Global Trade Network Simulator and Agent Based Modelling

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Dr Ugur Bilge

ugur@simworld.co.uk

Complexity Group
London School of Economics

Plan

- Agent Based Modelling, Simulations, Complexity
- IIASA Global Trade Network Simulator
- Demo
- Discussion

Background

- PhD in Computer Science from University College London 1993
- Research on “Intelligent Systems”: (ESPRIT II) 90-94
  - Neural Nets, Genetic Algorithms in Finance
- Consultancy for J. Sainsbury Plc Logistics Innovation Centre, 94-98
  - Data Mining, Forecasting and Optimisation
  - Agent Based Simulations, SimStore
- Set up SimWorld in 1998 -
- Development of SimFolio, in 2000, CommodiCast (now Qforma)
- Container World at Imperial College, 2001
- ICoSS Project at London School of Economics, 2001-2004
- Assistant Prof. at Akdeniz University, Faculty of Medicine, Dept of Biostatistics and Medical Informatics, 2003 -
- IIASA Global Trade Network Simulator, 2010
- REDD Game Project at LSE, 2011 -

Agent Based Modelling/Simulations

- Computational approach
- Autonomous agents
- Bottom-up modelling
- Simulate and observe
- Look for emergence and unexpected
- Educational
- Visualise and create virtual labs for discussion
- Generate insights, understand actors

Why Agent Based Models

- Social Events, Economic Depressions, Crises, Organisational Change
- Current approaches are not good enough
  - Linear Thinking
  - Top-down
  - Reductionist
- We need Complexity Thinking
  - Nonlinear
  - Bottom-up
  - Multi disciplinary

Complexity Thinking

- Inspired by Natural Science
  - Limits to our knowledge: Chaos Theory
  - Recent developments in Network Theory
  - Complex Systems, CAS, Complex Evolutionary Systems
- Natural Complex Systems:
  - Nonlinear, Positive Feedback, Adaptive and Evolving, Self Organising, Unpredictable, Uncertain, Sensitive to initial conditions, Path dependent, Far from equilibrium, Dissipative, Display Emergent, Spontaneous Phase Transitions
- Social Systems too?

  Ten Principles of Complexity (Eve Mitleton-Kelly)
- We need new tools

Tools for Complex Social Systems?

- Linear Analytic tools; when non-linear, break into small parts, make linear
- Optimisation tools (minimise or maximise a function, linear or nonlinear)
- Statistical tools (assume linear, normal distributions)
- Game theory, behavioural economics
- All ignore feedback and adaptation, all are unsuitable to an extent!

ABS Strengths

- Decentralised thinking
- Emergence and Self-Organisation
- What-if scenarios from many perspectives
- Working in past (validation) and in future
- Statistical “prediction” for betting and speculation ☺
- ABM is ideal for social problems where
  - There are a number of autonomous, interacting agents where we are interested in understanding some aspects of social behaviour

ABS Obstacles

- Technology too new?
- Too expensive?
- Not enough data (prototype development can help data collection)
- Expecting
  - too much!
  - too little: “You get back what you put in”?
- Resistance to change
  - in thinking
  - in management

Agent Based Simulation versus Conventional Simulation (CS)

Conventional Simulation	Agent Based Simulation
top-down, and uses given environment	bottom-up, creates environment
assumes homogeneous populations with given stats, and few parameters	can use heterogeneous agents with many parameters
uses equations and formulas	can use adaptive agents
to produce results	to generate insight and explanation
react to results	learn and understand

ABS Development

- There are no off-the-shelf packages available, so
  1. Use ABM simulation environments such as NetLogo for demonstration
  2. Write your own
  3. Team up with others

Global Trade Network Simulator IIASA

- International Institute for Applied Systems Analysis (IIASA)

  Extreme Events in Human Systems Initiative –

  Game Changers Project (Leena Ilmola, John Casti)
- Partners: Finland, Scotland, a number of research and business organisations
- Xevents Observatory and Simulation
  - Web Scanning
  - Global Trade Network Simulator

Game Changers (Ilmola, Casti)

Game Changers

ENDO - HUMAN SYSTEM

- Major loss of faith on political decision making
- Global order
- Integration of commercial and political power
- Public role in technology development
- Strength of the public sector
- IPR policies
- Growth decentralized
- Public role in financial market

TECHNOLOGY

- Zero energy
- Quantum computing
- Singularity almost there
- „Nanothreats"

ENDO ECONOMY

- Growth decentralized/
- Development of virtual money/ exchange

EXO HUMAN SYSTEM

- Climate Change
- Ice Age
- Plant diseases
- Bio-system collapses
- Weather pattern changes
- Volcanic activity
- Pandemics
- Migration

Global Trade Network Simulator

Phase 1 – SimFinn – Agent Based Simulation of Finland's Economy

Coarse grain country agents,

Finland's economy in the global economic context, interdependencies and economic crises contagion

Method: Network Simulation, and visualisation,

What if scenario analysis, Agent Based Simulation

- Data 1990 to 2009
  - GDP, Growth Rate, Exports, Imports, Population, Population Growth, revenues, expenditure, debt, sector data
- Projection into 2010 - 2030

GTNS Agents

22 Country Agents:

Euro:	Finland, Sweden, Denmark, Belgium, Holland, Germany, France, Spain, Italy
Americas:	USA, Mexico, Canada, Brazil
Asia:	China, India, Japan, Indonesia
Others:	UK, Norway, Russia, Turkey, South Africa

Data Source: CIA World Fact Book, World Bank, IMF

Initial Assumptions:

- Economic growth is linked to trade network
- Global events can change trade connectivity
- Countries (as agents) can change connectivity

GTNS Objectives

- Capture trade network dynamics
- Ability to display extreme behaviour (using what if scenarios)
- Display emergent behaviour using simple rules at the agent (country) level, in this case newly forming cliques, alliances can be visualised
- Ability to do a combination of what if and agent rules
- Accurately calculating future GDP, exports, imports is not our objective, as this is done by other simulators such as IFs and CAMS

Export Links in 1990

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SWE NOR 9.3 DEN 6.8 USA 9.8 UK 11.2 GER 12.1

NOR SWE 12.0 DEN 5.0 USA 6.0 UK 26.0 GER 12.0

DEN USA 6.0

USA JAP 11.8 CAN 22.9

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FRA USA 6.7 UK 9.8 GER 15.8 ITA 12.2 SPA 5.6 BEL 8.9 HOL 8.7

ITA USA 7.9 UK 7.1 GER 16.4 FRA 12.2 SPA 5.2 HOL 2.8

BRA USA 28.0 JAP 6.0

JAP USA 34.0 RUS 5.0

IND USA 19.0 RUS 17.0 JAP 10.0

INDO USA 16.0 JAP 42.0

TR USA 6.5 UK 4.9 GER 18.4 ITA 8.2

MEX USA 66.0 JAP 11.0

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4nt - java NetApp

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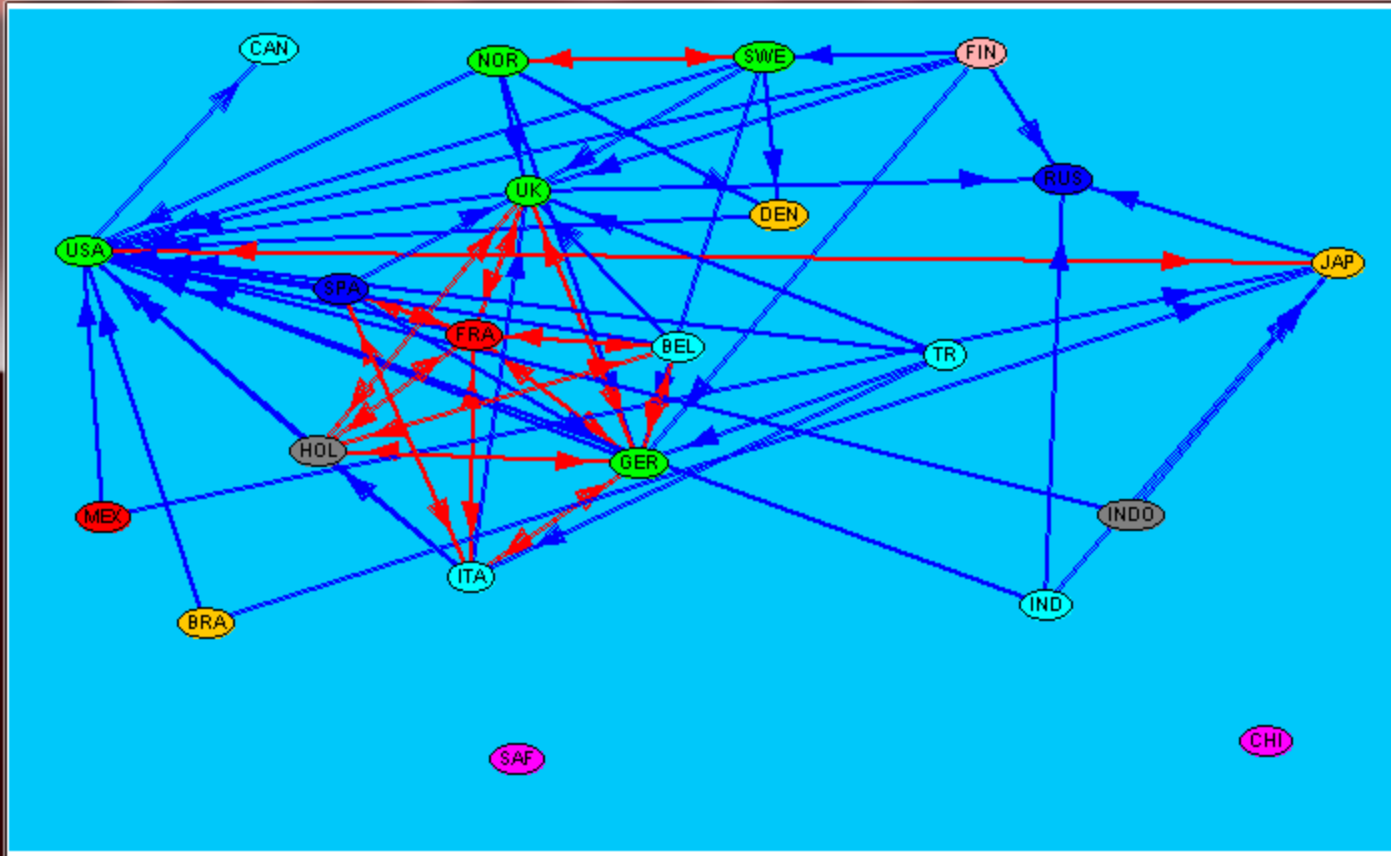
Global Trade Network Simulator



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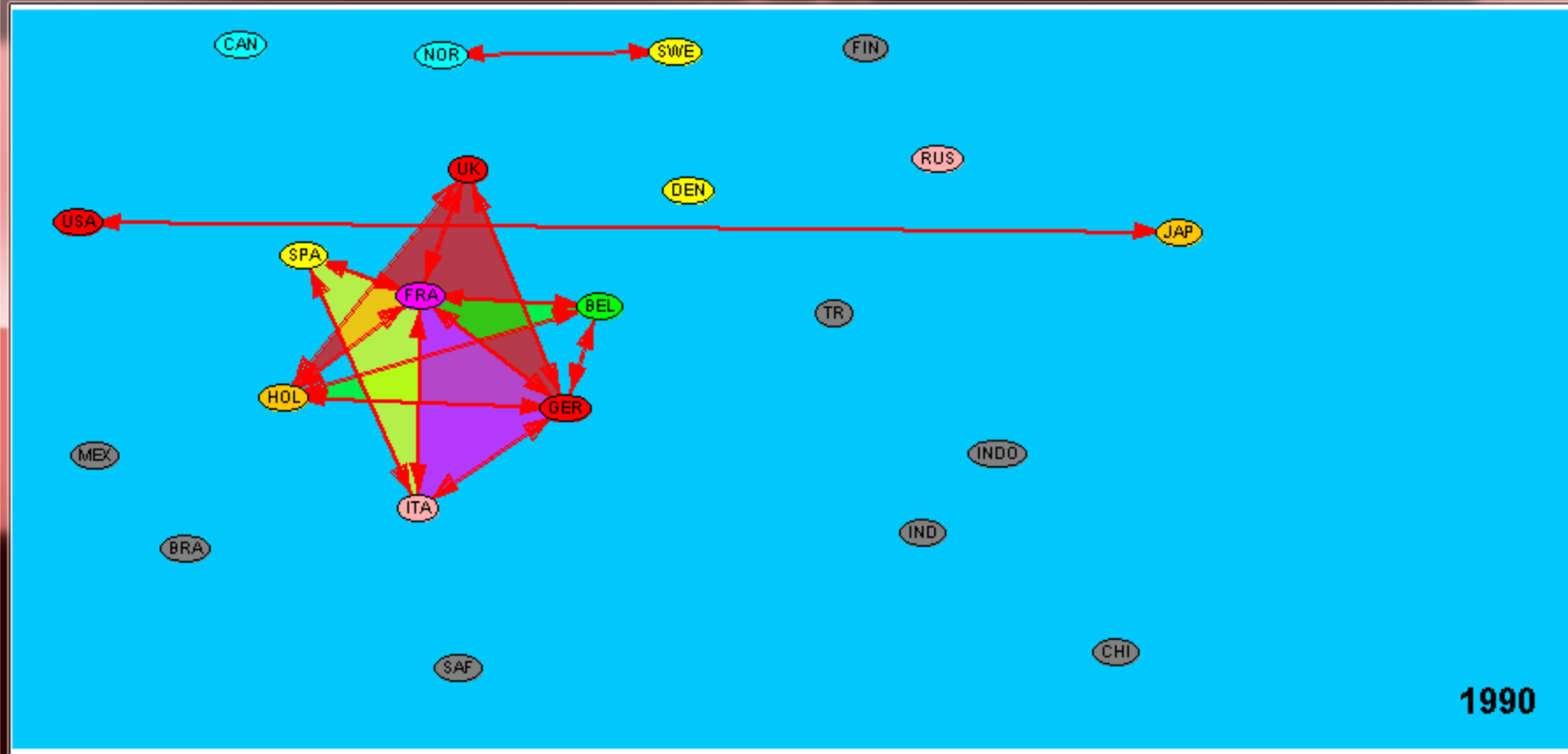

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HOL GER 22 BEL 20.2 UK 8.9 FRA 7.7 ITA 6.1 USA 4.6 SPA 3.4

