Globally-Consistent Risk Assessment

International Monetary Fund (IMF)

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The views expressed herein are those of the author and should not be attributed to the International Monetary Fund, its Executive Board, or its management.

WHAT we do…

- Stochastic simulations with **big multi-country** models

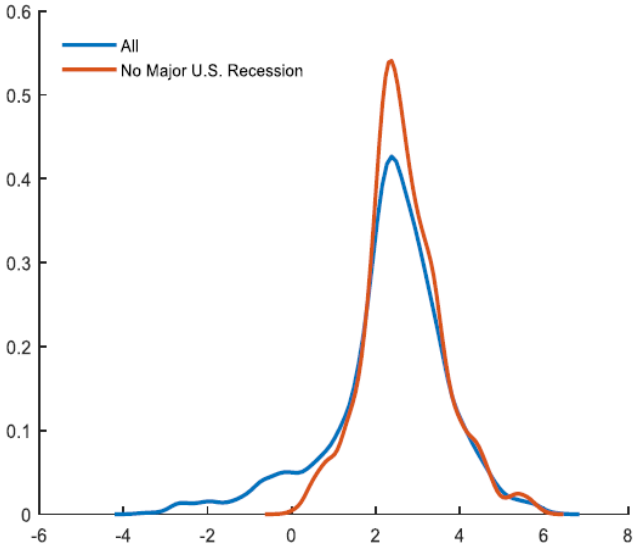
- Applications:
  A. **Analysis of alternative polices**

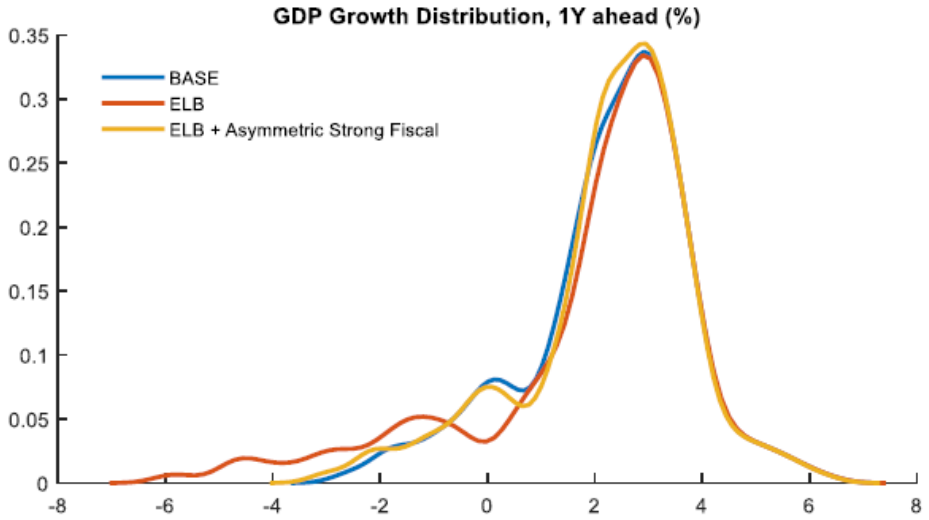
  B. **Globally-consistent risk assessment**

