Developing Statistical Tasks for Implementing Cross-Border Lesson Study Using Data from the APEC Energy Database

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Outline

This presentation will last 30 minutes, organized as follows:

- Introduction to the Development of Statistical Tasks on Energy Resiliency and workshop data distribution (5 min.)
- Reflections on the Workshop How to Develop Statistical Tasks on Energy Resiliency Using Data from the APEC Energy Database, held on February 11, 2017 (20 min.)
- Conclusion Remarks (5 min.)

APEC

University of Tsukuba Japan

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Creating the Vision for the Future! Challenge 1 and 2

- Developing Tasks and materials for Energy Efficiency and Security Education with mathematics at Secondary School level
- Developing useful statistics and probability education for this century

Let's pose the question using Energy data for producing the Future Vison of our Society

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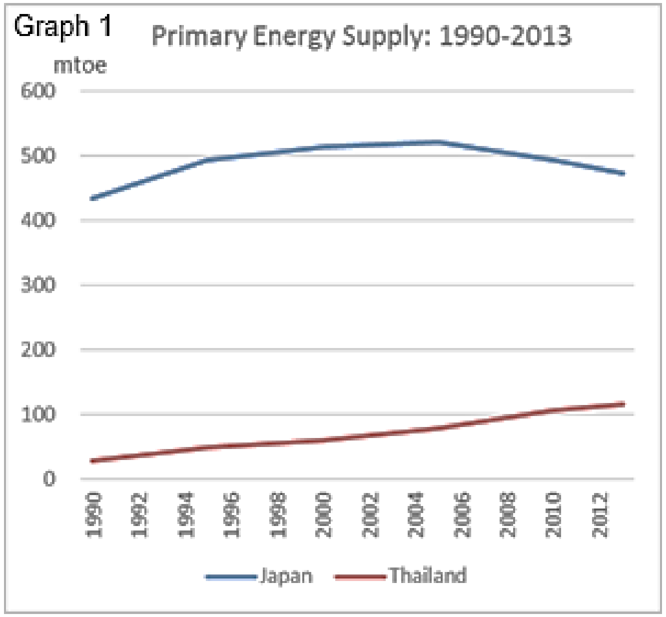
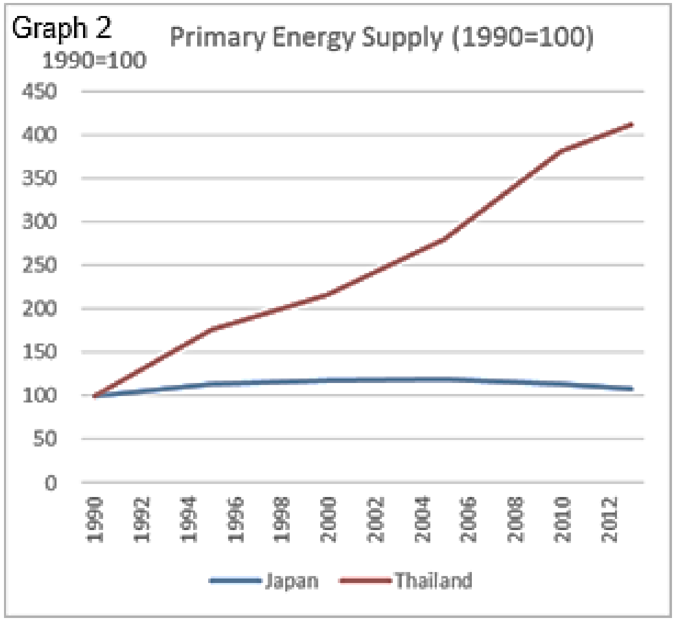
- From the cross-border lesson study between Japan and Thailand carried out during the last APEC meeting:





Primary Energy Supply means supply of coal, oil, natural gas, atomic, etc. Secondary Energy means energies such as electricity supplied from primary energy.
'MTOE' is million tons of oil equivalent.
1 million is 1,000,000.

