

SIMULATION MODELS FOR ECONOMICS
(Prof. Pietro Terna)

EFFECTS OF IMPORT DUTIES ON
SOUTH AMERICA COFFEE
CONSUMPTION

Simulation project in NetLogo

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INTRODUCTION

In a strongly connected world in which goods and services are exchanged faster and faster and all around the world, consumers may have products coming from every country.

But what happens, from the consumption point of view, if we introduce trade barriers?

The simulation is based on the study of the effect of duties on internal coffee consumption. The aim of the model is to provide the way consumers react when we introduce duties, given their wealth, level of education, economic and political freedom. The introduction of variables regarding economic and political freedom for each country can modify strongly the consumer behavior, having effects on consumption and trade.

Nations that we have selected are:

- Argentina
- Brazil
- Venezuela

The accuracy of the simulation is confirmed by data taken by local institutions, so that the model will respond as much as possible to reality.

THE MODEL

We create a simulation model with three Nations that consume and produce coffee in different proportions and quantities.

For simplicity, we assume that production equates the demand in every instant, so that in the model we can analyse just the demanded quantities. These quantities will be set taking into account real data on production and consumption.

The model is not based on the estimation of individuals' demand but just on the quantity of each good that every individual demands. In order to do that, we assume that the price of each product is the same in the three countries and that the difference in price among the products is included (as information) in the demanded quantities. Also duties will not modify the prices but directly the demanded quantities following a given rule based on the demand elasticity.

1. FRAMEWORK

3 NATIONS: Brazil, Argentina, Venezuela
1 GOODS: coffee

Products are not perfectly homogeneous with respect to the country of origin (consumers have preferences about the origin, so they will consume coffee just from one country, but such preferences vary across the population of the same country).

Consumer individual variables: they influence preferences and then the demand of every good.

- *Economic freedom index* (National variable)
It represents the degree of internal liberalization of different sectors of every country
(index taken from www.heritage.org)
- *Press freedom index* (National variable)
From a survey about direct attacks on journalists and indirect sources of oppression against the free press
(index taken from <http://en.rsf.org>)
- *Political system* (National variable)
Democracy → Dictatorship
- *Wealth*
Different value for each individual, but it depends on the average level and variability of the origin country
- *Education level*
Different value for each individual, but it depends on the average level and variability of the origin country
(correlated with wealth)
- *Tastes*
Assigned randomly through the population of a country while keeping the consumption proportion of each product (with respect to both products and countries) emergin from data

2. SET UP

We create X individuals for each country (where X reflects the cardinality of the population in every country).

We assign to every individual i the following characteristics:

- Nationality (B, A, V) which implies:
 - economic freedom level (Business freedom index: Bra 58 Arg 48 Ven 38)
 - political freedom level (0 if democracy, 1 if dictatorship)
 - press freedom index
- Individual wealth level
(assigned randomly from the CDF of income across population)
- Individual education level
(derived from the average individual expenditure on education as a share of individual income)
- INDIVIDUAL CONSUMPTION
Quantity (and nationality) of coffee

3. TIME LAG RULE

Reaction lag of the consumer to a change in price due to the duty.

Lag: 1 – 2 – 3 – 4

A lag corresponds to a quarter so every cycle corresponds to a year.

- the first three lags are determined by wealth (e.g. the richer a person is, the more she takes to reduce the demand) and education level (the more educated a person is, the more she understands that a duty imposed at $t=0$ means an increase in price during next periods, in a way such that she will reduce the demand earlier)
- Information / public announcement about the duty introduction: if not + 1 lag

4. GO

$t = 0$: new duty

$t = 1, 2, 3, 4$ tick or continuous: reaction to the duties

At the beginning of every cycle (i.e. every 4 ticks) each country has a given probability of introducing a new duty; at the same time the duty can be removed with a given probability.

All these probabilities are fixed with sliders.

Then, if the duty is effectively introduced in a country, individuals react and change their consumption.

