relative to the Final Settlement Price.

26. What is the delivery logic of the contract?

- The contract is cash settled contract. The rainfall-based derivative is a purely cash-settled contract. There is no physical delivery, storage, transportation, or quality-related obligation involved at any stage of the contract lifecycle.

27. What additional information is available on NCDEX website related to product

- The NCDEX website provides the following key information for participants:

- Historical spot values for the last five years, based on actual rainfall observed over Mumbai during 2021–2025
- Real time daily cumulative rainfall data, updated at 15 minute intervals, sourced from Automatic Weather Station (AWS) data
- External links to reputed meteorological agencies providing weather forecasts for Mumbai
- Daily Long Period Average (LPA) rainfall values, for reference and comparison

28. Can this product help improve overall market transparency on weather risk?

- Yes. - By offering exchange-traded, publicly observable prices for rainfall risk, the contract contributes to:
 - **Better price discovery of weather risk**
 - Improved **planning and decision-making**
 - Increased awareness of rainfall variability impacts across sectors