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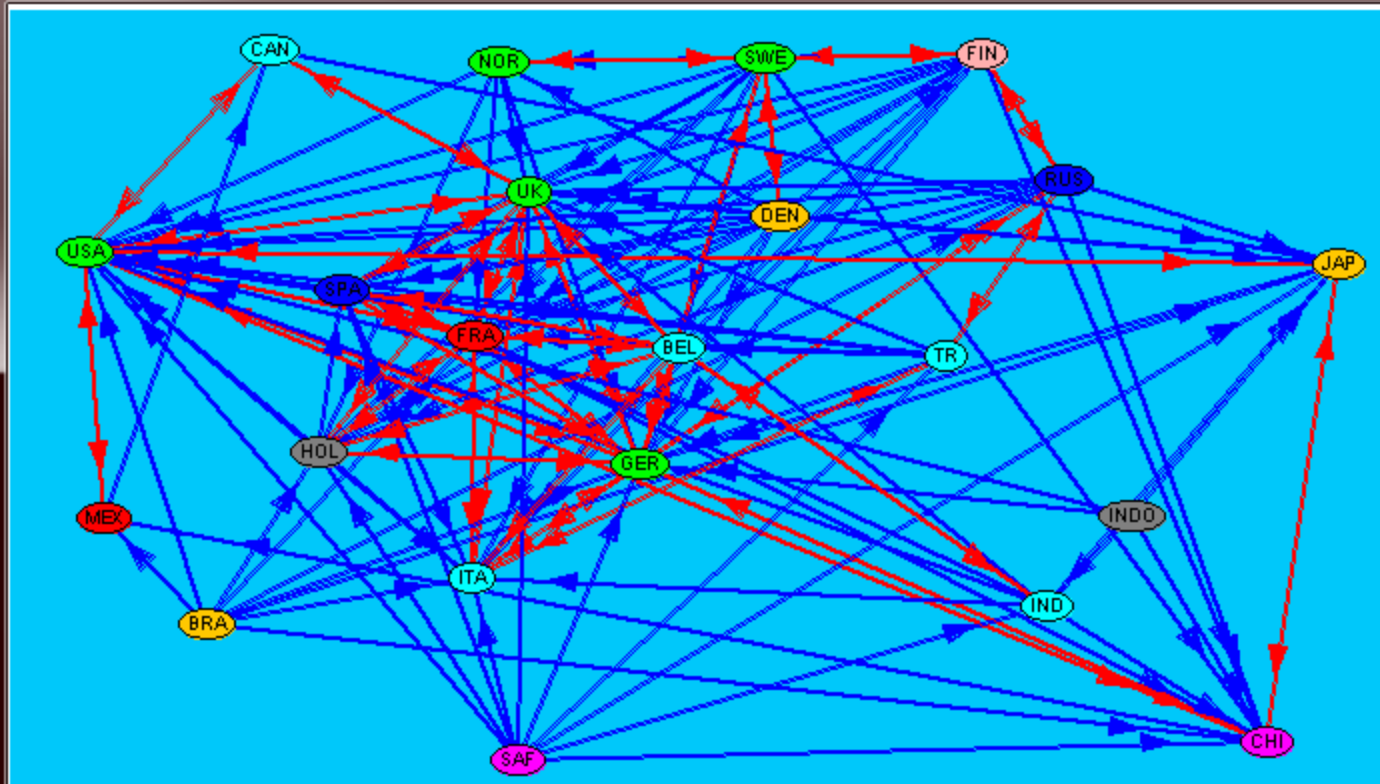
Global Trade Network Simulator



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Emergence of Cliques in 2009

(as a result of mutual trade connections)

In 2009: There are 15 Cliques:

UK GER FRA ITA BEL

UK GER FRA SPA BEL

UK GER FRA BEL HOL

USA UK GER FRA

USA GER CHI

USA UK CAN

ITA RUS TR

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cliq.txt

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15 Cliques:
UK GER FRA ITA BEL
UK GER FRA SPA BEL
UK GER FRA BEL HOL
USA UK GER FRA
USA GER CHI
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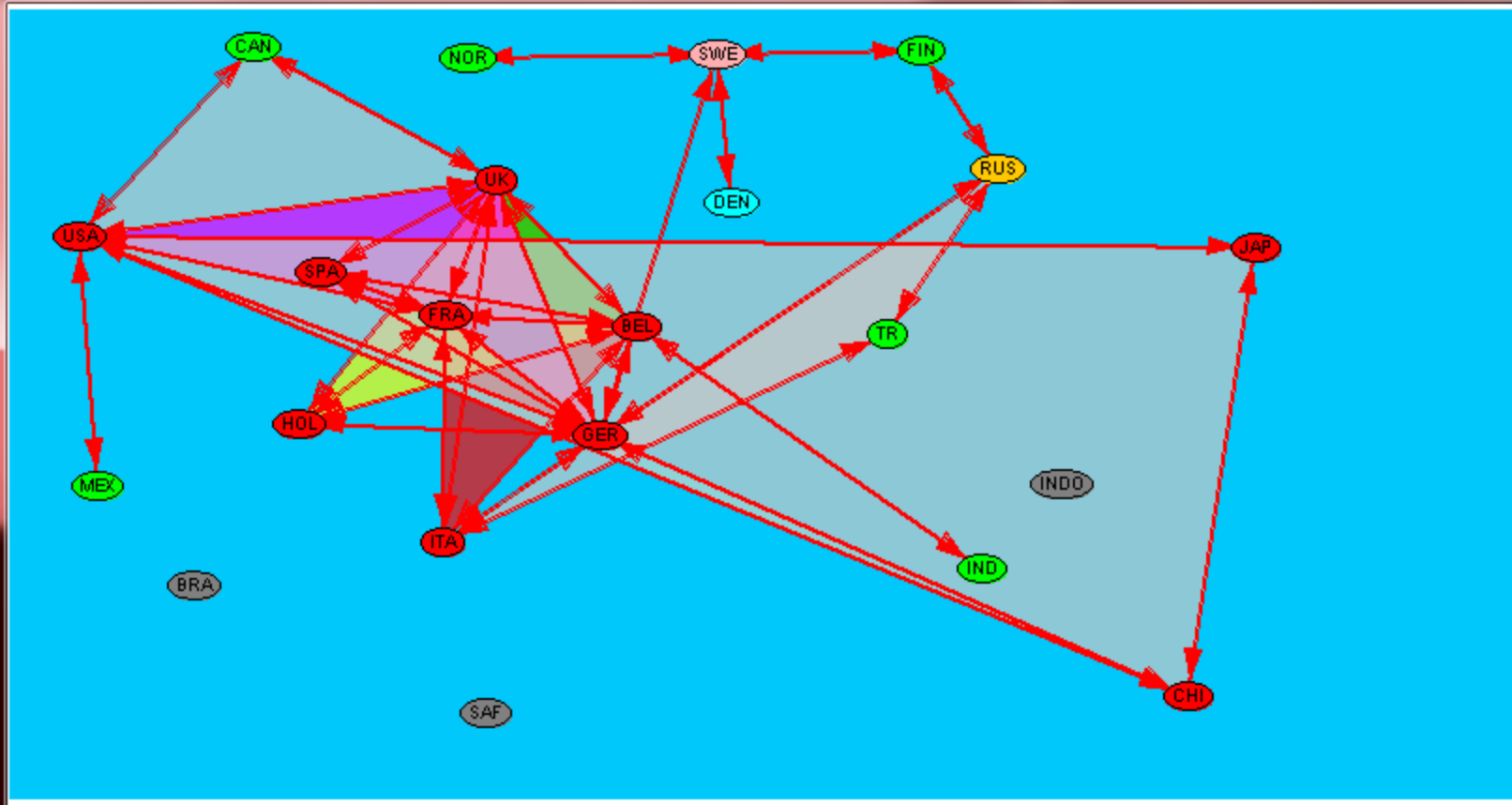

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Resilience?

- Using breadth first search technique, establish sensitivity of each country to external shocks by all others in the network. We call this resilience of each agent.
- We can then establish the overall resilience of the network.
- Increased connectivity will cause the overall resilience to go down.

Impact of GDP shocks by others

Finland's Exposure to GDP shocks in 2009 (all values are %)

2009 IMPACT of GDP (-10%) event by FIN ON FIN: -10.0

2009 IMPACT of GDP (-10%) event by GER ON FIN: -2.34

2009 IMPACT of GDP (-10%) event by USA ON FIN: -1.45

2009 IMPACT of GDP (-10%) event by UK ON FIN: -1.36

2009 IMPACT of GDP (-10%) event by SWE ON FIN: -1.31

2009 IMPACT of GDP (-10%) event by RUS ON FIN: -1.05

2009 IMPACT of GDP (-10%) event by FRA ON FIN: -0.91

2009 IMPACT of GDP (-10%) event by ITA ON FIN: -0.78

2009 IMPACT of GDP (-10%) event by CHI ON FIN: -0.71

2009 IMPACT of GDP (-10%) event by BEL ON FIN: -0.62

2009 IMPACT of GDP (-10%) event by HOL ON FIN: -0.61

2009 IMPACT of GDP (-10%) event by SPA ON FIN: -0.55

2009 IMPACT of GDP (-10%) event by NOR ON FIN: -0.42

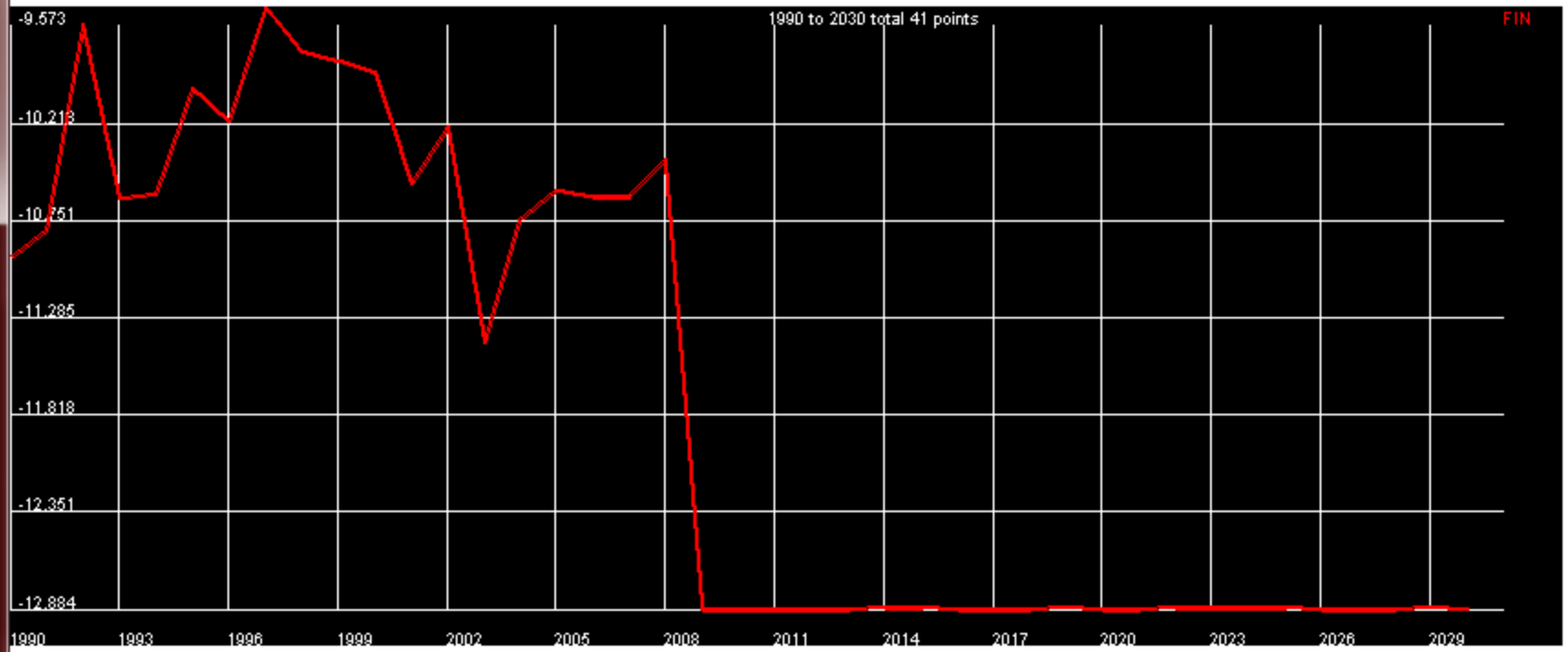
2009 IMPACT of GDP (-10%) event by CAN ON FIN: -0.3

2009 IMPACT of GDP (-10%) event by MEX ON FIN: -0.18

2009 IMPACT of GDP (-10%) event by JAP ON FIN: -0.13

total exposure =-12.88%

GFrame 0



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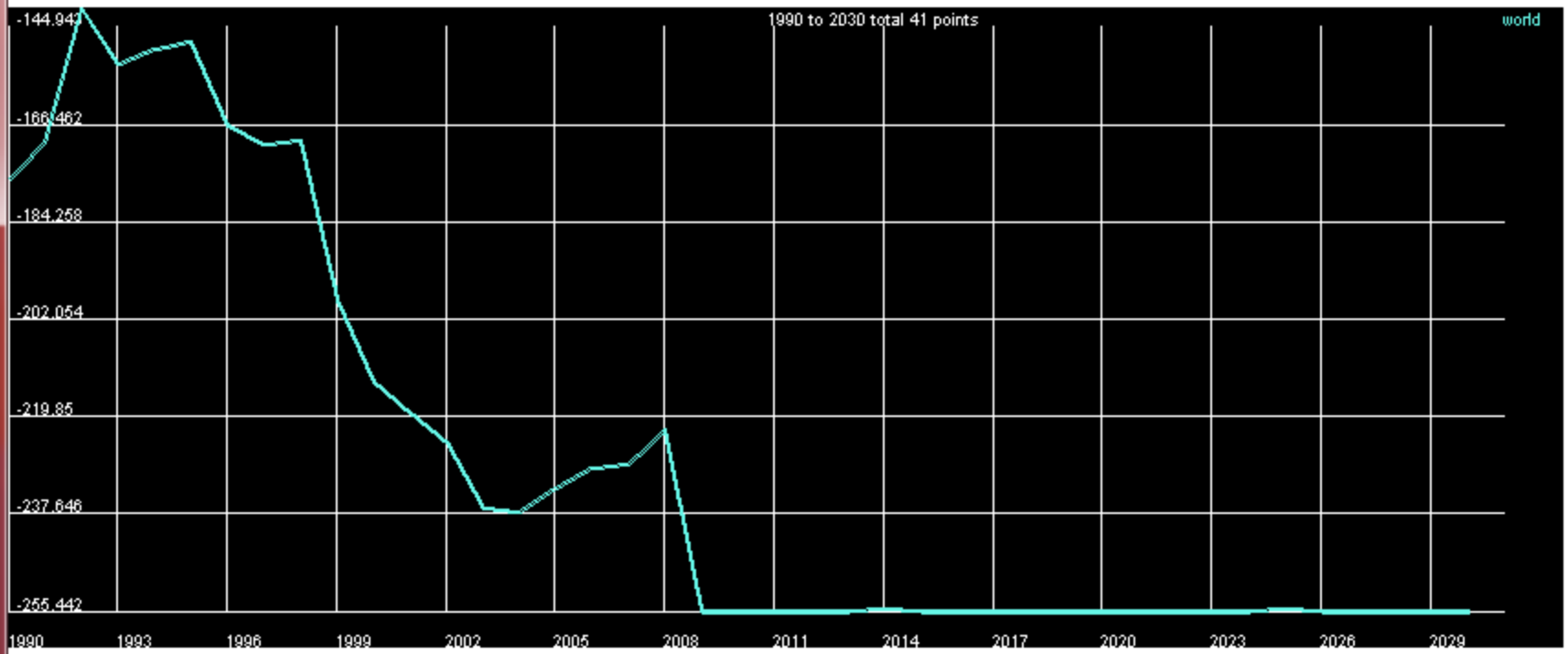
Global Resilience 1990-2009