EXAMPLE of final reactions

Brazil introduces a duty on coffee import

- individuals who consume Brazilian coffee do not change their consumption (independently from their nationality)
- individuals who consume Venezuelan coffee in Argentina or Venezuela do not change their consumption
- Brazilians who consume Venezuelan coffee reduce their consumption according to the demand elasticity and the duty magnitude after the reaction period (lag).

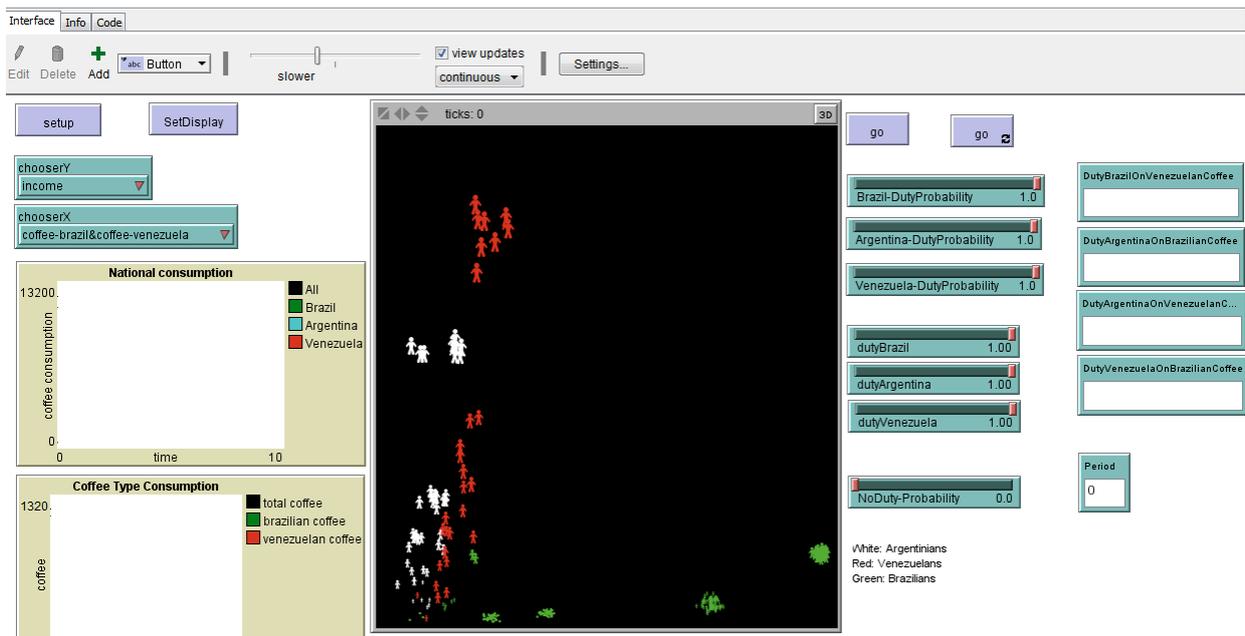
RESULTS

1. REACTION LAG

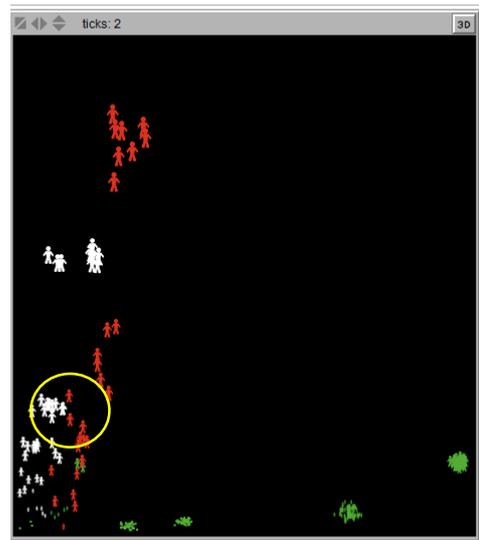
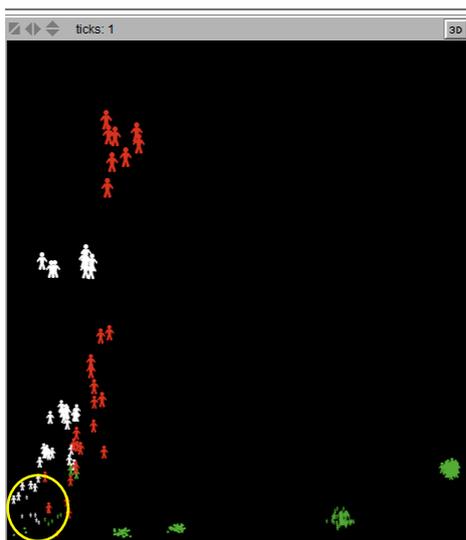
Agents react to the duty introduction with different lags.