When we read both graphs, we may be able to have questions with two contexts:

On the context of mathematics and statistics:

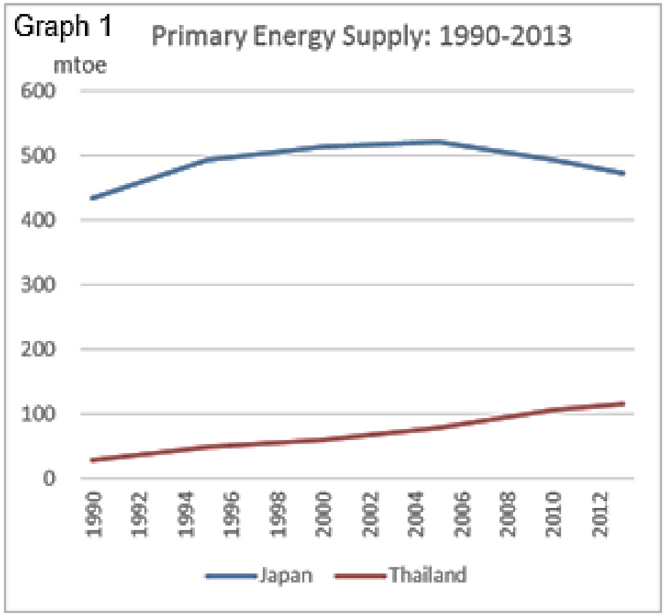
Could you explain what every graph represents? How much MTOE did Thailand use in 1990? Could you find it appropriately using Graph 1 and 2. How many times of Thailand does Japan use? Can you imagine when Thailand will overtake Japan? Can you imagine when did Japan use primary energy as same amount as current Thailand?

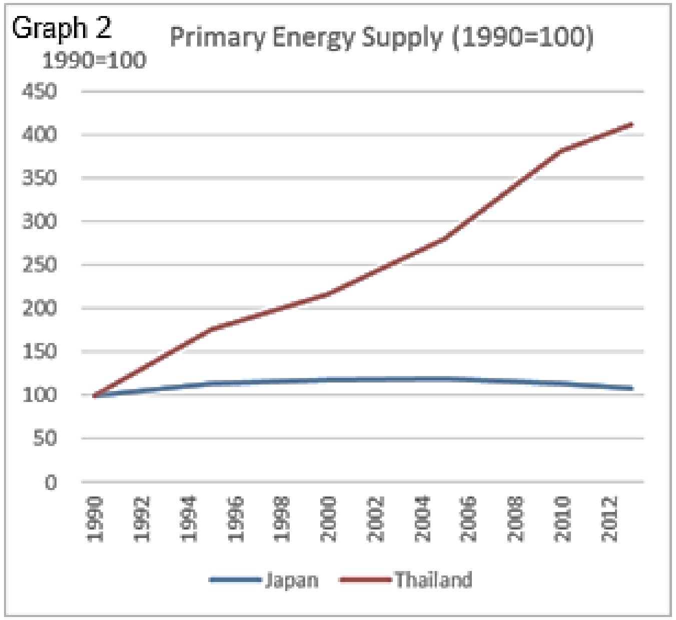
On the context of life/social-economical-welfare:

How do you explain the difference between Thailand and Japan? Why can you explain like that? What is the hidden variable? If we read the graphs in relations to GDP which country uses more energy to product and why?

On the context of Sustainable Development Goals, the goal is to grow with less energy.

- From the cross-border lesson study between Japan and Thailand carried out during the last APEC meeting:





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1. Theme of lesson study for mathematics

Imagine hidden variables and relations through the questioning the graphs, and appreciate the significance of being able to analyze the situation and predict the future by using them.

3. Class Objective

Based on simple and primordial questions for comparing the graph 1 and 2, students begin to explain the different economic development status and realize the difference of society with comparison and necessity of sharing the issues for sustainable development.

- What kind of questions, involving data representation and data analysis, would you pose from this lighting scenario?