1990	-176.68
1991	-169.95
1992	-144.94
1993	-155.60
1994	-152.65
1995	-151.37
1996	-166.84
1997	-170.16
1998	-169.62
1999	-198.72
2000	-213.60
2001	-219.41
2002	-224.95
2003	-236.86
2004	-237.44
2005	-233.21
2006	-229.36
2007	-228.93
2008	-222.32
2009	-255.44
2010	-255.44
2011	-255.44
2012	-255.44

Total of all fitness values in the trade network

Increased connectivity (globalisation) reduces overall fitness

GFrame 1



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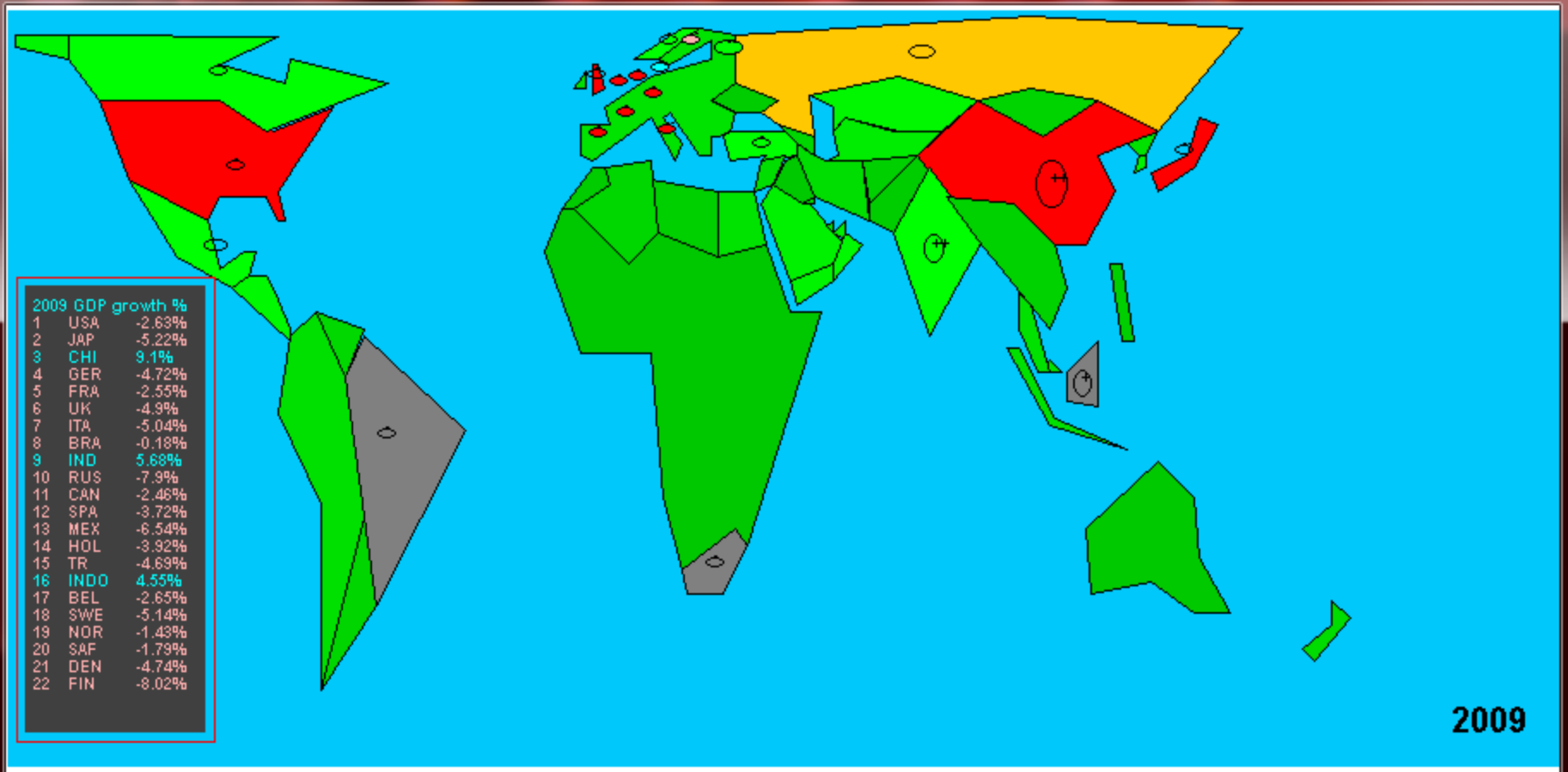
Fitness 2029 -255.4
Fitness 2030 -255.4
Done

Map View

- In addition to the network view, we can use map view to probe into individual countries
- Map view also provides a score table for the GDP of the countries
- We can run what if and ABS scenarios and see comparative outcomes in the score table

Global Trade Network Simulator



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Future Projections

- Current assumptions use the mean values of the last N years values as the basis for the future GDP, import and export growth rates.
- As the system is driven by variable percentage growth rates, it displays exponential GDP growth in the period between 2010-2030
- Growth rates and connectivity can be changed by user defined What if scenarios and by ABM rules

Baseline Finland Growth Rate

1991	-6.013175
1992	-3.487695
1993	-0.801915
1994	3.616135
1995	3.963618
1996	3.584693
1997	6.204201
1998	5.019533
1999	3.902237
2000	5.342477
2001	2.285974
2002	1.821209
2003	2.000858
2004	4.112752
2005	2.917545
2006	4.409525
2007	5.332781
2008	0.922102
2009	-8.018789
2010	1.687248
2011	1.687248
2012	1.687248

Graph Frame1

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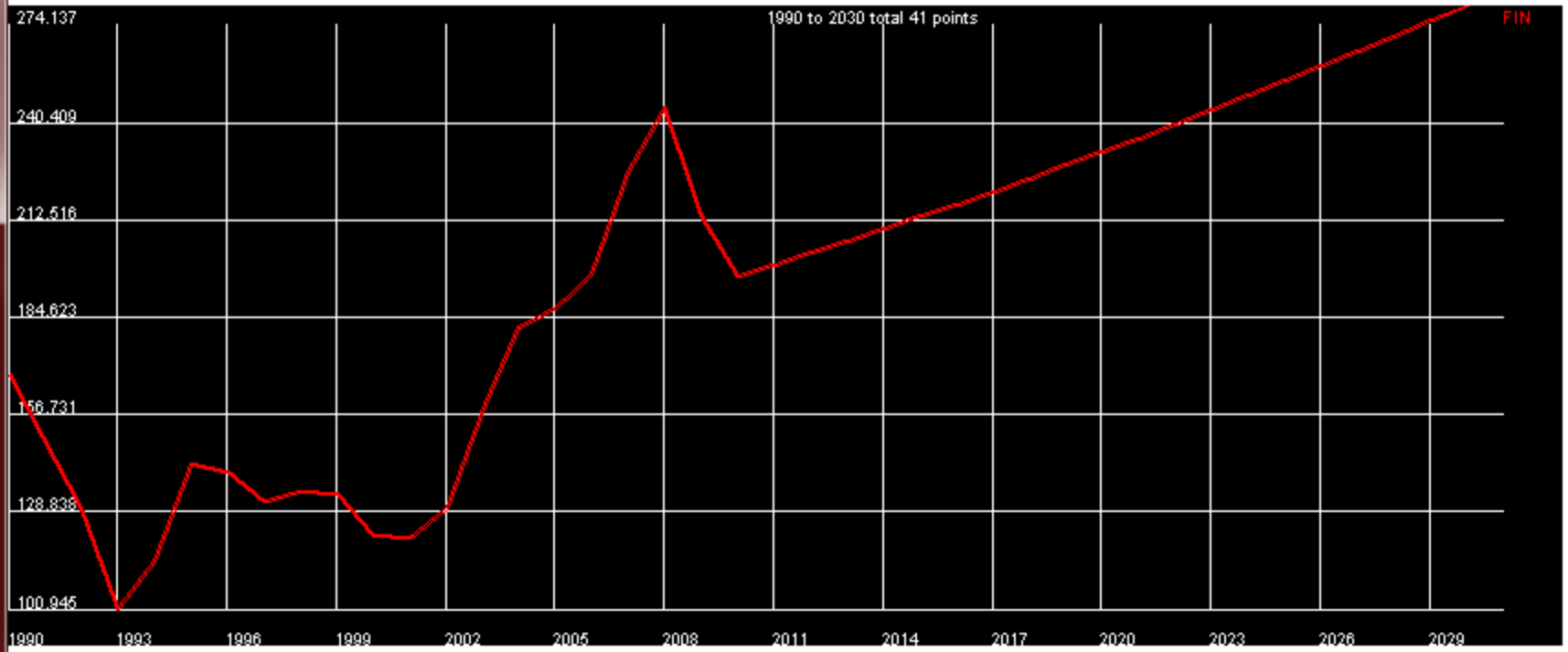
b600 | Rdrw | 5.0 | 8 | ABM | WhatIf | ImapactAll | Impact | FIN | Draw | Map | GR: | GDP: | CMP: | Loop | 3

Graph Frame1



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1995

Text Data | Animate | Play | 600 | Pause | STEP | Resume | Stop | gdp | size: | growth | Col | bar | y0 | rawdata | RST | ALL | Clr

LAYRUN | Scramble | Shake | Jump | Clus | Circ | Dtec | Hier | Grid | 4 | 150 | EPIRUN | All | Rule0 | Srt | Forget | Reset | RndS | 5 | Cliq

b600 | Rdrw | 5.0 | 8 | ABM | WhatIf | ImapactAll | Impact | FIN | Draw | Map | GR: | GDP: | CMP: | Loop | 3

Growth Rate and Trade Rules

- The simulator does not calculate GDP. It has a baseline GDP growth rate, and assumes this will continue unless global trade events occur, such as:
  - An increase/decrease in exports/imports, or
  - An increase/decrease in an export partner's GDP (in turn causes a change in the exports, and change in growth rate)
  - Currency rate changes also trigger changes in trade

  So the change in the growth rate:

  dGrowthRate = (dExports - dImports) / GDP

In summary: GTNS models the change in the Growth Rate as a result of changes in Exports and Imports

What if scenarios

Simulation Scope 1990 – 2030

- Current Assumptions Prevail: GDP, Population, Global Trade, Economic Blocks
- Possible Economic Crisis in one of the Agents (USA, EU, ...) its impact, spread (contagion, and cascades) on the global trade, and GDP growth
- Trade wars, new economic blocks (changing connectivity), add/delete, weaken/strengthen modify trade connections, change GDP growth profiles
- Test totally different network structures

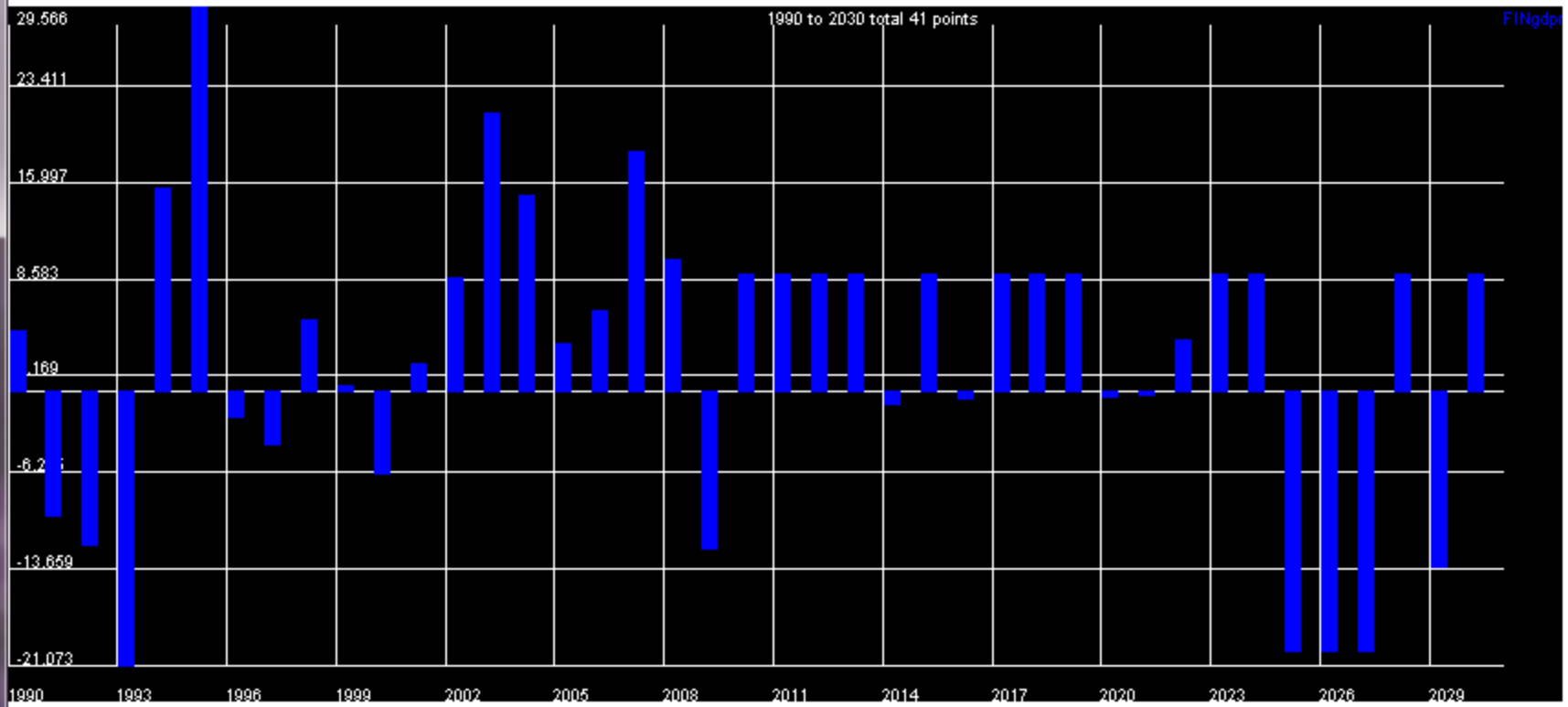
Sample What if Scenario

Here is a user defined sample What if scenario:
In 2014 Russia's GDP will go down by 5%,
In 2016 USA imports from the rest of the world will go down by 10%
In 2020 USA exports to UK and Germany will go down by 10%
In 2022 Finland's export links are USA 30%, UK 30% and Russia 10%
In 2025 World wide economic crisis causes 20% drop in GDP in 3 consecutive years
In 2029 Finland's exports to USA go down by 1%, to UK go up by 1%, to France go up by 1%