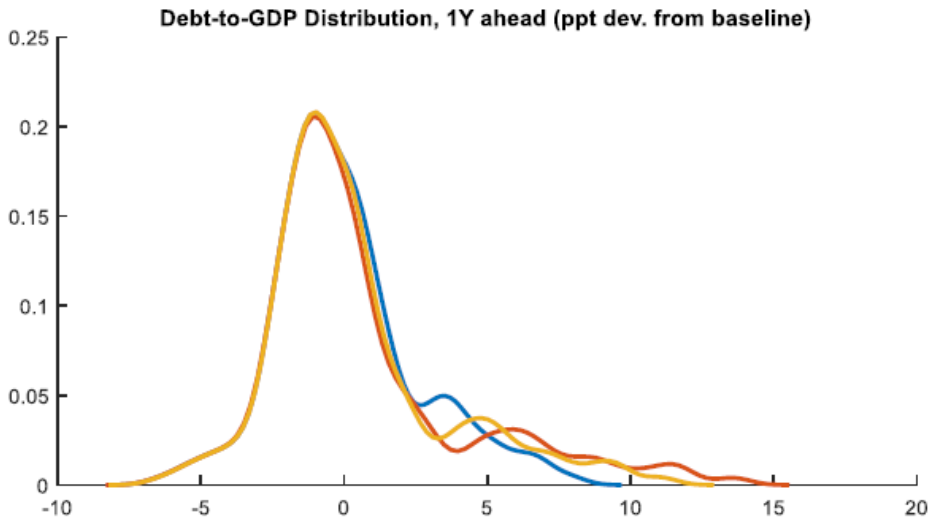
Applications

- **Fiscal rules in the euro area** [Andrle et al. 2015]

- **Cyclical fiscal rules with the ZLB** [IMF WEO, April 2020]

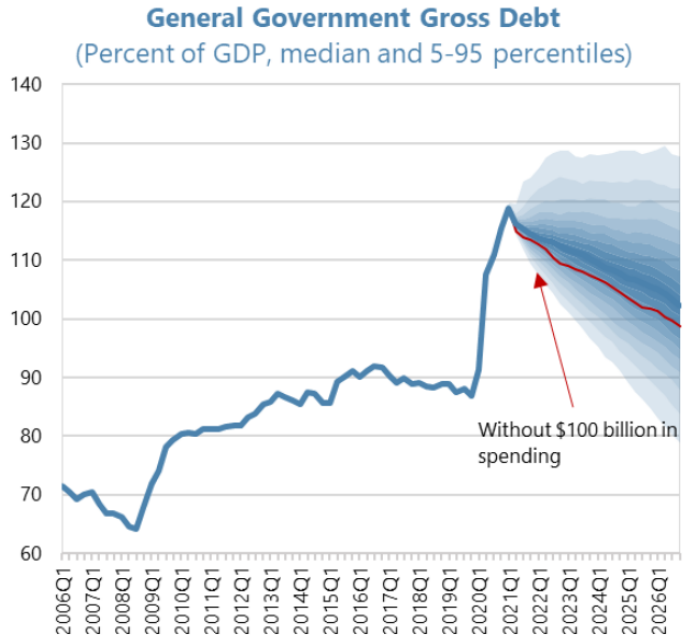






Applications

- **Risk Assessment of Canada's Debt/GDP projection**
  [Canada's Article-IV, 2021]



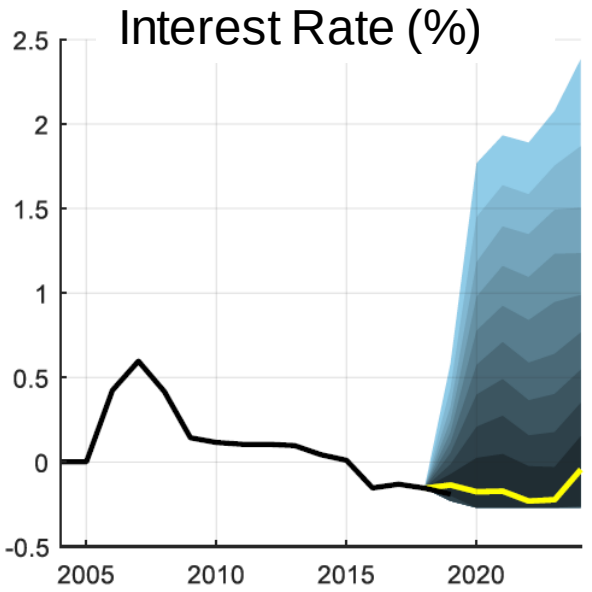
Sources: Statistics Canada and IMF staff calculations.

- **Global Risk Assessment for the IMF WEO** [prob of recession, etc.]