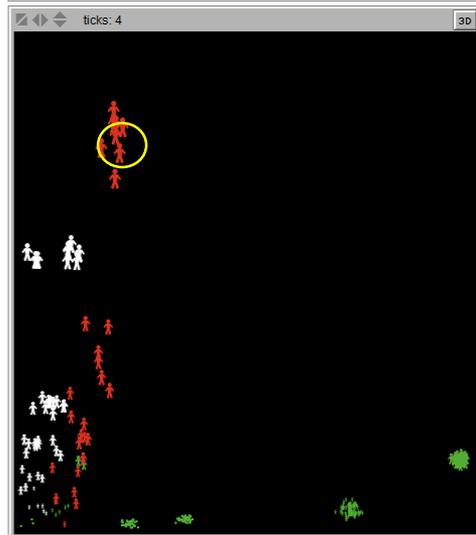
The most influent characteristic is income. Richer people react later to the duty since coffee consumption does not really affect the budget constraint. On the other hand, poorer people react immediately (at the first or second lag).

This is the setup:



In this simulation we set all probabilities at extreme levels in order to stress the income effect. In particular the probability of introducing a new duty is one for every country and the probability of removing it is zero; in this way at each cycle all the three countries introduce a duty with the same magnitude ($=1$) and differences in reaction depend only on income and on the other characteristics of agents.





In some cases we can see agents with roughly the same income reacting with different lags. This is due to the negative effect of education (i.e. more educated people understand the effect of a duty and react earlier) and the effect of government (i.e. in a dictatorship economic policies are announced in a wrong way or with delay and hence people react later to the duty).