2014	1	RUS	GDP	-5	
2016	1	USA	IMPORT	-10	World
2020	1	USA	EXPORT	-10	UK,GER
2022	1	FIN	LINK	100	USA,30,UK,30,RUS,10
2025	3	World	GDP	-20	
2029	1	FIN	CHANGE	100	USA,-1,UK,1,FRA,1

The simulator is able to run this what if scenario and show outcomes for all countries in terms of GDP, Growth Rate, Imports, Exports
Using the format above users can test their own scenarios

CanFrame 7



FINgdp
FINgdprate
FINpop
FINpoprate
FINexp
FINexprate
FINimp
FINimprate
FINexp_gdp
FINimp_gdp
FINigdp_trad

Anim | Save | Load | out.dat | MA | 13 | Col | bg | bar | Log | Sort | Stat | R | T | Dens | dif | y0 | % | raw | FINgdprat | RST | ALL | Clr

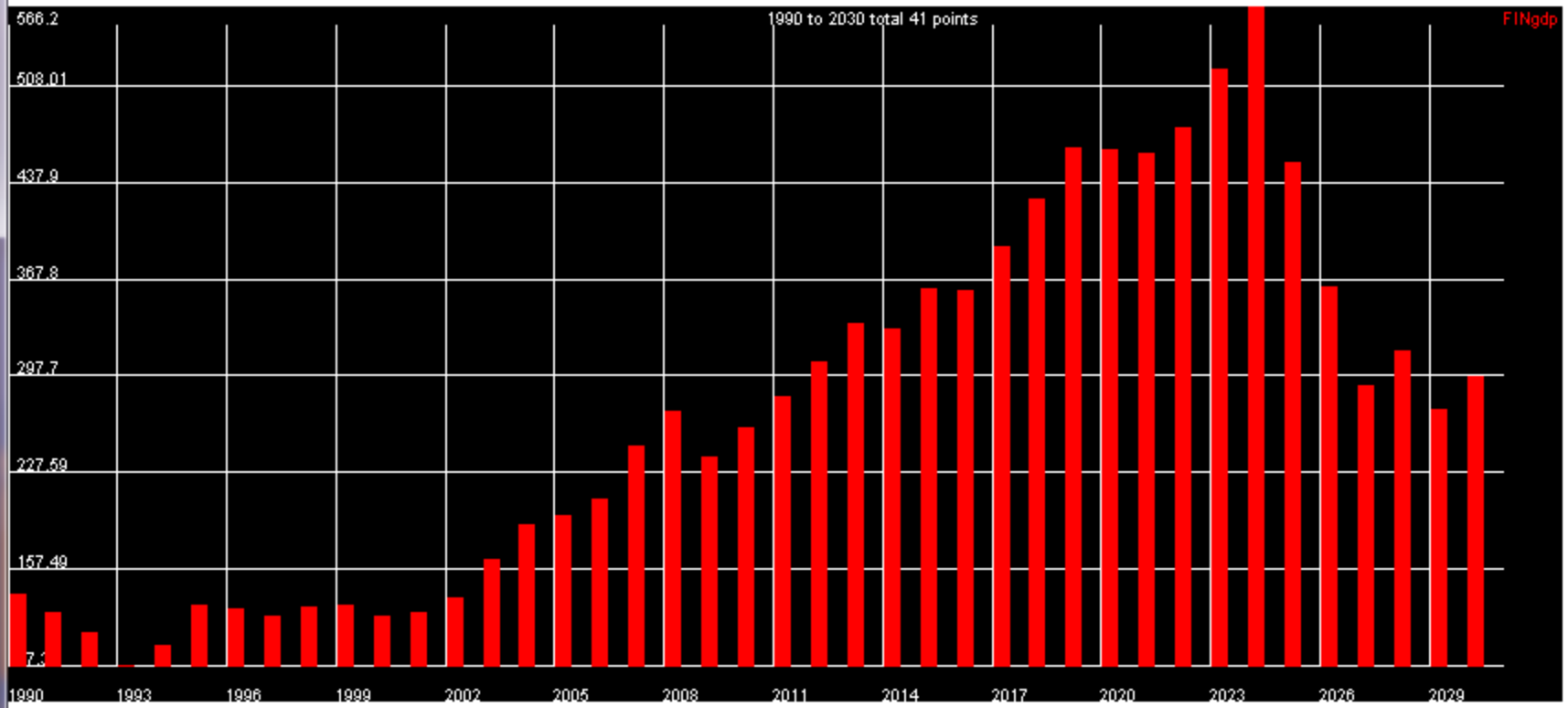
IND 0.152
INDO 0.116
TR 0.119
SAF 0.153
MEX 0.299
CAN 0.201
SPA 0.169

LAYRUN | Scramble | Shake | Jump | Clus | Circ | Dtec | Hier | Grid | 4 | 150 | EPIRUN | All

Font | 9 | Refresh | ABM | WhatIf | Fitness | FindIf | FIN | GDP | Draw | MAP

Event data updated
Applying 10 events... Done!
Event data not updated

CanFrame 5



FINgdp
FINgdprate
FINpop
FINpoprate
FINexp
FINexprate
FINimp
FINimprate
FINexp_gdp
FINimp_gdp
FINigdp_trad

Anim | Save | Load | out.dat | MA | 13 | Col | bg | bar | Log | Sort | Stat | R | T | Dens | dif | y0 | % | separate | FINgdp | RST | ALL | Clr

LAYRUN | Scramble | Shake | Jump | Clus | Circ | Dtec | Hier | Grid | 4 | 150 | EPIRUN | All

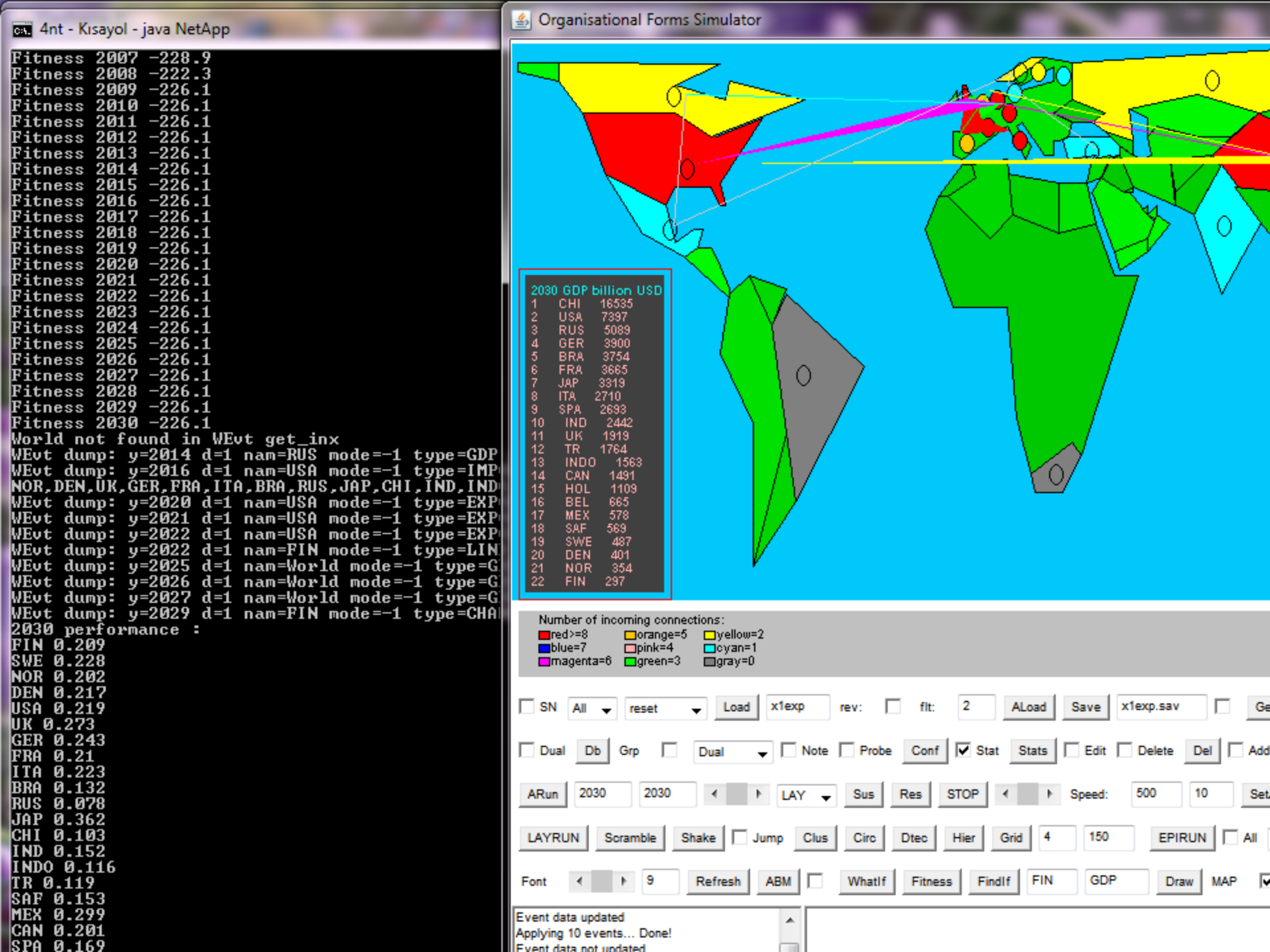
Font | 9 | Refresh | ABM | WhatIf | Fitness | FindIf | FIN | GDP | Draw | MAP

Done
Event data updated
Applying 10 events ... Done!

23

Analysis and Refining Simulation Results

* Cluster and group scenarios from Finland's


4nt - Kısayol - java NetApp
Fitness 2007 -228.9
Fitness 2008 -222.3
Fitness 2009 -226.1
Fitness 2010 -226.1
Fitness 2011 -226.1
Fitness 2012 -226.1
Fitness 2013 -226.1
Fitness 2014 -226.1
Fitness 2015 -226.1
Fitness 2016 -226.1
Fitness 2017 -226.1
Fitness 2018 -226.1
Fitness 2019 -226.1
Fitness 2020 -226.1
Fitness 2021 -226.1
Fitness 2022 -226.1
Fitness 2023 -226.1
Fitness 2024 -226.1
Fitness 2025 -226.1
Fitness 2026 -226.1
Fitness 2027 -226.1
Fitness 2028 -226.1
Fitness 2029 -226.1
Fitness 2030 -226.1
World not found in WEvt get_inx
WEvt dump: y=2014 d=1 nam=RUS mode=-1 type=GDP
WEvt dump: y=2016 d=1 nam=USA mode=-1 type=IMP
NOR,DEN,UK,GER,FRA,ITA,BRA,RUS,JAP,CHI,IND,IND
WEvt dump: y=2020 d=1 nam=USA mode=-1 type=EXP
WEvt dump: y=2021 d=1 nam=USA mode=-1 type=EXP
WEvt dump: y=2022 d=1 nam=USA mode=-1 type=EXP
WEvt dump: y=2022 d=1 nam=FIN mode=-1 type=LIN
WEvt dump: y=2025 d=1 nam=World mode=-1 type=G
WEvt dump: y=2026 d=1 nam=World mode=-1 type=G
WEvt dump: y=2027 d=1 nam=World mode=-1 type=G
WEvt dump: y=2029 d=1 nam=FIN mode=-1 type=CHA
2030 performance :
FIN 0.209
SWE 0.228
NOR 0.202
DEN 0.217
USA 0.219
UK 0.273
GER 0.243
FRA 0.21
ITA 0.223
BRA 0.132
RUS 0.078
JAP 0.362
CHI 0.103
IND 0.152
INDO 0.116
TR 0.119
SAF 0.153
MEX 0.299
CAN 0.201
SPA 0.169
Organisational Forms Simulator
2030 GDP billion USD
1 CHI 16535
2 USA 7397
3 RUS 5089
4 GER 3900
5 BRA 3754
6 FRA 3665
7 JAP 3319
8 ITA 2710
9 SPA 2693
10 IND 2442
11 UK 1919
12 TR 1764
13 INDO 1563
14 CAN 1491
15 HOL 1109
16 BEL 665
17 MEX 578
18 SAF 569
19 SWE 487
20 DEN 401
21 NOR 354
22 FIN 297
Number of incoming connections:
red>=8
orange=5
yellow=2
blue=7
pink=4
cyan=1
magenta=6
green=3
gray=0
SN
All
reset
Load
x1exp
rev:
flt:
2
ALoad
Save
x1exp.sav
Dual
Db
Grp
Dual
Note
Probe
Conf
Stat
Stats
Edit
Delete
Del
ARun
2030
2030
LAY
Sus
Res
STOP
Speed:
500
10
LAYRUN
Scramble
Shake
Jump
Clus
Circ
Dtec
Hier
Grid
4
150
EPIRUN
All
Font
9
Refresh
ABM
WhatIf
Fitness
FindIf
FIN
GDP
Draw
MAP
Event data updated
Applying 10 events... Done!
Event data not updated