Table 1: Probability of World GDP Growth of less than 2.5 Percent

Assessment*	Full sample: 1962+	Smaller sample: 1992+
October 2019	8.9	7.5
April 2019	7.8	5.9
October 2018	7.6	5.7

Note: * pseudo real-time using the assumptions in this paper and vintage IMF WEO data



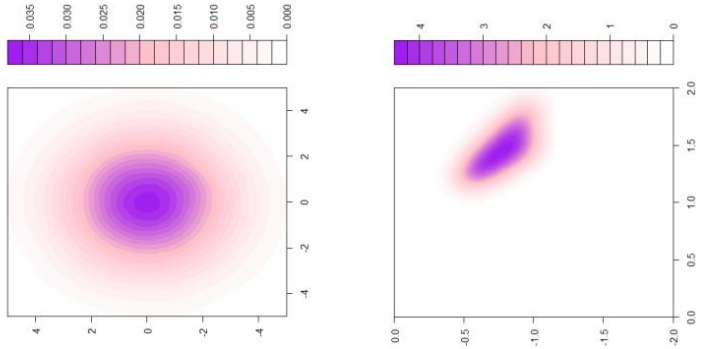
WHY we do that...

- Need a realistic risk assessment for the global economy's key macro variables [#countries x #variables]

- Very hard to do using non-structural or **non-parametric** models
- Wanted something "**agnostic**"

- Complements "Growth-at-Risk" analysis

What is the GOAL?



1. **“Objective”** – realistic stochastic simulations with the model
   The goal is to let the past and the model to challenge staffs’ view.

2. **“Subjective” –** *extra information available*, condition on its distribution [distribution of an extra constraint]
   [Waggoner (1999) “**soft tunes**” + **System Priors** (Andrle at al) + integrate NTF models (Benes et al.)].

Baseline projection is always “judgmental” and conditioned on staffs’ views.
Place it within the predictive distribution.

It’s important not to fool oneself by “double” counting the risk by moving

Key steps

1. Solution techniques & sampling speed
2. Shock Estimation
3. Drawing from the distribution of shocks

4. …

Solution Techniques

Solving Big Nonlinear Global Models

- Used with IMF's GIMF, G20mod/FSGM, and GPM

- **Fully non-linear**
  - A version of stack-time algorithm (nonlinear, ignores Jensen inequality)
  - Stoch. simulations in parallel (20+ workers, when the IMF sleeps…)

- **"Path-linearized"**
  - Linear combination of non-linear IRFs, with the ELB constraint