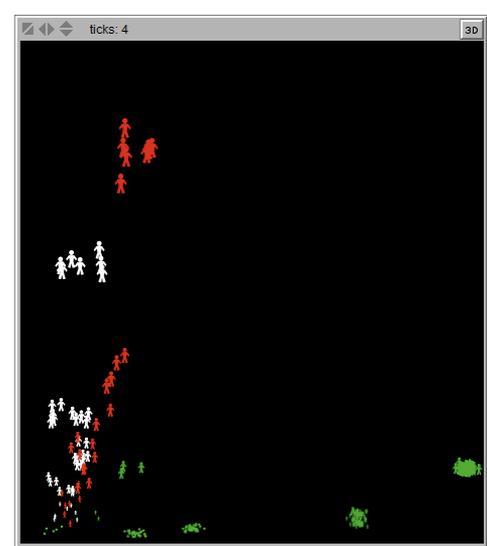
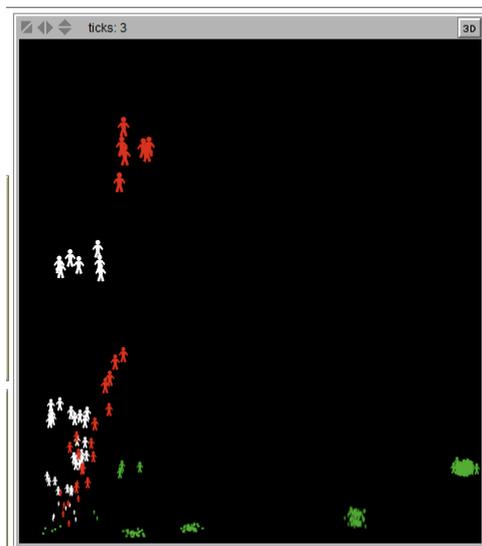
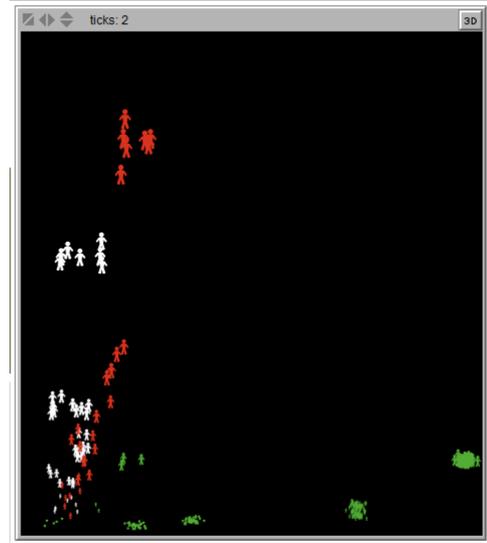
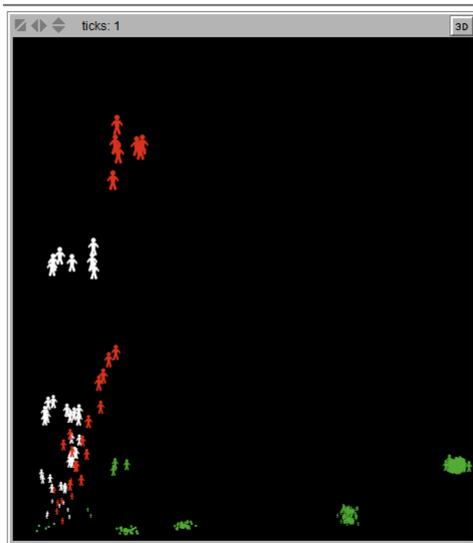
2. DUTY MAGNITUDE

The amount of consumption reduction after the introduction of a duty depends on the magnitude of that duty. We can simulate what happens in three different cases:

- When the duty magnitude is equal to zero

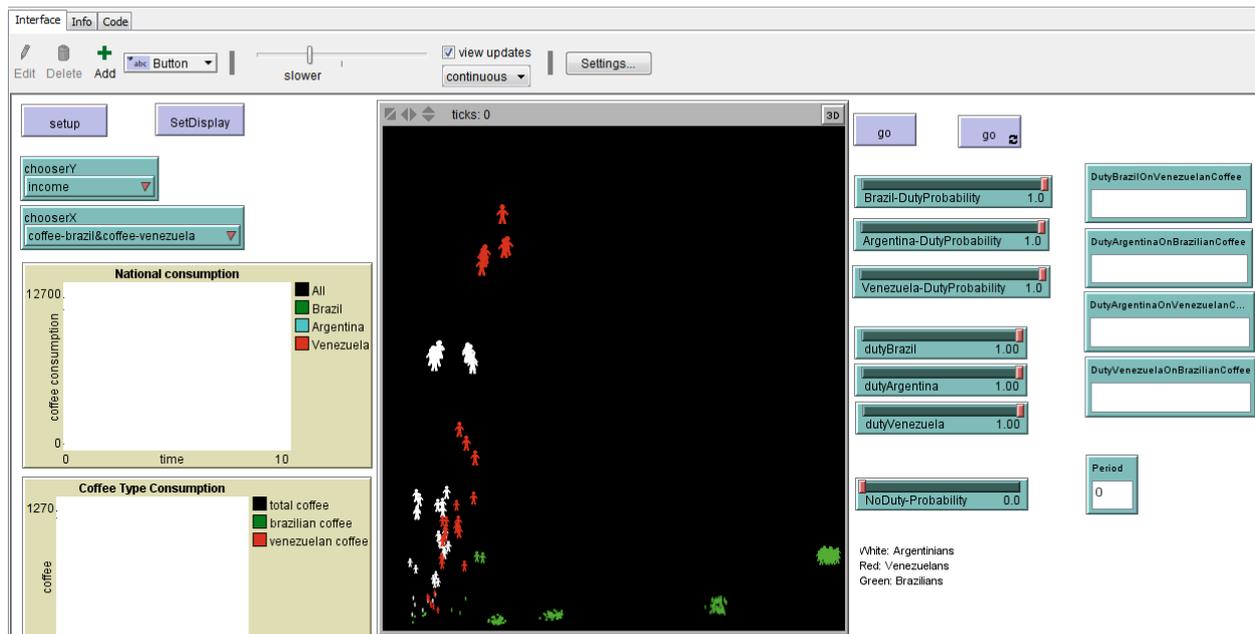
This is the setup:

We expected a zero-reduction in consumption: instead we notice that some agents change a little their consumption; in our model this is due to a shock which can be explained in this way: after the announcement of the introduction of a duty, consumers reduce consumption. It might be the case that the duty is not effectively introduced (magnitude =0) : if so, the reduction is exclusively related to the announcement, creating a small final contraction in the demand.

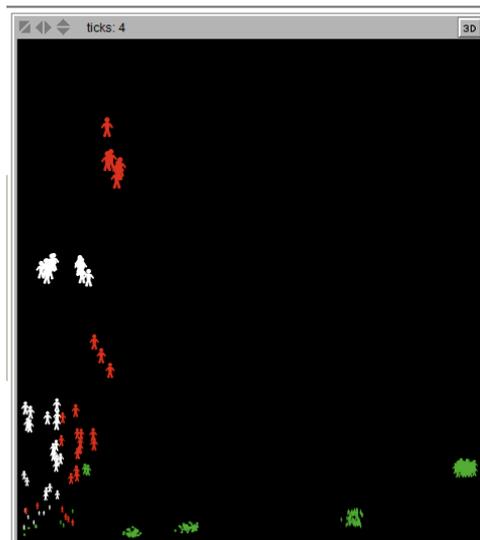
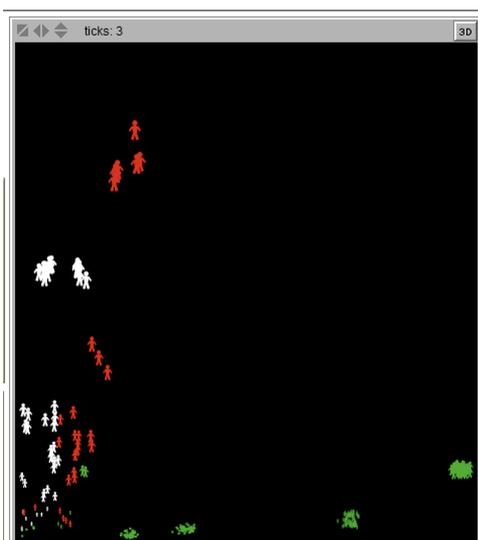
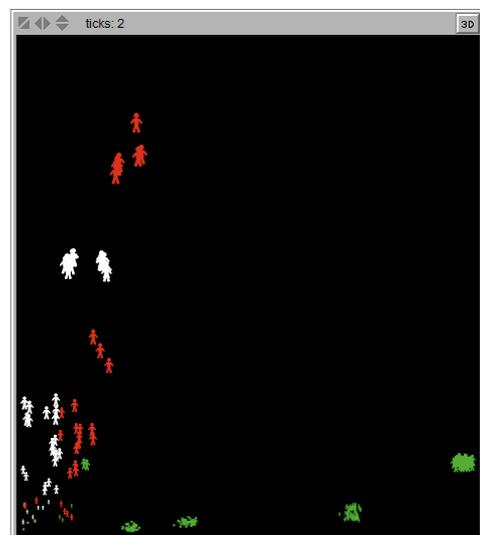
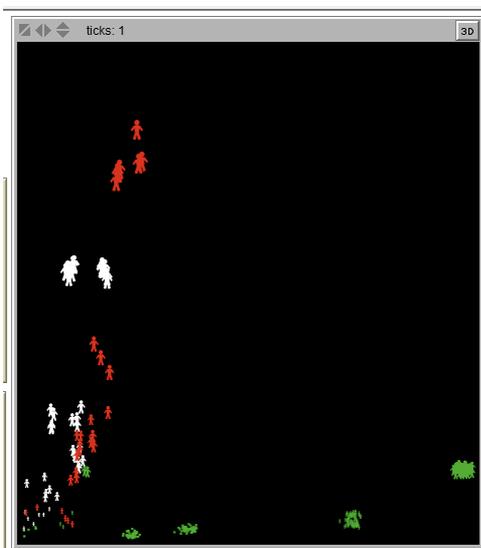