ABS Rules

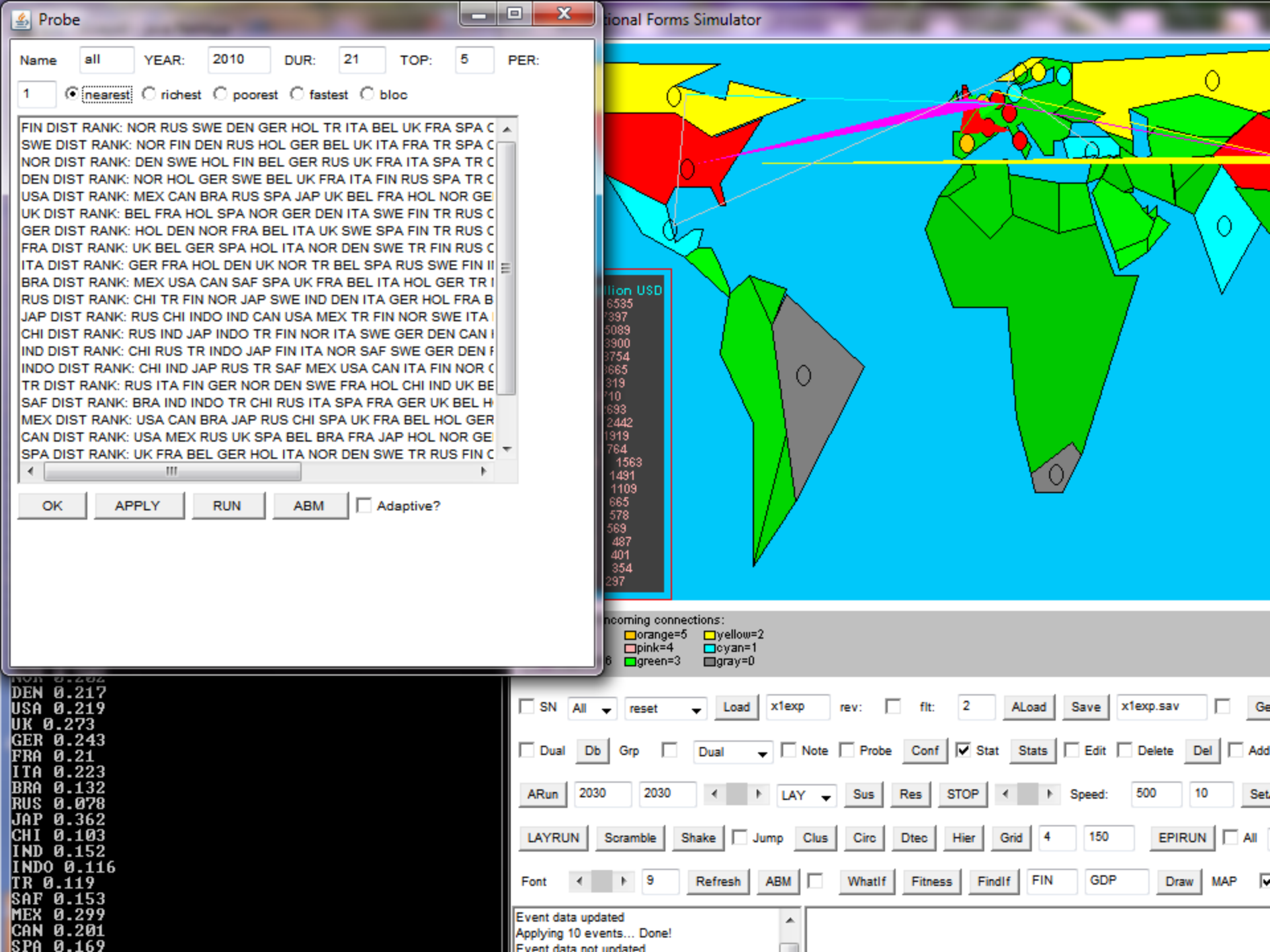
- ABM functionality enables us to test agent level strategies such as a nation increasing trade with its nearest neighbour, (or the richest, or the poorest, or the fastest growing or the same bloc) nations
- Agents can also be initialised with randomly assigned rules, and check their performance every year, if they are not doing “well”, then switch to another rule

ABS Rule Structure

- A country agent or to all agents can use the following agent rules:
  - Rule 1. Increase trade with nearest N neighbours, and decrease trade with furthest N neighbours by X%
  - Rule 2. Increase trade with richest N agents, and decrease trade with poorest N agents by X%
  - Rule 3. Increase trade with poorest N agents, and decrease trade with richest N agents by X%
  - Rule 4. Increase trade with fastest growing N agents, and decrease trade with slowest growing N agents by X%
  - Rule 5. Increase trade with the same bloc N agents based on nearest neighbours, and decrease trade with other blocs N by X%

ABS and What if scenarios together

- ABS can be used in conjunction with user defined What if scenarios. This joint set up will provide insights into complexity of the global economy, and difficulties in policy making in a complex world


Probe
Name all YEAR: 2010 DUR: 21 TOP: 5 PER:
1 nearest richest poorest fastest bloc
FIN DIST RANK: NOR RUS SWE DEN GER HOL TR ITA BEL UK FRA SPA C
SWE DIST RANK: NOR FIN DEN RUS HOL GER BEL UK ITA FRA TR SPA C
NOR DIST RANK: DEN SWE HOL FIN BEL GER RUS UK FRA ITA SPA TR C
DEN DIST RANK: NOR HOL GER SWE BEL UK FRA ITA FIN RUS SPA TR C
USA DIST RANK: MEX CAN BRA RUS SPA JAP UK BEL FRA HOL NOR GE
UK DIST RANK: BEL FRA HOL SPA NOR GER DEN ITA SWE FIN TR RUS C
GER DIST RANK: HOL DEN NOR FRA BEL ITA UK SWE SPA FIN TR RUS C
FRA DIST RANK: UK BEL GER SPA HOL ITA NOR DEN SWE TR FIN RUS C
ITA DIST RANK: GER FRA HOL DEN UK NOR TR BEL SPA RUS SWE FIN I
BRA DIST RANK: MEX USA CAN SAF SPA UK FRA BEL ITA HOL GER TR I
RUS DIST RANK: CHI TR FIN NOR JAP SWE IND DEN ITA GER HOL FRA B
JAP DIST RANK: RUS CHI INDO IND CAN USA MEX TR FIN NOR SWE ITA
CHI DIST RANK: RUS IND JAP INDO TR FIN NOR ITA SWE GER DEN CAN I
IND DIST RANK: CHI RUS TR INDO JAP FIN ITA NOR SAF SWE GER DEN F
INDO DIST RANK: CHI IND JAP RUS TR SAF MEX USA CAN ITA FIN NOR C
TR DIST RANK: RUS ITA FIN GER NOR DEN SWE FRA HOL CHI IND UK BE
SAF DIST RANK: BRA IND INDO TR CHI RUS ITA SPA FRA GER UK BEL H
MEX DIST RANK: USA CAN BRA JAP RUS CHI SPA UK FRA BEL HOL GER
CAN DIST RANK: USA MEX RUS UK SPA BEL BRA FRA JAP HOL NOR GE
SPA DIST RANK: UK FRA BEL GER HOL ITA NOR DEN SWE TR RUS FIN C
OK APPLY RUN ABM Adaptive?
tional Forms Simulator
lion USD
6535
397
5089
3900
3754
665
319
10
693
2442
1919
764
1563
1491
1109
665
578
569
487
401
354
297
ncoming connections:
orange=5 yellow=2
pink=4 cyan=1
green=3 gray=0
DEN 0.217
USA 0.219
UK 0.273
GER 0.243
FRA 0.21
ITA 0.223
BRA 0.132
RUS 0.078
JAP 0.362
CHI 0.103
IND 0.152
INDO 0.116
TR 0.119
SAF 0.153
MEX 0.299
CAN 0.201
SPA 0.169
SN All reset Load x1exp rev: flt: 2 ALoad Save x1exp.sav
Dual Db Grp Dual Note Probe Conf Stat Stats Edit Delete Del
ARun 2030 2030 LAY Sus Res STOP Speed: 500 10
LAYRUN Scramble Shake Jump Clus Circ Dtec Hier Grid 4 150 EPIRUN All
Font 9 Refresh ABM WhatIf Fitness FindIf FIN GDP Draw MAP
Event data updated
Applying 10 events... Done!
Event data not updated

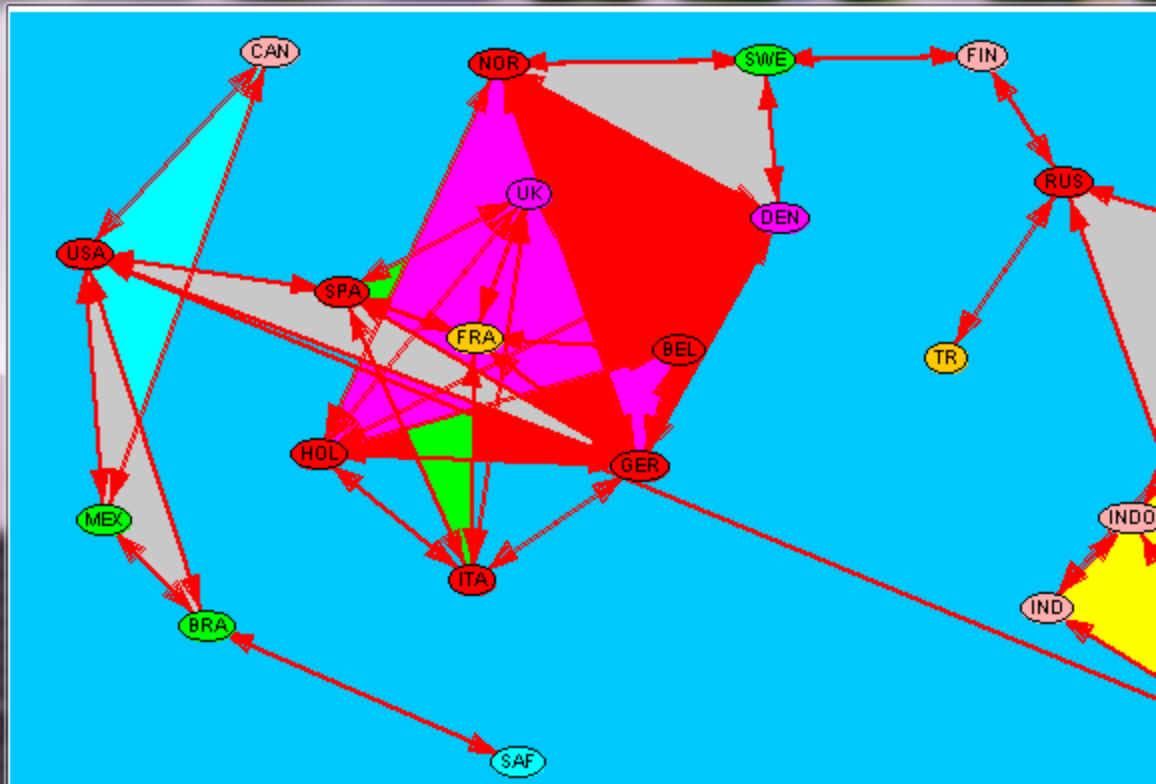
cliq.txt

```
14 Cliques:
NOR DEN GER HOL
UK FRA ITA SPA
JAP CHI IND INDO
NOR GER BEL HOL
USA MEX CAN
RUS JAP CHI
SWE NOR DEN
FIN SWE NOR
USA BRA MEX
USA GER SPA
BRA SAF
FIN RUS
USA CHI
RUS TR
```

Sort | Save | Load | cliq.txt

```
WEvt dump: y=2030 d=1 nam=ITA mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=BRA mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=RUS mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=JAP mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=CHI mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=IND mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=INDO mode=1 type=CHA
WEvt dump: y=2030 d=1 nam=TR mode=1 type=CHANG
WEvt dump: y=2030 d=1 nam=SAF mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=MEX mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=CAN mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=SPA mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=BEL mode=1 type=CHAN
WEvt dump: y=2030 d=1 nam=HOL mode=1 type=CHAN
2030 performance :
FIN 1.449
SWE 0.575
NOR 2.986
DEN 2.017
USA 0.635
UK 0.574
GER 1.135
FRA 0.386
ITA 0.497
BRA 0.222
RUS 0.289
JAP 1.435
CHI 0.544
IND 0.751
INDO 0.865
TR 0.545
SAF 0.418
MEX 1.337
CAN 0.487
SPA 0.399
```

Organisational Forms Simulator



Number of incoming connections:
red>=8 | orange=5 | yellow=2
blue=7 | pink=4 | cyan=1
magenta=6 | green=3 | gray=0

SN | All | reset | Load | x1exp | rev: | flt: | 2 | ALoad | Save | x1exp.sav

Dual | Db | Grp | Dual | Note | Probe | Conf | Stat | Stats | Edit | Delete | Del | Add

ARun | 2030 | 2030 | LAY | Sus | Res | STOP | Speed: | 500 | 10 | Set

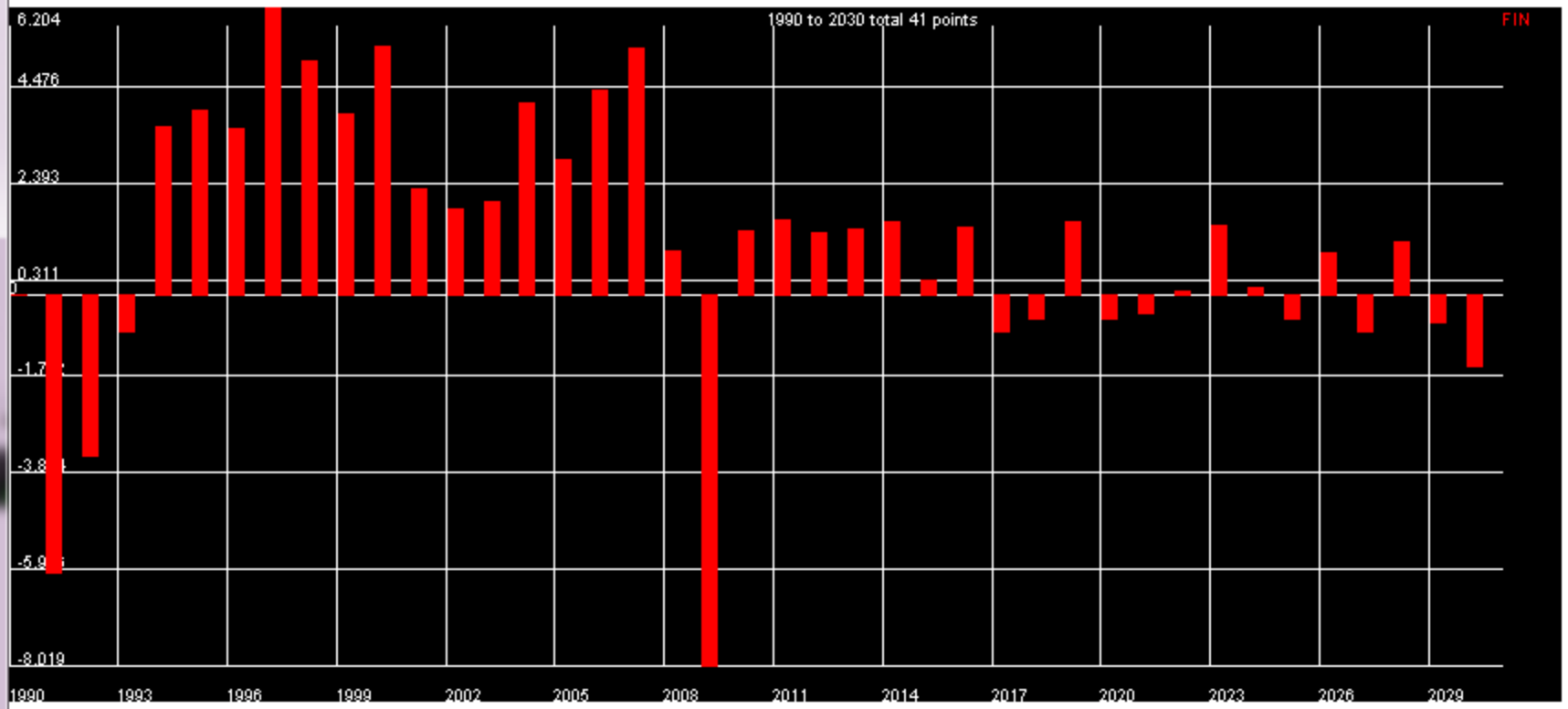
LAYRUN | Scramble | Shake | Jump | Clus | Circ | Dtec | Hier | Grid | 4 | 150 | EPIRUN | All

Font | 9 | Refresh | ABM | WhatIf | Fitness | FindIf | FIN | GDP | Draw | MAP

```
Applying 10 events... Done!
Event data not updated
Applying 462 events... Done!
```

Multi Runs (Imagination?)