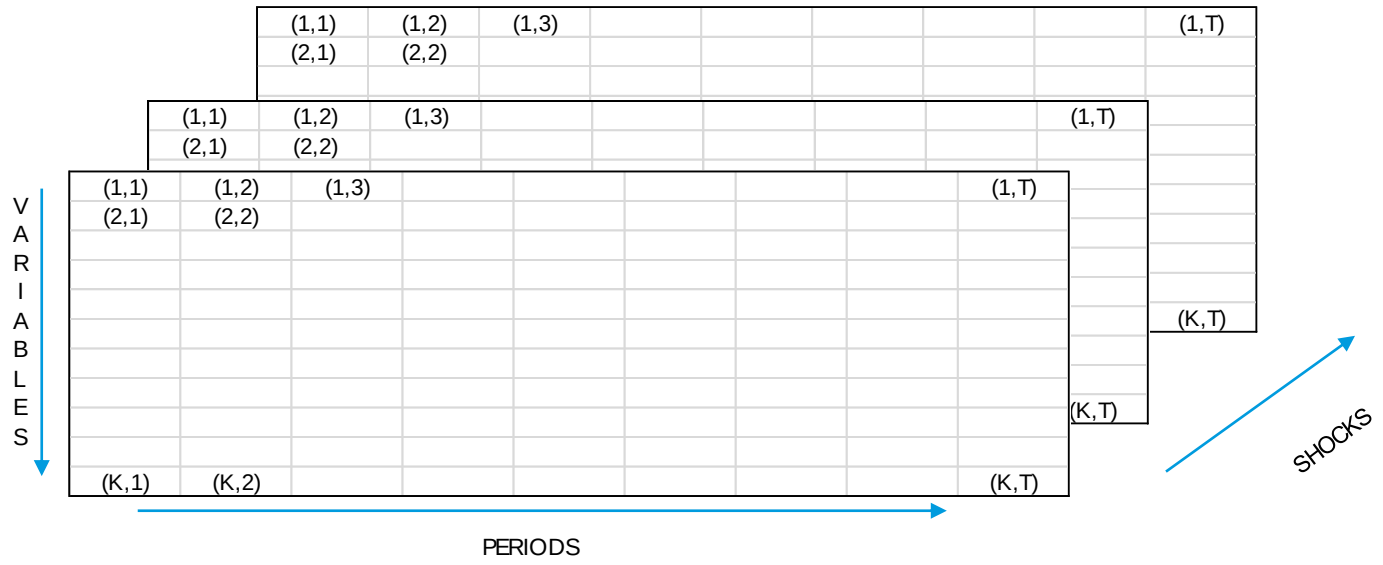
Path-Linearized Solution

- Simulate IRFs for **R** shocks with **T** periods using the non-linear model in advance…

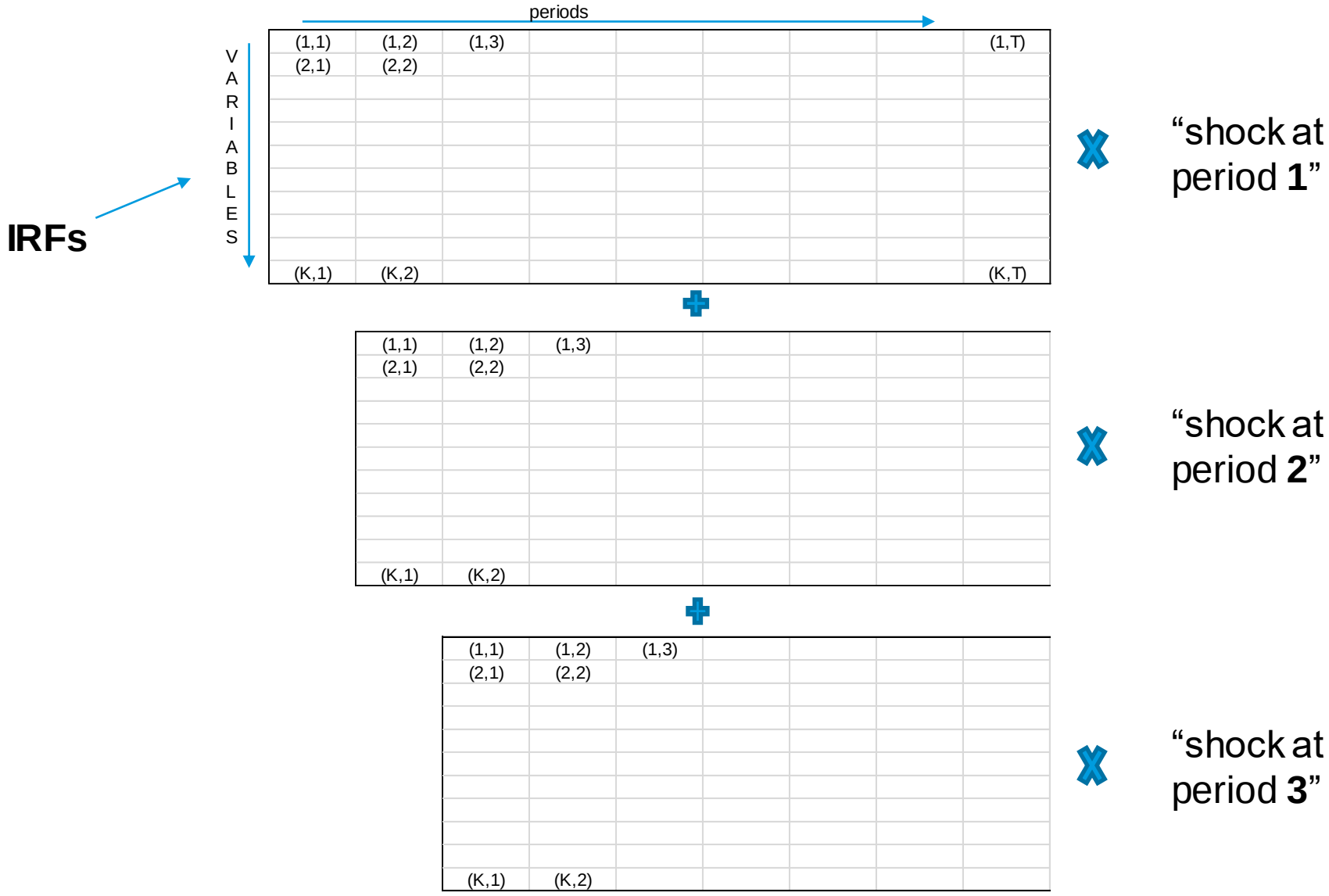
- Select **K** outcome variables of interest out of **N** model variables **N >> K**, from thousands to dozens…