- When duty magnitude is equal to 1

This is the setup:

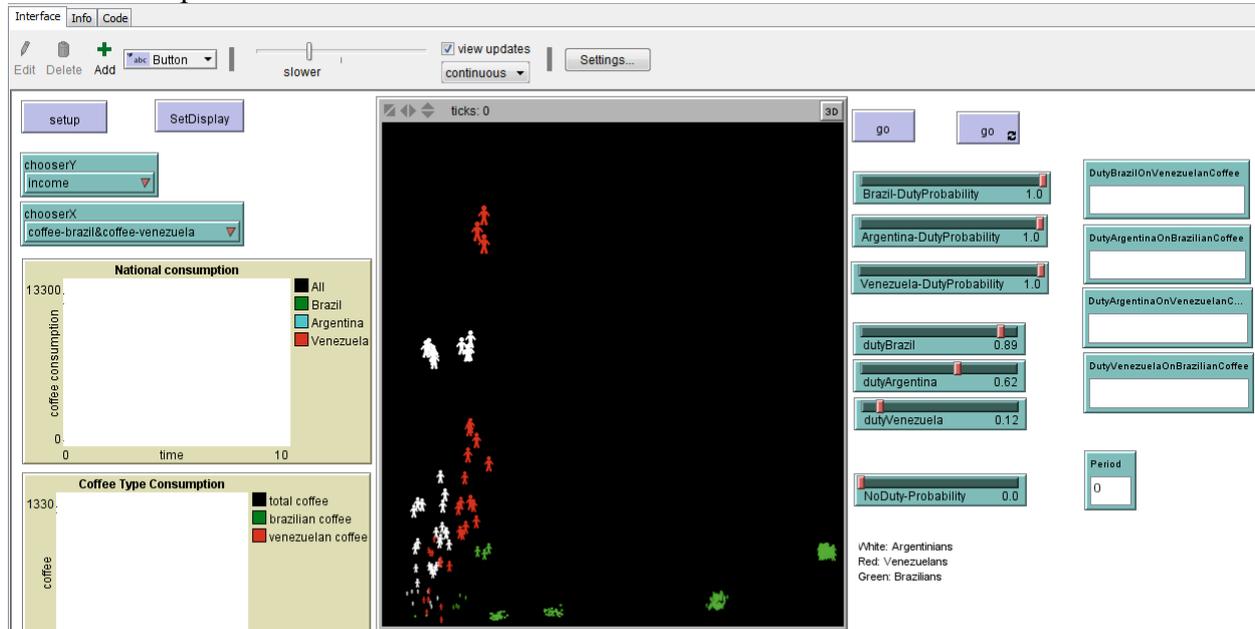


The reduction in consumption is very significant for each agent involved.