- Loop randomly selected N countries GDP all going down 10% at the same time.
- Randomly selecting different N countries every year between 2010 – 2030
- Every run produces different results, enables a search for extreme or unexpected outcomes
- Generate results
  - Difference from the default scenario
  - Display GDP, growth rates, etc
- Analyse results



GDP -10.0 (repeated)

Save Load

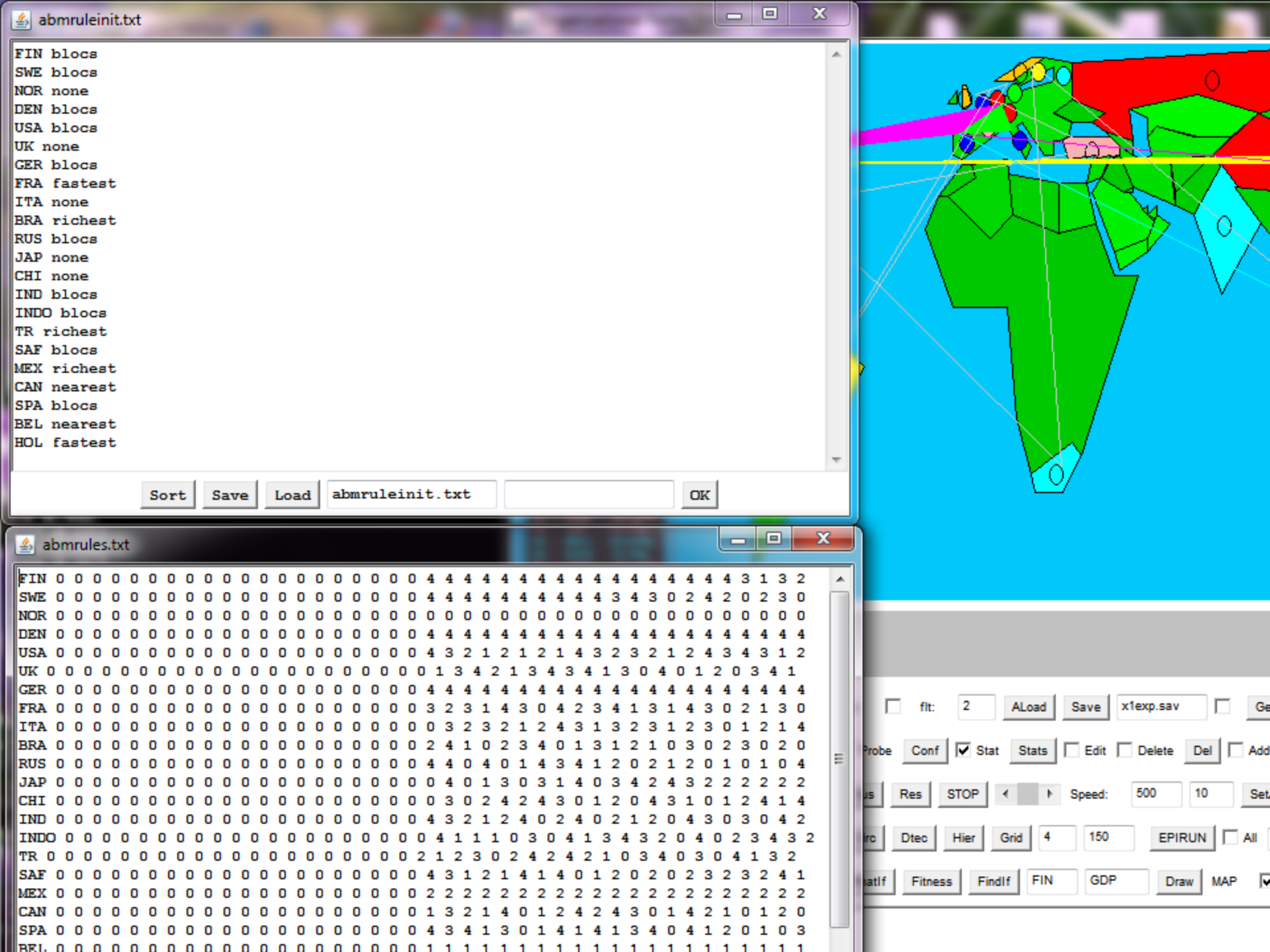
1995

Text Data | Animate | Play | 600 | Pause | STEP | Resume | Stop | growth | size: | growth | Col | bg | bar | y0 | rawdata

Jump | Clus | Circ | Dtec | Hier | Grid | 4 | 150 | EPIRUN | All | Rule0 | Srt | Forget | Reset | RandState | 5

BM | WhatIf | Fitness | FindIf | FIN | MAP | Draw | GR: | GDP: | CMP: | Cliq | ShowCliq: | Loop | 3

Loop


abmruleinit.txt
FIN blocs
SWE blocs
NOR none
DEN blocs
USA blocs
UK none
GER blocs
FRA fastest
ITA none
BRA richest
RUS blocs
JAP none
CHI none
IND blocs
INDO blocs
TR richest
SAF blocs
MEX richest
CAN nearest
SPA blocs
BEL nearest
HOL fastest
Sort
Save
Load
abmruleinit.txt
OK
abmrules.txt
FIN 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 3 1 3 2
SWE 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 4 4 4 4 4 4 4 4 4 4 4 3 4 3 0 2 4 2 0 2 3 0
NOR 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
DEN 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
USA 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 3 2 1 2 1 2 1 4 3 2 3 2 1 2 4 3 4 3 1 2
UK 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 3 4 2 1 3 4 3 4 1 3 0 4 0 1 2 0 3 4 1
GER 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
FRA 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3 2 3 1 4 3 0 4 2 3 4 1 3 1 4 3 0 2 1 3 0
ITA 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3 2 3 2 1 2 4 3 1 3 2 3 1 2 3 0 1 2 1 4
BRA 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 4 1 0 2 3 4 0 1 3 1 2 1 0 3 0 2 3 0 2 0
RUS 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 4 0 4 0 1 4 3 4 1 2 0 2 1 2 0 1 0 1 0 4
JAP 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 0 1 3 0 3 1 4 0 3 4 2 4 3 2 2 2 2 2 2 2
CHI 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3 0 2 4 2 4 3 0 1 2 0 4 3 1 0 1 2 4 1 4
IND 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 3 2 1 2 4 0 2 4 0 2 1 2 0 4 3 0 3 0 4 2
INDO 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 1 1 1 0 3 0 4 1 3 4 3 2 0 4 0 2 3 4 3 2
TR 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 1 2 3 0 2 4 2 4 2 1 0 3 4 0 3 0 4 1 3 2
SAF 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 3 1 2 1 4 1 4 0 1 2 0 2 0 2 3 2 3 2 4 1
MEX 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
CAN 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 3 2 1 4 0 1 2 4 2 4 3 0 1 4 2 1 0 1 2 0
SPA 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 3 4 1 3 0 1 4 1 4 1 3 4 0 4 1 2 0 1 0 3
flt:
2
ALoad
Save
x1exp.sav
Probe
Conf
Stat
Stats
Edit
Delete
Del
Res
STOP
Speed:
500
10
Dtec
Hier
Grid
4
150
EPIRUN
All
Fitness
FindIf
FIN
GDP
Draw
MAP

Phase 1 - Summary

- Scenario-driven tool to test user defined what if scenarios
- ABM functionality to test trading strategies for each country
- Complexity of global events and agent strategies
- To understand:
  - Economic Interdependencies
  - Contagion of crises
  - Success scenarios
- Cluster and group scenarios from a country's perspective, winning/losing scenarios

Areas of Contention

Global Economy
- trade and exchange rates
- holding of US Treasuries
- demand for energy

Geopolitical Issues and Global Security
- narrowing competitive power gap
- Taiwan
- future of North Korea
- competition for key resource regions

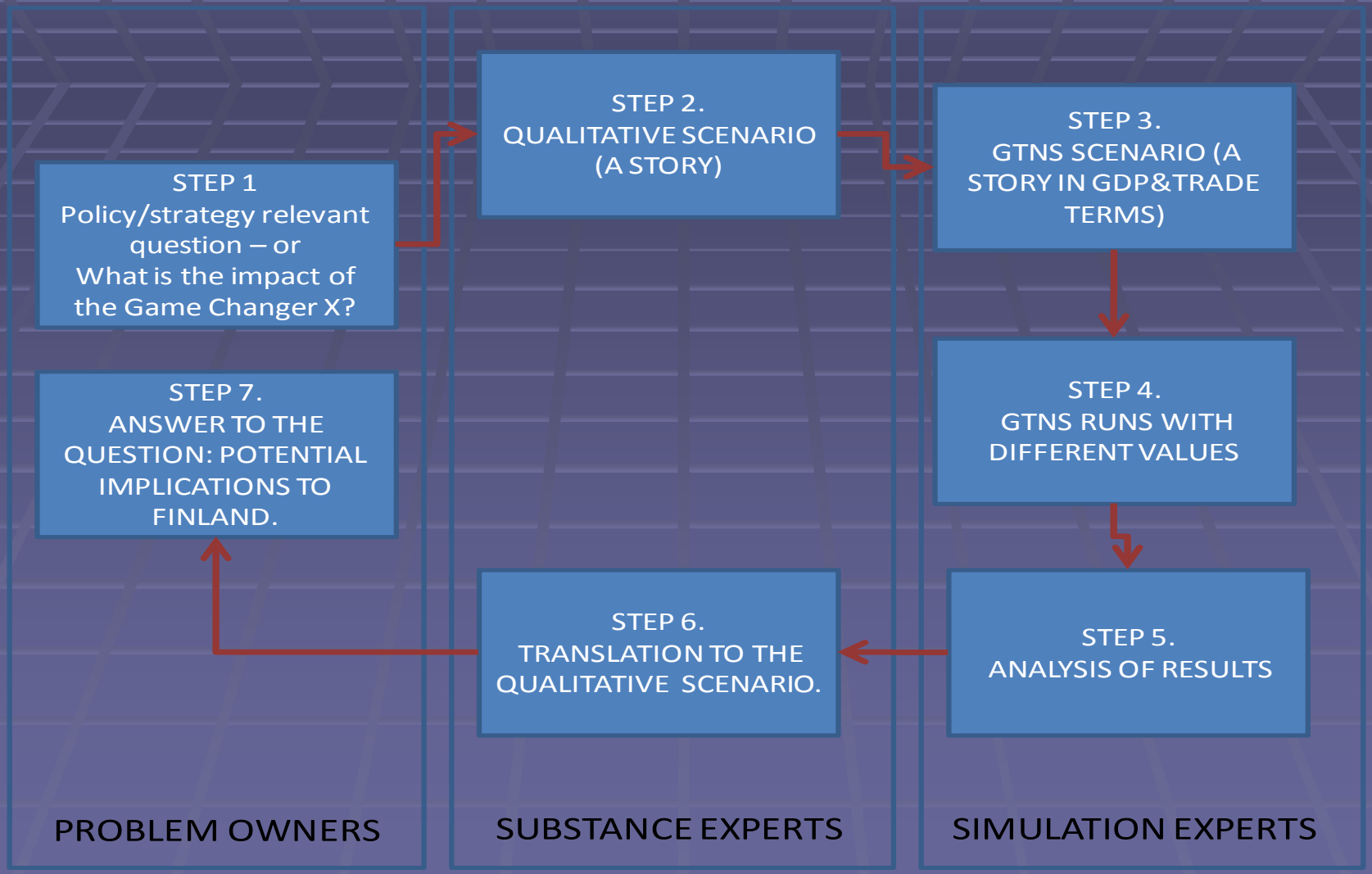
Ideological and Philosophical Issues
- democracy
- human rights
- religious freedom

Scenario Examples

The US is still the world's sole superpower, while China is rapidly emerging as one and is the only country that can realistically challenge the US for global dominance.

Meanwhile, their economic ties are now so important that China and the US have since 2007 been described as 'Chimerica' - two sides of a single economy that comprises a third of global GDP. Therefore, any deterioration in this relationship would be detrimental for global political, economic, and financial stability.