- Create the "**cube**" – a [K x T x R] matrix of the IRFS to represent the model

The “CUBE” – [K x T x R]



Path-Linearized Solution (a)



The Effective Lower Bound (ELB)*

- The path-linearized simulation enforces the “ELB”

- **A “shocks” approach**
  - Designate a “scenario/shock” to deploy should the rates breach the ELB. Uses “multiplier” matrix. *Iterative, converges quickly*

  - Using the difference between a demand shock with and without the ELB using a fully nonlinear solution, or simply “policy shock”, …

  - Can be used also with “anticipated” shocks [e.g. 2-year rolling…]

* Works for **other constrained variables** too (e.g. if debt-to-GDP limit, trigger a negative govt consumption shock, etc…)

Shock Estimation

Shock Estimation

- Process the data, **focus on a subset** of shocks (N = #countries x shocks + global shocks)

- **Invert** the [non]-linear model using the available data (feasible both linear and non-linear)

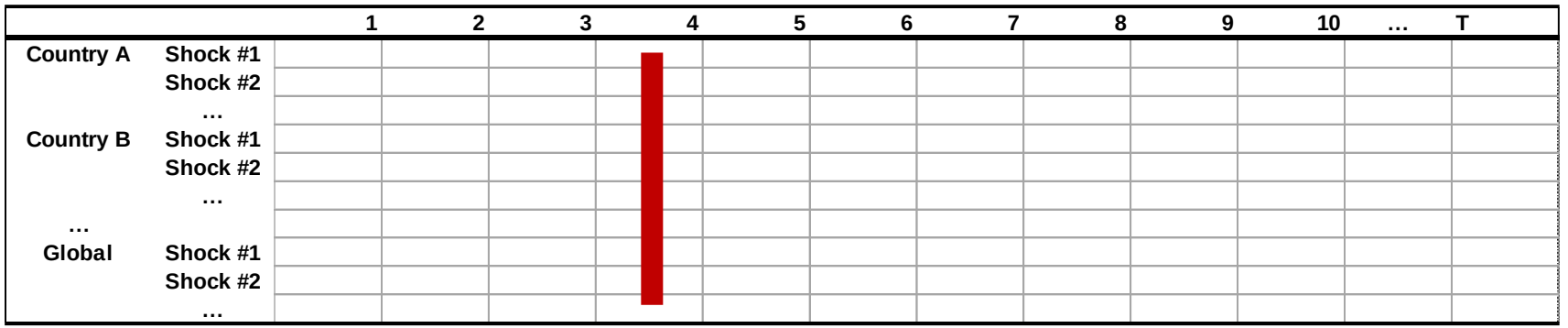
- **Distribution-free estimate**

		1	2	3	4	5	6	7	8	9	10	…	T
Country A	Shock #1												
	Shock #2												
	…												
Country B	Shock #1												
	Shock #2												
	…												
…													
Global	Shock #1												
	Shock #2												
	…												

Sampling: “Bootstrap with Jitter”

- Use the [N x T] shock matrix **E** to estimate the shock distribution and sample from it…

- Effectively a “**bootstrap with jitter**”
- Resampling columns + RANDN(0, **H**)



Why “Jitter”?