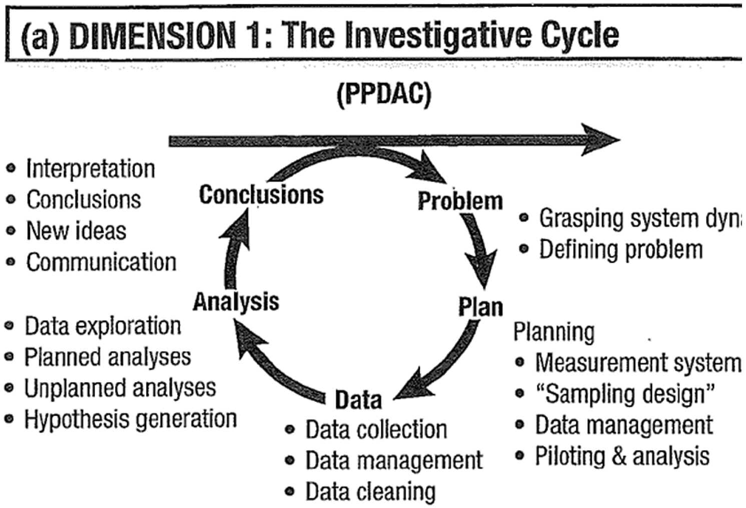
- Remember: When analyzing data, the role of a student or a statistician is to be a "data detective," to uncover the stories that are hidden in the data.

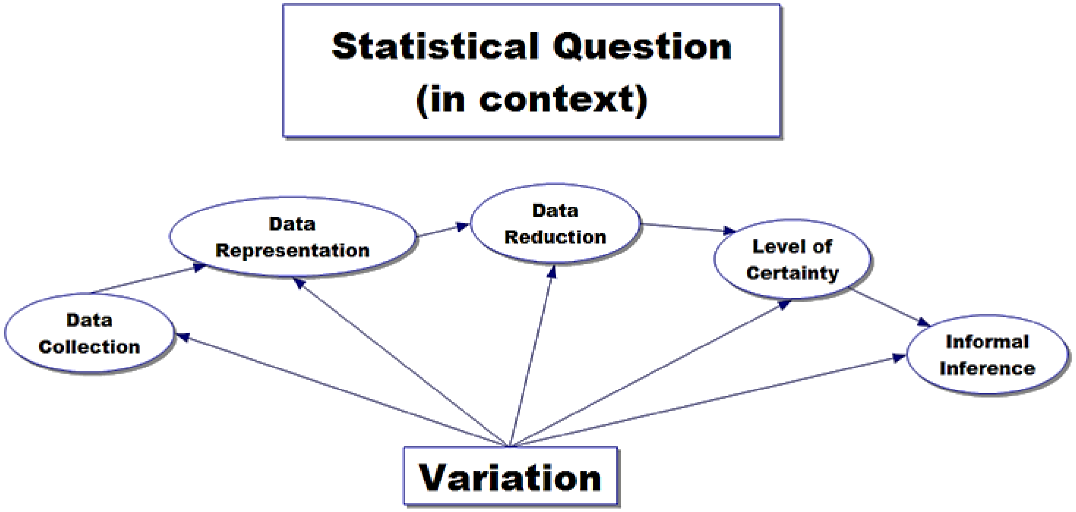
- As "data detectives", people are expected:
  - to note important signals in the variability of the data,
  - to develop and share their reasoning about sources of variation in data over time, and
  - to engage in informal inferential reasoning ("imagine the future") by using data as evidence of estimations, predictions and generalizations.

(English & Watson, 2015; Makar & Rubin, 2009; Shaughnessy, 2007).

- By doing so, we will have opportunities to engage in the following 4 levels of reading graphs (Shaughnessy, 2007):
  - Reading the graph/data
  - Reading within the graph/data
  - Reading beyond the graph/data
  - Reading behind the graph/data
- When "reading behind the graph", one might conjecture about the possible causes that might affect the phenomenon represented over time (i.e., historical, economic, or demographic potential sources of variation in the data), and use some "data detective" skills to analyze graphical information.

- Challenging students with problems and questions in which they have to analyze data collected over time using graphical representations, provide students with opportunities to:
  - empower them as statistically literate citizens, and
  - engage in the "Practice of Statistics".





- Also, students will be able to engage in the following eight behaviors regarding understanding of graphs, fundamental to develop students' basic graph sense, and critical, mathematical and statistical literacy (Shaughnessy, 2007):

1. Recognizing components of graphs (*Reading* the data).
2. Speaking the language of graphs (*Reading* the data).
3. Understanding relationships among tables, graphs, and data (Reading *within* the data).
4. Making sense of a graph, but avoiding personalization and maintaining an objective stance while talking about the graphs. (Reading *within* the data).
5. Interpreting information in a graph and answering questions about it (Reading *beyond* the data).
6. Recognizing appropriate graphs for a given data set and its context (Reading *beyond* the data).
7. Looking for possible causes of variation (Reading *behind* the data).
8. Looking for relationships among variables in the data (Reading *behind* the data).