What if Scenario Process (Leena Ilmola)



China Scenarios

- 1. China challenges US dominance
  - 1.a China increasingly assertive in all domains ("hard" path)
    - *Wildest card: Military confrontation between China and US*
  - 1. b China assertive but more subtly ("soft" path)

Scenarios 1.a 1.b

- Scenario 1.a

Between 2010 and 2015 China increases trade in Asia, then 2015 to 2030 Asia turns back to USA

2010	5	CHI	EXPORT	10	IND
2010	5	CHI	EXPORT	10	INDO
2010	5	CHI	EXPORT	10	JAP
2010	5	CHI	GDPD	12	gdpevent
2015	10	CHI	EXPORT	-30	IND
2015	10	CHI	EXPORT	-30	INDO
2015	10	CHI	EXPORT	-30	JAP
2015	10	USA	EXPORT	30	JAP
2015	10	USA	EXPORT	30	IND
2015	10	USA	EXPORT	30	INDO
2015	15	CHI	GDPD	5	gdpevent

- Scenario 1.b

Between 2010 and 2020 China increases exports to Asia slowly

2010	10	CHI	EXPORT	5	JAP
2010	10	CHI	EXPORT	5	IND
2010	10	CHI	EXPORT	5	INDO
2010	10	CHI	GDP	1	gdpevent

loopevt.txt

2010	1	CHI	CHANGE	10.0
2010	1	CHI	CHANGE	10.0
2010	1	CHI	CHANGE	10.0
2010	1	CHI	GDP	1.23
2011	1	CHI	CHANGE	10.0
2011	1	CHI	CHANGE	10.0
2011	1	CHI	GDP	1.23
2011	1	CHI	CHANGE	10.0
2012	1	CHI	CHANGE	10.0
2012	1	CHI	CHANGE	10.0
2012	1	CHI	GDP	1.23
2012	1	CHI	CHANGE	10.0
2013	1	CHI	CHANGE	10.0
2013	1	CHI	CHANGE	10.0
2013	1	CHI	GDP	1.23
2013	1	CHI	CHANGE	10.0

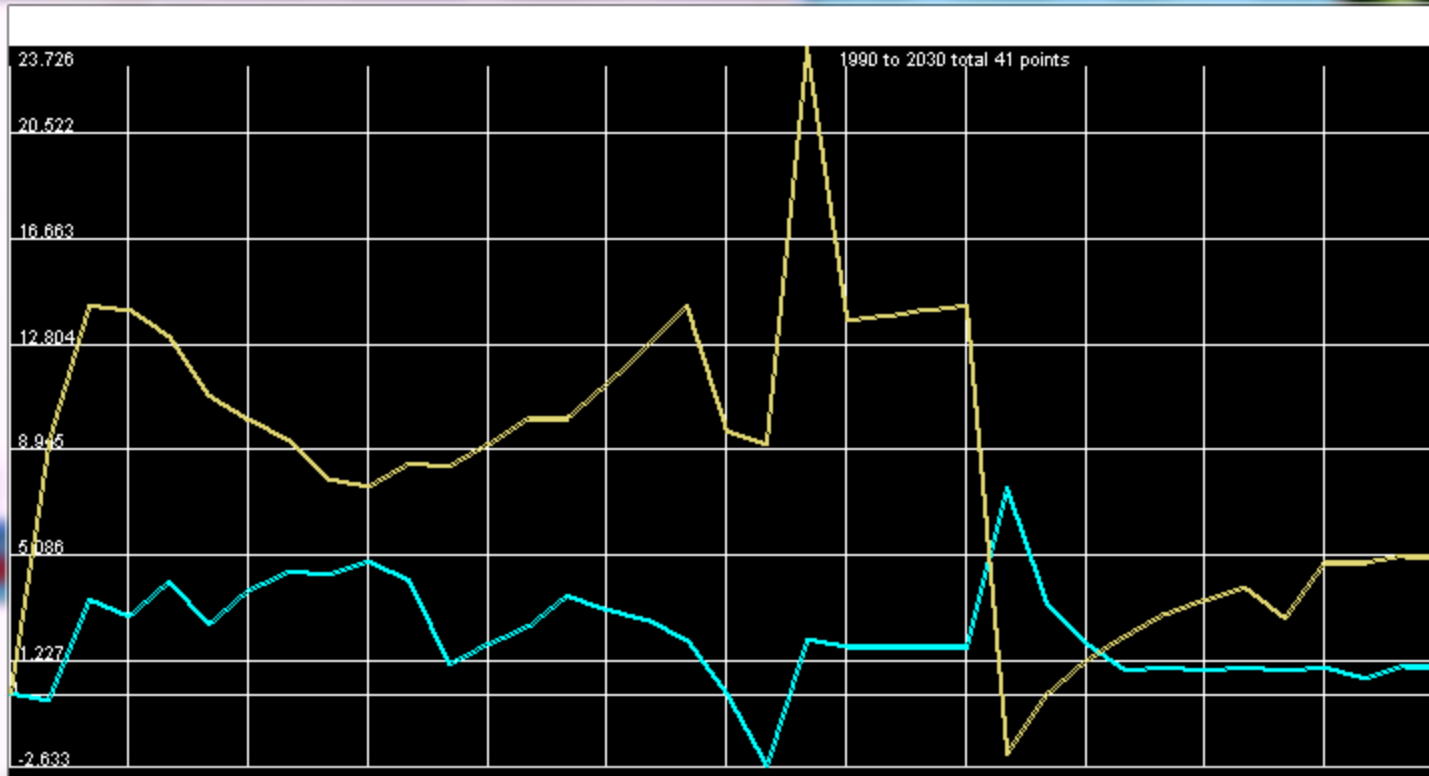
Sort Save Load

performance.txt

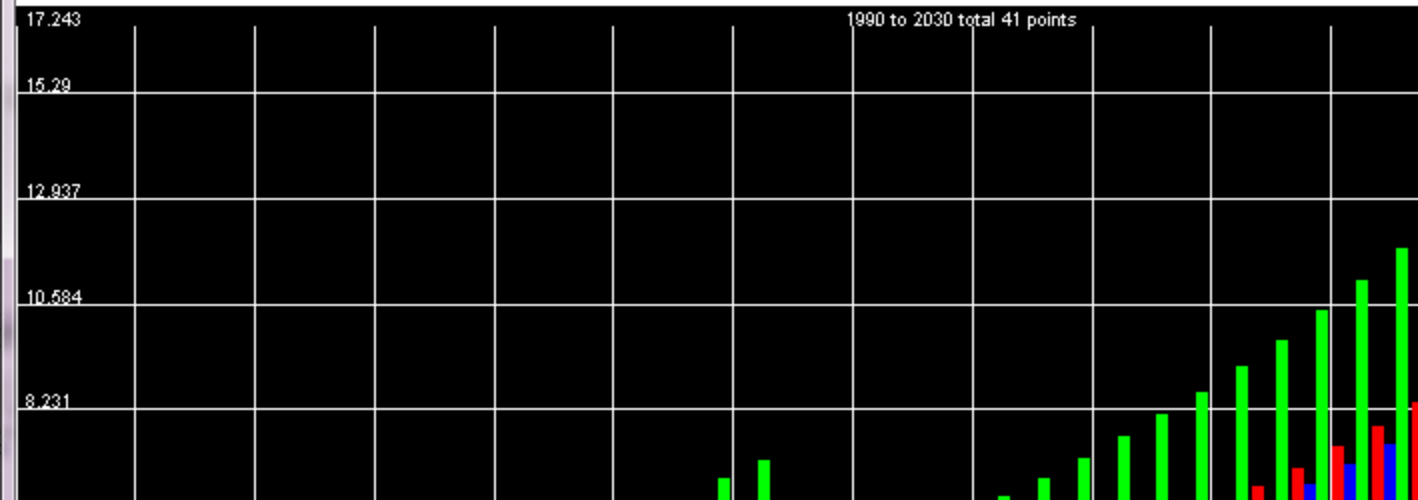
```
IND 0.084
HOL 0.0
SPA -0.0010
TR -0.0020
BEL -0.0020
DEN -0.0020
FRA -0.0020
ITA -0.0020
NOR -0.0020
SWE -0.0020
FIN -0.0050
USA -0.0080
UK -0.02
GER -0.03
RUS -0.057
MEX -0.064
```

Sort Save Load

Graph Frame5



GFrame 4



LAYRUN Scramble Shake Jump Clus

Refresh 5.0 8 ABM WhatIf

Event data updated
Applying 114 events... Done!
Applying 84 events... Done!

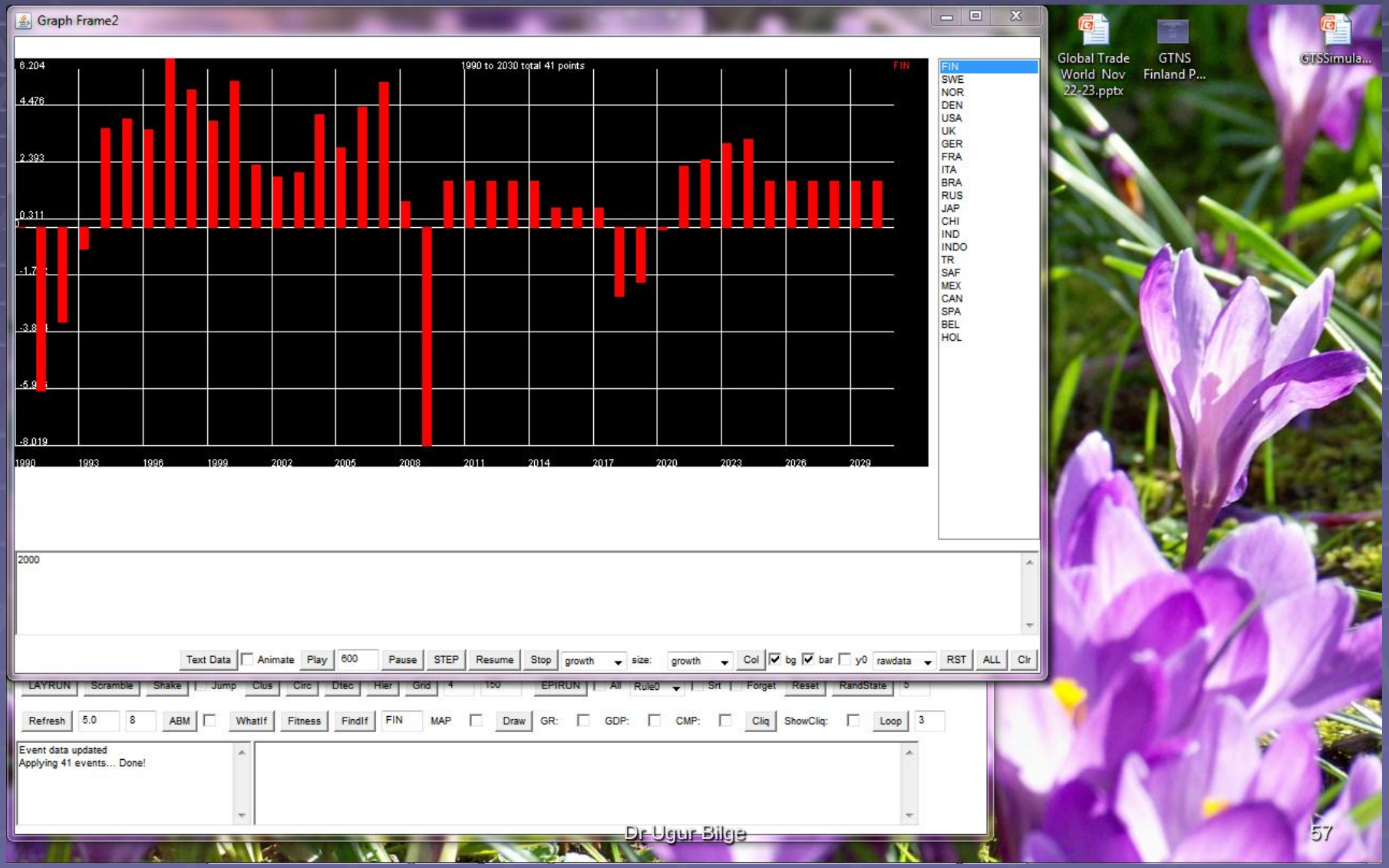
Scenario 2

- China weakens, while US resurges, increasingly slower Chinese growth, while US regains confidence and influence

- Between 2010 and 2020 China shrinks by 3% while USA grows by 1%, then after 2020 China shrinks by 5% for 10 years

2010	10	CHI	GDP	-3	gdpevent
2010	10	USA	GDP	1	gdpevent
2020	10	CHI	CURR	-5	gdpevent

FIN Growth Rate fluctuates



The “unexpected” Sectors and Exports

- Assumptions: Exports sector breakdown stays static, and change in exports will impact on sector growth.
- We have data for 42 different sectors and they are given with a text file:

	sec1	sec2	sec3	sec...
GER	10%	20%	30%	5% ...
USA	40%	20%	30%	0% ...
UK	10%	20	40%	0 %...

- Simulate the impact of global trade scenarios on specific sectors

Sector List

1 pdr	paddy rice
2 wht	wheat
3 gro	cereal grains nec
4 v_f	vegetables, fruit, nuts
5 osd	oil seeds
6 c_b	sugar cane, sugar beet
7 pfb	plant-based fibers
8 ocr	crops nec
9 ctl	bovine cattle, sheep and goats, horses
10 oap	animal products nec
11 rmk	raw milk
12 wol	wool, silk-worm cocoons
13 for	forestry
14 fsh	fishing
15 col	coal
16 oil	oil
17 gas	gas
18 omn	minerals nec
19 cmt	bovine cattle, sheep and goat meat products
20 omt	meat products
21 vol	vegetable oils and fats
22 mil	dairy products
23 pcr	processed rice
24 sgr	sugar
25 ofd	food products nec
26 b_t	beverages and tobacco products
27 tex	textiles
28 wap	wearing apparel
29 lea	leather products
30 lum	wood products
31 ppp	paper products, publishing
32 p_c	petroleum, coal products
33 crp	chemical, rubber, plastic products
34 nmm	mineral products nec
35 i_s	ferrous metals
36 nfm	metals nec
37 fmp	metal products
38 mvh	motor vehicles and parts
39 otn	transport equipment nec
40 ele	electronic equipment
41 ome	machinery and equipment nec
42 omf	manufactures nec

Expected Sector Exports
(top sectors in 2030 default or baseline scenario)

Sector	Billion USD in 2030
31ppp	29.462583
41ome	28.036383
40ele	24.054416
33crp	15.647307
35is	13.912657
32pc	10.363702
36nfm	8.404746
38mvh	8.001278
30lum	6.83153
37fmp	3.282103
39otn	2.419151
34nmm	1.841485

Sector	Billion USD in 2030
27tex	0.899825
22mil	0.710027
25ofd	0.552375
10oap	0.537957
28wap	0.502739
42omf	0.250542
18omn	0.22667
21vol	0.223833
13for	0.219815
20omt	0.174198
26bt	0.174198
29lea	0.108726

European Scenario

In 2015 Russia's GDP will go down 10% per year for 5 years.

In 2018 Germany and UK will also go down by 5% from their default growth rate for 3 years.