- **G20mod/FSGM** is an annual model – **T** can be small…

- Using a [N x T] shock matrix **E**, we estimate a **kernel-density** estimate (KDE), using a Gaussian kernel N(0, **H**) {H regularized bandwidth matrix}

- Sampling from the kernel-density distribution?
  1. With a probability **p**, pick a data point **X** (a col vector from E[:,i])
  2. Add a draw from N(0,H) “kernel” to **X**

Sampling – Blocks & Weights

Shocks organization after identification

		1	2	3	4	5	6	7	8	9	10	…	T
Country A	Shock #1												
	Shock #2												
	…												
Country B	Shock #1												
	Shock #2												
	…												
…													
Global	Shock #1												
	Shock #2												
	…												

Weight/Distance/Regime	w1	w2	w3	w4	w5	w6	w7	w8	w9	w10	…	wT

Sampling – Blocks

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Weight/Distance/Regime	w1	w2	w3	w4	w5	w6	w7	w8	w9	w10	…	wT

World Economic Outlook (WEO) horizon is 5 Years

Blocks to reflect time-dependence among shocks ☹

Sampling – Weights

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Sampling – Weights

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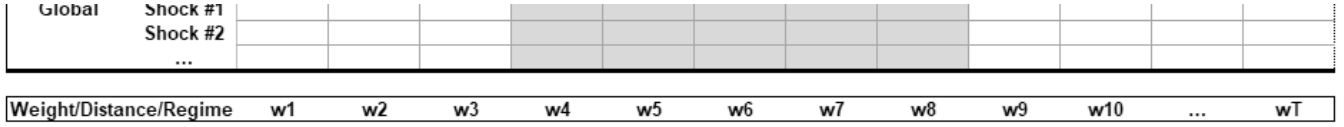
Weight/Distance/Regime	w1	w2	w3	w4	w5	w6	w7	w8	w9	w10	…	wT

Each period is be assigned its “**weight**”, reflecting the probability of being drawn

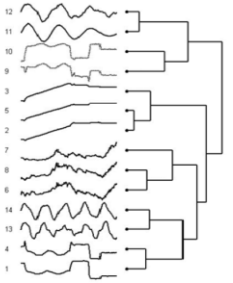
Weights

- We use weights to select sample size, “kill” time periods, pick regimes, and **reflect the current state of the global economy**

- Most commonly:
  a) **Uniform weights** – for “unconditional distributions”
  b) **State-dependent weights –** forecast risk assessment