APEC 2017 Workshop Summary

- From the workshop, nine activities were developed.
- Today, we would like to share two activities from that workshop.
  - *Task 1: Predicting the Energy Consumption for Japan and Thailand (by Prof. Wagner)*
  - *Task 2: Comparing the Ratio of the Total CO_2 Emissions and the Total Energy Consumed by Japan and Thailand (by Prof. Patsy and Prof. Roberto)*

Task 1: Predicting the Energy Consumption for Japan and Thailand (by Prof. Wagner)

- Using the "Fuel Energy Consumption" data from the APEC Energy Database, Prof. Wagner designed the following task.

Twisting Data

Your task is to write an argument that Energy consumption in Japan and Thailand will be equal *as soon as possible* using the "Fuel Energy Consumption Table".

You will develop a model for predicting the energy consumption for each country. For your model, write an equation that goes through three data points. You will have to do the following for each country:

- Graph the data to show the trend.
- Decide what kind of curve best describes the data.
- Choose three points from the data
- Find the equation of the function that will pass through those three points.

Try to do this in a way that seems to be a fair representation of the data, and yet the models intersect *as soon as possible*.

To appear fair, it would be best to use the same three years for both countries, and better yet if they seem to be fairly periodic (e.g., every 10 years).

Task 1: Predicting the Energy Consumption for Japan and Thailand (by Prof. Wagner)

Write a short newspaper article that includes a graph and your equations/models to make your argument.

Reflection questions:

- How did you decide on the shape of each curve?
- How did you choose your points?
- You are making a mathematical argument in your article. Is it valid?
  - Think about your models. Do they make sense in relation to energy consumption?
  - Think about your choices.

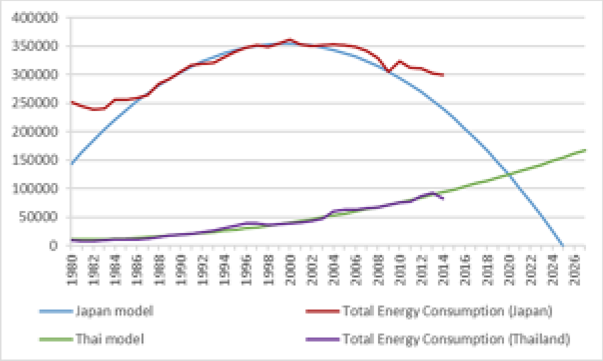
Half the class has the same task but aiming for *as far into the future as possible* instead of *as soon as possible*.

- We need to see this task from the perspective of the following contexts:
  - on the context of mathematics and statistics,
  - on the context of daily life or socio-economical welfare, and/or
  - on the context of sustainable development goals.

Japan to match Thailand's energy consumption by 2020

Japan is working toward sustainability by reducing its energy consumption, while neighbouring countries in the region are increasing their consumption. For example, this chart shows the energy consumption in Japan and Thailand, and the continued trend (in ktoe).

Year	Japan	Thailand
1989	293,243	17,448
1999	354, 504	37,946
2009	305,706	72,030
2019	146,849	119,700



The trend can be calculated with the following formulas:

$$\text{Japan} = -550.295 \, x \, (\text{year} - 1989)^2 + 11629.05 \, x \, (\text{year} - 1989) + 293243$$

$$\text{Thailand} = 67.93 \, x \, (\text{year} - 1989)^2 + 1370.5 \, x \, (\text{year} - 1989) + 17448$$

These mathematical models are graphed above with the annual data below.
The red and purple lines show the actual energy consumption of Japan and Thailand respectively. The blue and green lines show the calculated model amount of energy consumption each year.

APEC 2017 Workshop Summary

How did I decide on the shape of each curve?

I thought that a parabola would make the growth and decline larger every year, so the curves would meet sooner rather than later.

How did I choose my points?

I wanted to use 2009 because Japan had a sudden drop in energy consumption that year. I wonder why that happened.

Is my argument valid?