In 2018 Finland has problems with Russia, and exports to Russia will go down by 20% for 5 years,

In 2020 Exports to Germany go up by 10% a year for 5 years

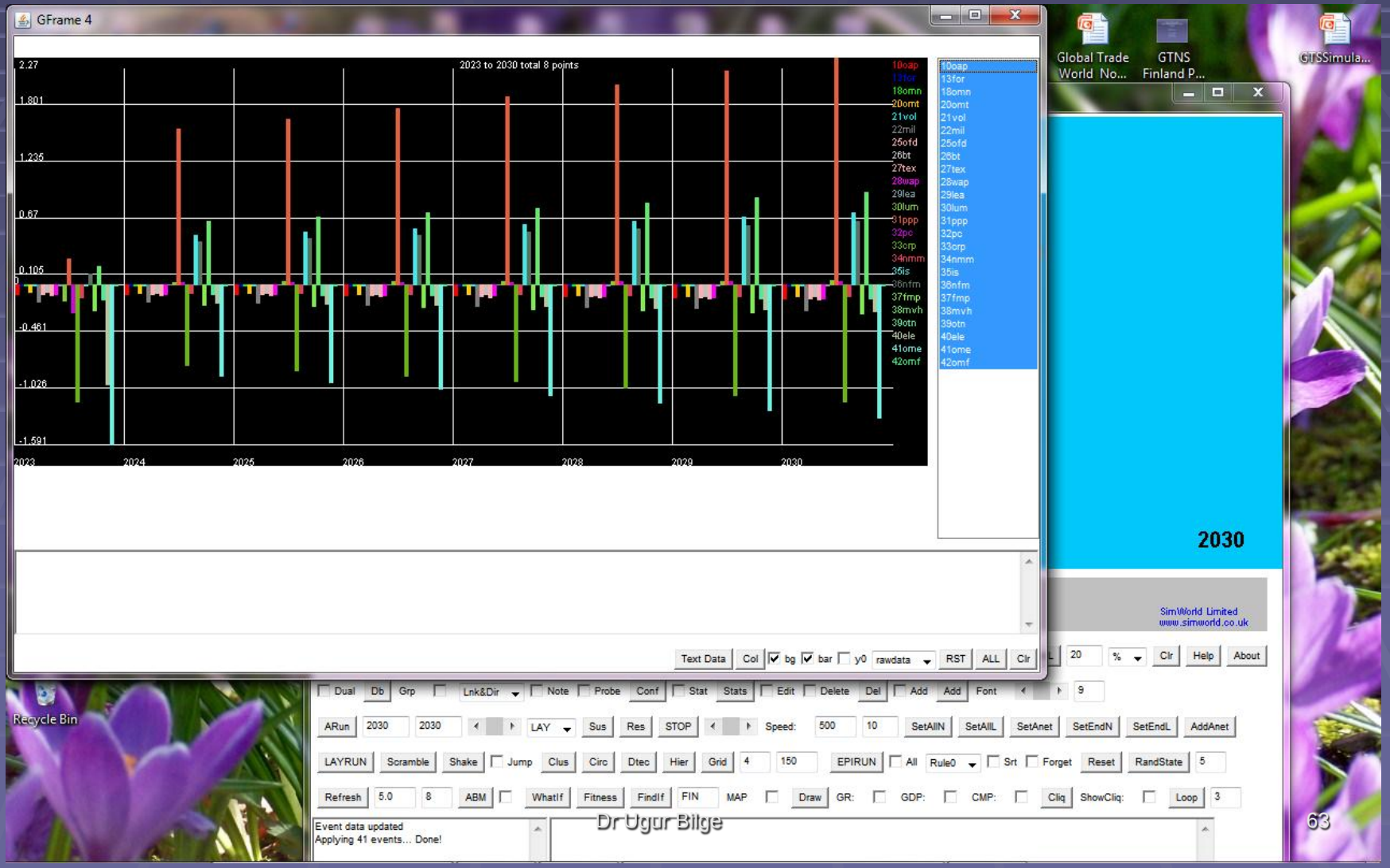
2015	5	RUS	GDP	-10	Internal Problems
2018	3	GER	GDP	-5	Problems
2018	3	UK	GDP	-5	Problems
2018	5	FIN	EXPORT	-20	RUS deepening crisis
2020	5	FIN	EXPORT	10	GER recovery

European Scenario
Sector Performance by 2030
difference between baseline scenario

Sector	(billion USD over performing)
31ppp	2.1361
38mvh	0.8793
35is	0.6953
36nfm	0.5936
30lum	0.0353

Sector	(billion USD underperforming)
20omt	-0.1202
26bt	-0.1202
34nmm	-0.1257
10oap	-0.132
28wap	-0.1327
25ofd	-0.1327
39otn	-0.1516
27tex	-0.1517
22mil	-0.2578
37fmp	-0.3006
40ele	-0.3585
33crp	-1.222
41ome	-1.4335

Sector Performance (European Scenario causes some sectors outperforming while others underperforming)



4 New Scenarios

- We developed 4 new scenarios to highlight what kind of questions we can ask with GTNS to give us insights about Finland's economy and its sector performance by 2030
  - China Germany Scenario

    China's trade is weaker and Germany is stronger
  - BRIC Scenario

    BRIC countries are strong but Europe is weaker
  - China Revaluates Scenario

    China revaluates Yuan
  - Euro Scenario

    What if Euro disintegrates

China Germany Scenario

Between 2015 and 2020

China's trade with the rest of the world goes down by 10% a year.

During this period Germany increases its imports from the Euro zone by 2% a year and increases exports to USA, Japan and UK by 2% a year.

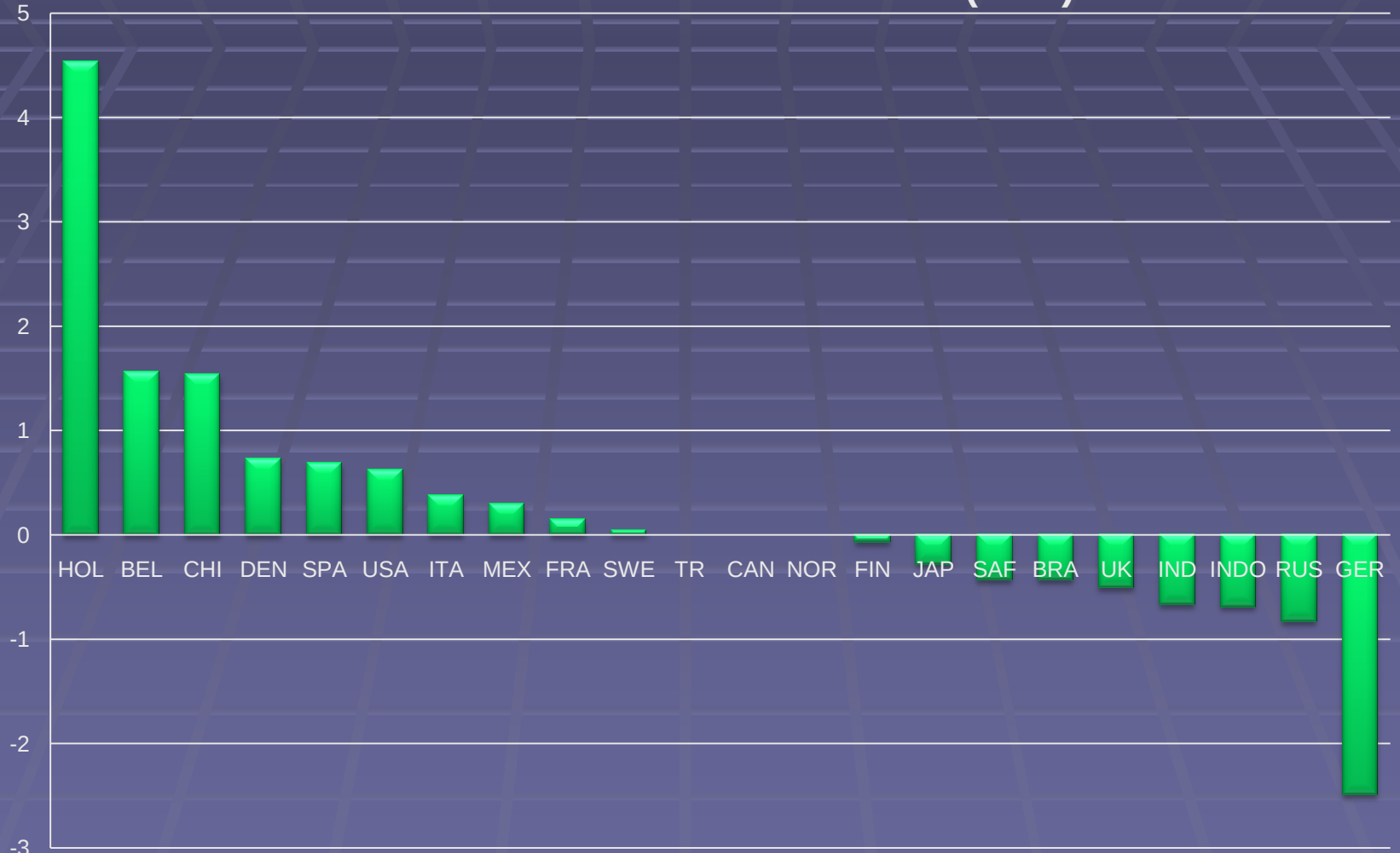
This scenario has a number of unexpected consequences for Finland,

While Finland's growth is affected very little, some sectors do rather well, others do badly.

Growth Rates (%)

#date	FIN	GER	CHI
2010	1.687248	0.505070	10.769666
2011	1.687248	0.505070	10.769666
2012	1.687248	0.505070	10.769666
2013	1.687248	0.505070	10.769666
2014	1.687248	0.505070	10.769666
2015	1.652979	0.093129	11.209699
2016	1.663116	0.058367	11.18451
2017	1.673248	0.007872	11.109166
2018	1.683381	-0.048506	11.046493
2019	1.693564	-0.111496	10.993958
2020	1.687248	0.505070	10.769666

China Germany Scenario - GDP Performance in 2030
difference from baseline scenario (in %)



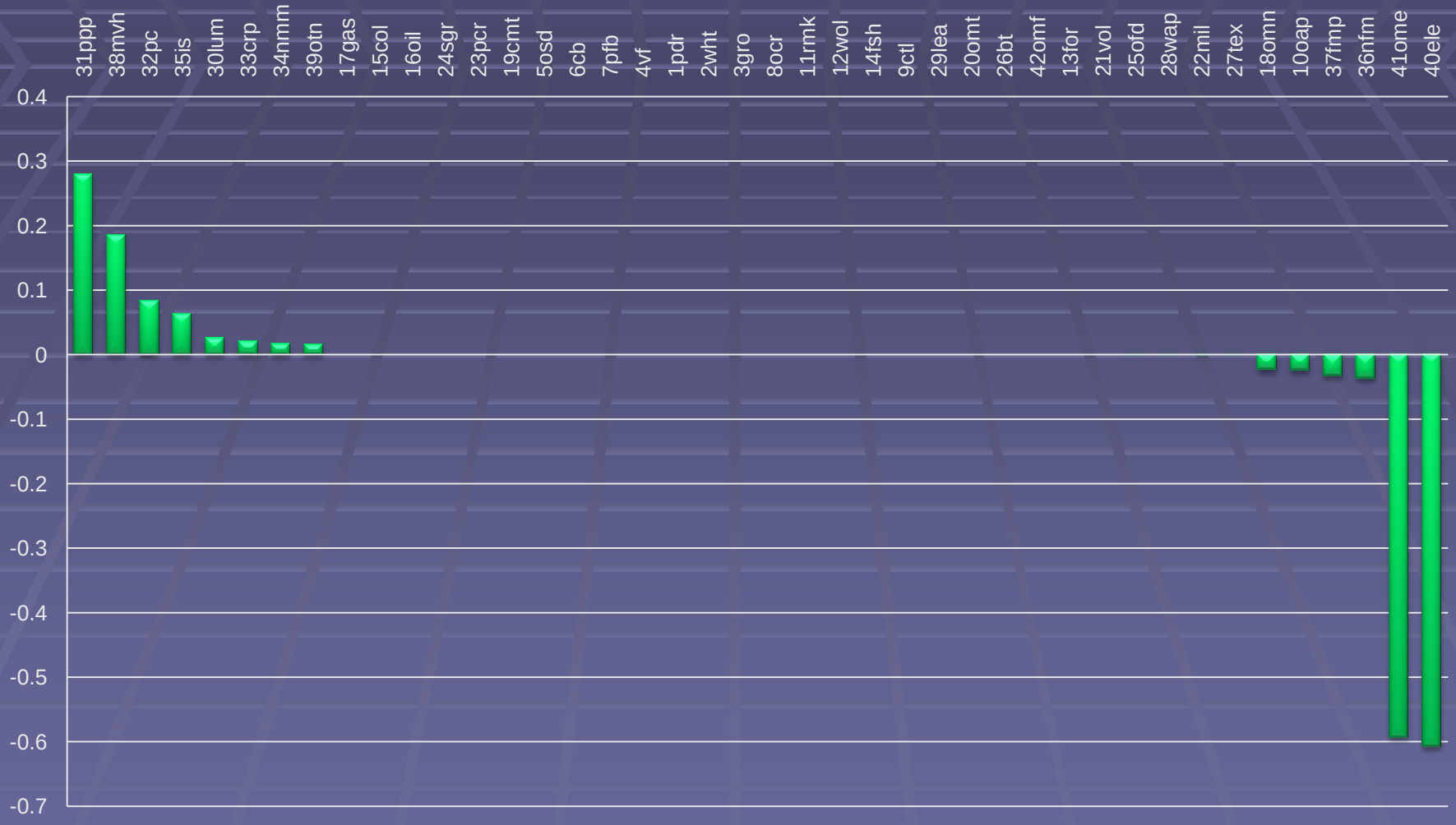
China Germany Scenario Sector Performance by 2030

(difference between baseline scenario)

Sector	(billion USD over performing)
31ppp	0.28
38mvh	0.186
32pc	0.083
35is	0.063
30lum	0.026
33crp	0.02
34nmm	0.017

Sector	(billion USD underperforming)
25ofd	-0.0010
28wap	-0.0010
22mil	-0.0010
27tex	-0.0010
18omn	-0.024
10oap	-0.025
37fmp	-0.033
36nfm	-0.037
41ome	-0.593
40ele	-0.608

China Germany Scenario - Finland Sectors Export Performance in 2030 difference from baseline (bn USD)



China Germany Scenario - Finland Sectors Export Performance between 2010 – 2030 difference from baseline (bn USD)

Future Work

- Include in the Global Trade World Simulator:
  - Investment, Consumption and Government Spending
  - Revenues, Expenditure, Savings, Debt, Deficit
- Household Simulation, using a region of Finland developing an Agent Based Simulation
  - Employment, Savings, Education, Age, Health, Confidence, and Mood
- Link Global Trade World Simulator and Household ABS for policy making

Further Reading

1. Stuart Kauffman, **At home in the Universe**, Penguin Books, 1995
2. Joshua M. Epstein and Robert Axtell, **Growing Artificial Societies – Social Science from the bottom up**, 1996
3. John L. Casti, **Would-be Worlds**, John Wiley & Sons, 1997
4. Albert Laszlo Barabasi, Linked **– The new science of Networks**, Perseus Publishing, 2002
5. Mark Buchanan, **Small World: Uncovering nature's hidden networks**, Weidenfeld & Nicolson, 2002
6. Eve Mitleton-Kelly, **Ten Principles of Complexity & Enabling Infrastructures**, Complex Systems and Evolutionary Perspectives on Organisations: The Application of Complexity Theory to Organisations, Elseiver, 2003