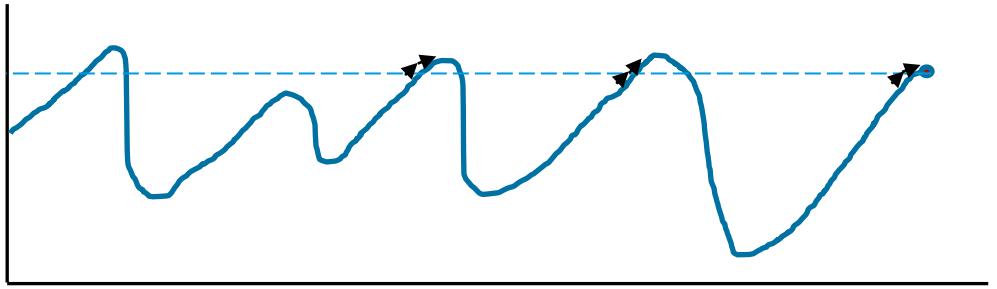


State-Dependent Weights

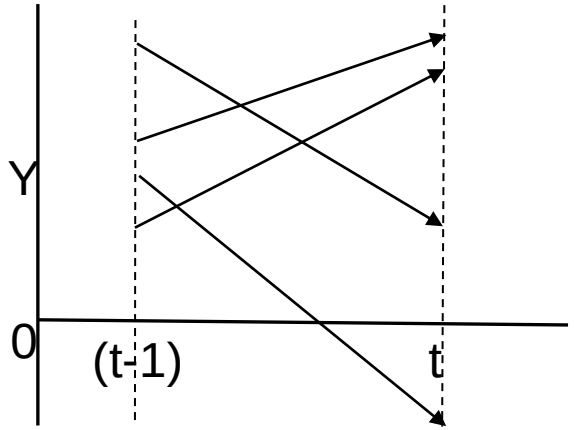


- Weights reflect the **similarity** between the current state of the economy, **X**, and each previous period… ~ "*nearest neighbors*"

- X can be **univariate** [y(t)] or **multi-variate** [y(t), y(t-1)]



- Similarity/distance metrics:
  - **Cosine** similarity, Euclidian, shape-based similarity measures



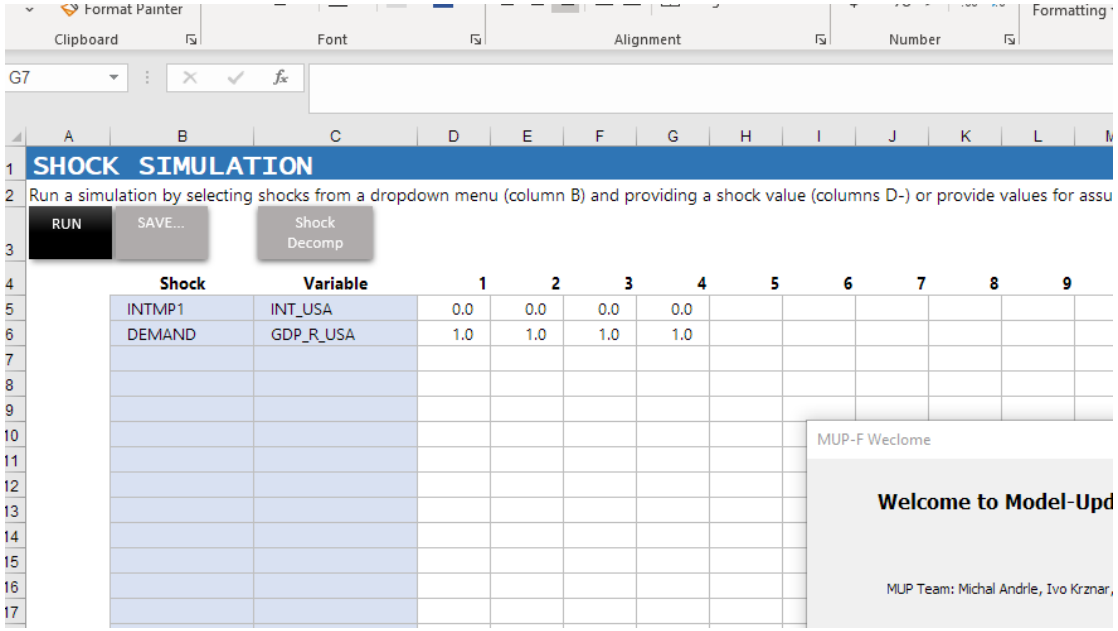
Models in a Spreadsheet…?