I know that the trend cannot be quadratic because if I follow Japan's consumption to 2025 it becomes negative. That is not possible. My modelled curves look very close to the actual data in the range of the actual data, so the models look convincing, but I know they are misleading. I felt dirty writing my misleading article.

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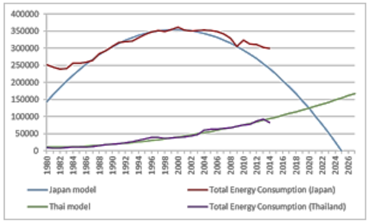

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- This task addresses two very interesting mathematical ideas: obtaining the equation for a parabola given three points (matrixes, system of equations), and quadratic regression.
- Solving the system of equations will be needed to answer this task, as well as the use of technology (e.g., carry out regression and obtaining the trendline through Excel, or solving the system of equations using online resources, such as the Wolfram website, which will allow students to engage in a modelling context).

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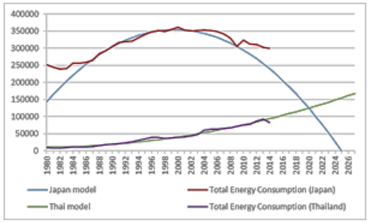

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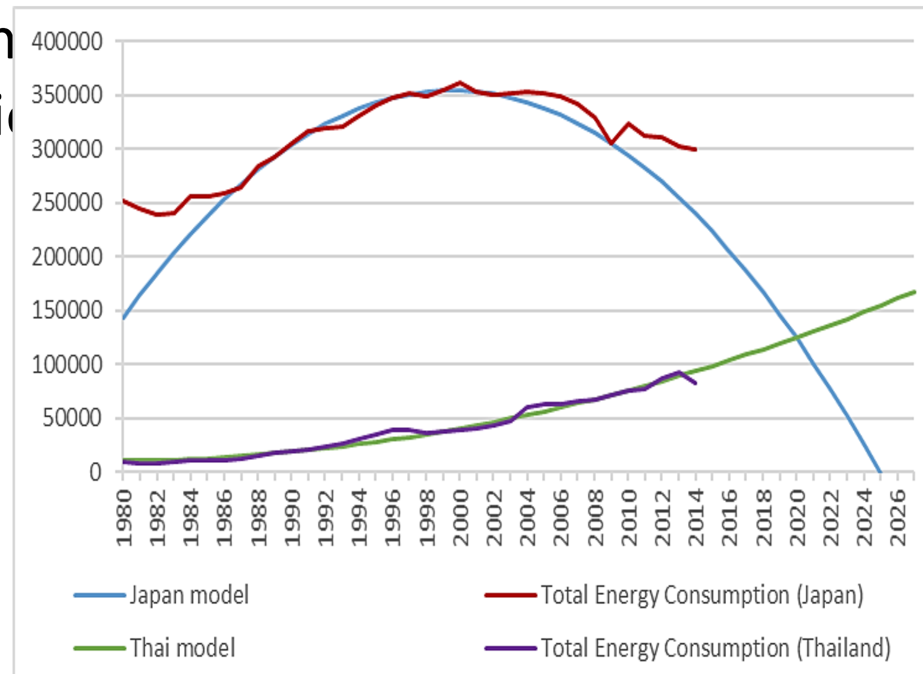
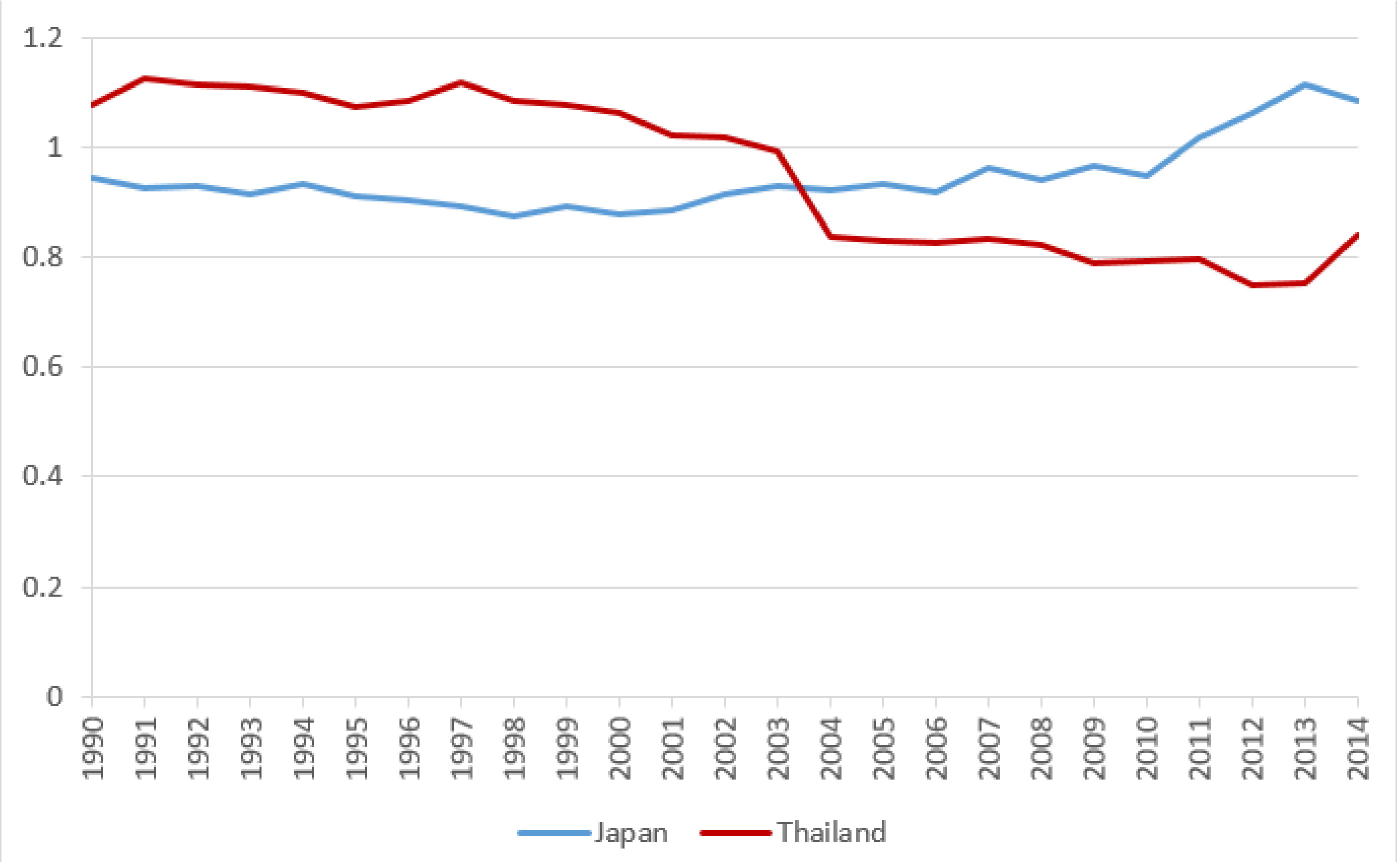
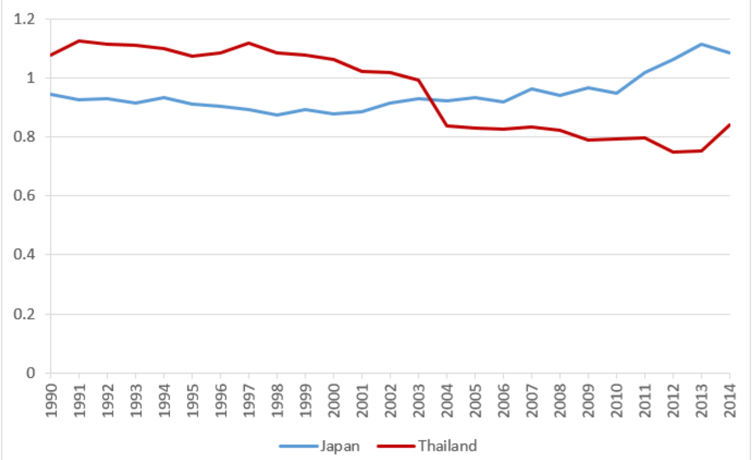
- After obtaining the regression should be able to make predicti
- The model should not be blindly followed (e.g., Japan energy consumption from 2025.) Never stop being a data detective!
- Impact on ourselves? On our country? On our world?



Task 2: Comparing the Ratio of the Total CO_2 Emissions and the Total Energy Consumed by Japan and Thailand (by Prof. Patsy and Prof. Roberto)

- Using the “Total CO2 Emission” data and the “Total Energy Consumption” data from the APEC Energy Database, Prof. Patsy and Prof. Roberto designed the following graph, representing the ratio “Total CO2 emission” / “Total Energy Consumed” in Japan and Thailand, respectively.



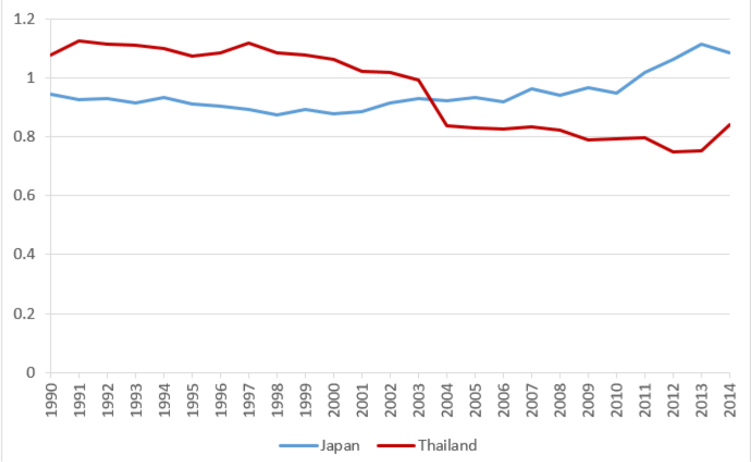


- The task designers were impressed by two particular "discontinuities" (or "sudden changes") in the graph.

- They believed such changes in the graph behavior would attract the attention of students and everyone.

- The first discontinuity is that on the Japanese curve, a big increase on CO_2 emission per unit of energy consumed starting around 2011.

- The second discontinuity is on the Thai curve, in which a big drop on CO_2 emission per unit of energy is seen from around 2004.



- Statistically speaking, what does this ratio means? How can we handle this ratio?
- Total energy consumption (ktoe) vs. Total CO2 Emission (kt-c).

- How could the intersection of the lines be understood?
- Consider population, country area, geography, climate, …
- Providing data-based explanations to the behavior of the variable in this graph is rooted on critical questioning (Gal 2004), and will enhance data-based argumentation and statistical reasoning in students (delMas 2002).

Conclusions

- Dynamic graphs can elicit critical questions from students, such as the following:
  - What is the overall pattern in the data?
  - Why might be the data varying in the way it is?
  - Why does this variable have a similar/different trend that the one shown by another country?
  - What might happened in a particular period of time (e.g., in 2011) in the region under examination, to explain the behavior of the variable during that period?
  - What might happen in the next five years, and why?

Conclusions

- The analysis of energy-related data proposed here corresponds to Level B of statistical reasoning outlined in the GAISE framework (Franklin et al. 2007).
- Students are expected to generate dynamic graphs and consider how a particular variable varies for a single case but also how it varies between different cases (Franklin et al. 2007).
- Analyzing dynamic graphs encourage good questions and good conversation in the mathematics classroom.

Conclusions

- Starting with a counterintuitive idea (e.g., the refrigerator acting as a heater, or city lights as light pollution) will motivate students to collect data, and then engage in statistical investigations.
- Law of Conservation of Energy (on an intuitive level, before the formalization).
- The heat doesn't vanish, it's transferred to the room and after to the outside.

Conclusions

- Estimate the energy spent by a washer machine by kilogram of laundry load.
- Water consumption, electric consumption, coal consumption, oil consumption, ...
- Comparison between the energy consumption of mercury-filament light bulbs, LED bulbs, fluorescent lamps.
- Make sure students take into account the difference in countries' climatic conditions.

Conclusions

- Students will have the opportunity to compare their own empirical results with national and regional data, using the APEC Energy database.

- Data on energy sources, energy consumption, CO_2 emissions, etc., are available in the database, very useful for verifying students' hypotheses.

Conclusions

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- Developing Tasks and materials for Energy Efficiency and Security Education with mathematics at Secondary School level
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- Let us assume the role of "data detectives" in our classrooms! Let's use real-life energy data from APEC!

Thank You for your Attention!