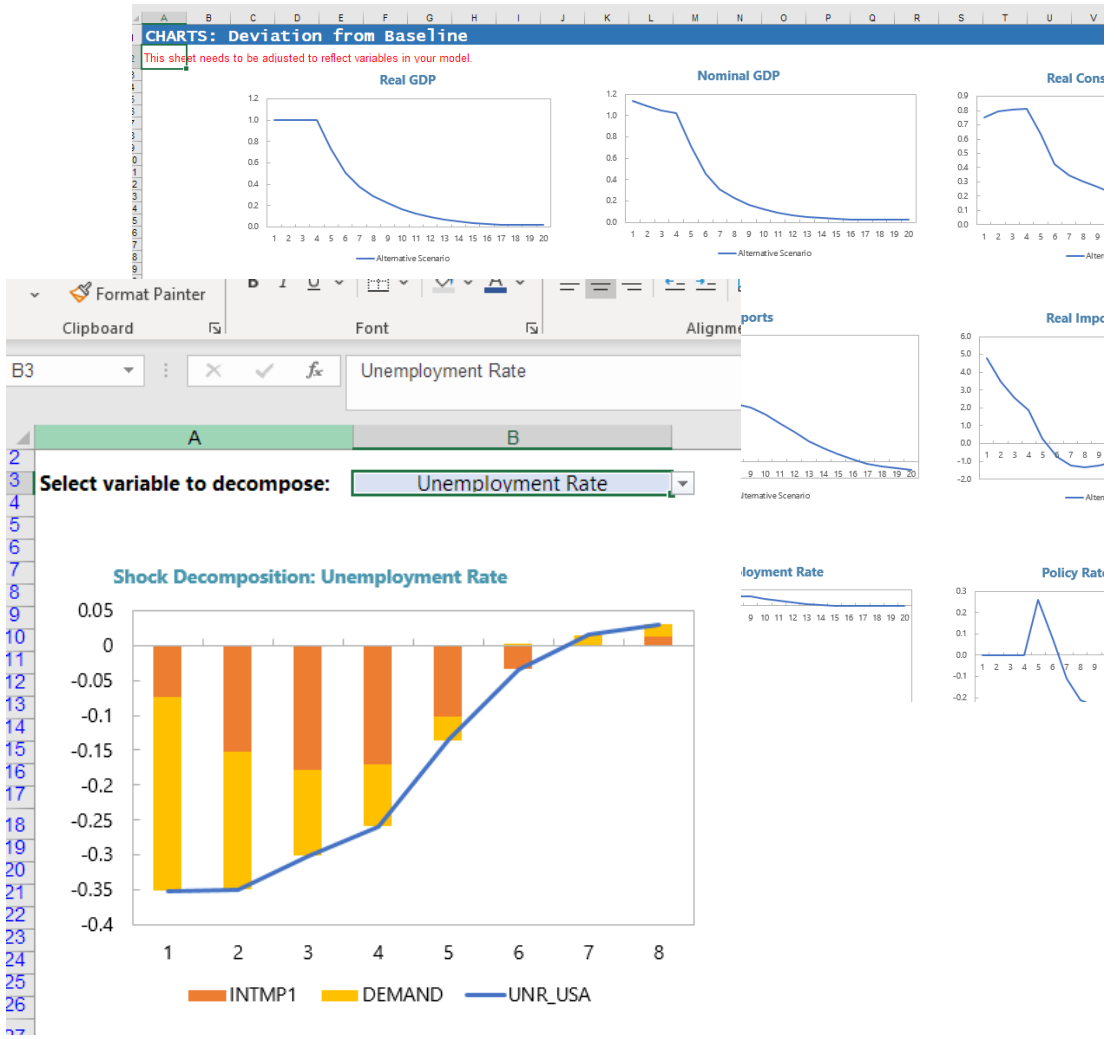
- Most of the linear computations mentioned above have been also implemented in a standalone **MS Excel sheet** for technical assistance (TA) purposes

- Simulates models, “flips” endogenous and exogenous variables, provides shock decompositions, runs stochastic simulations, …

- And more…

Models in a Spreadsheet…?





Extensions:

- Improved shock estimation [faster, regularized]
- Improved sampling
- Estimating the “hidden tail” for climate change applications

Problems:

- **Household’s and firms SHOULD KNOW about the cross-correlation patterns in the shocks, regimes, or weights**
- **Shocks are not “structural”…**

THANK YOU

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