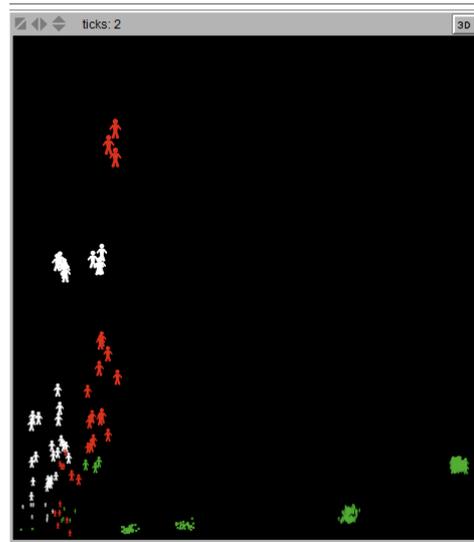
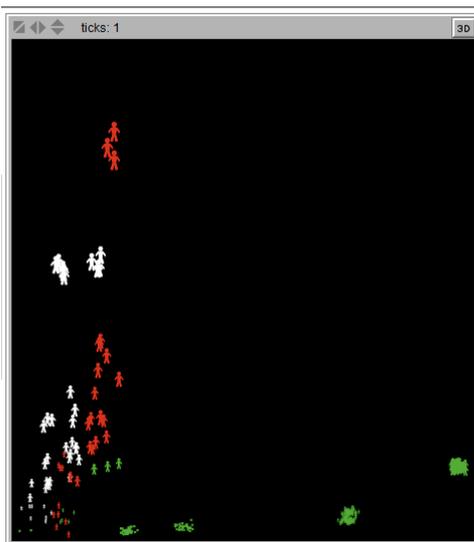


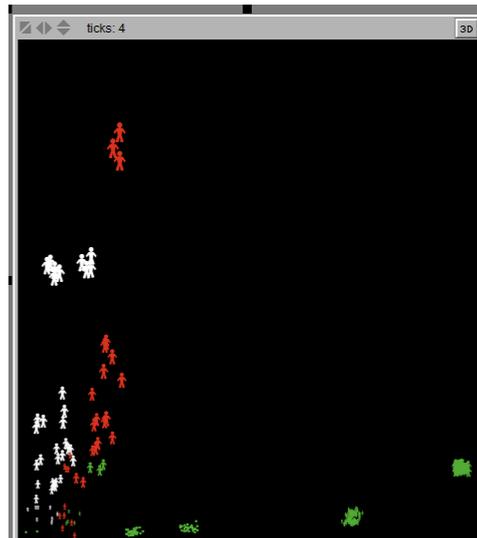
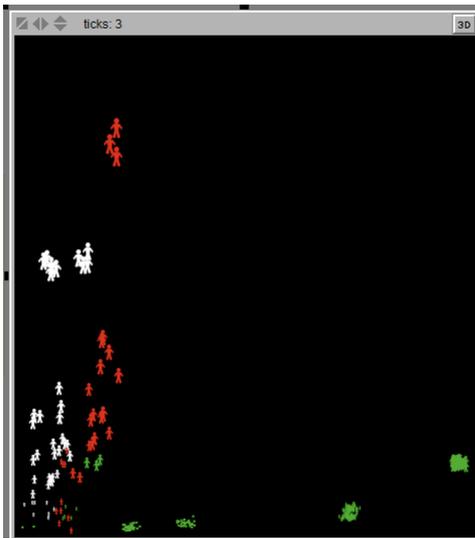
- An intermediate case: duty magnitude of Brazil equal to 0.89, duty magnitude of Argentina equal to 0.62 and duty magnitude of Venezuela equal to 0.12

This is the setup:



The reduction in consumption of Brazilians and Argentinians for which the duty magnitude is relatively high, is greater than the one of Venezuelans for which the duty magnitude is relatively low.





3. NO-DUTY PROBABILITY

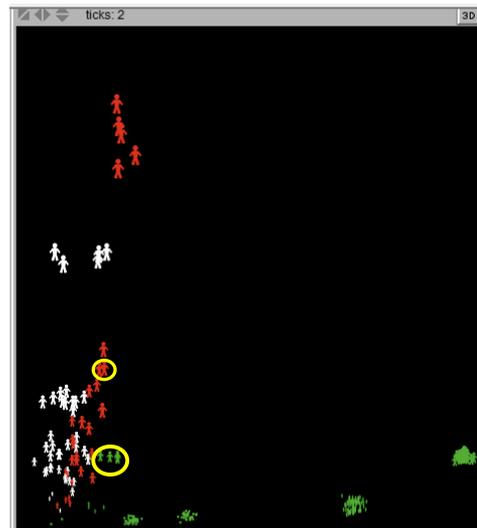
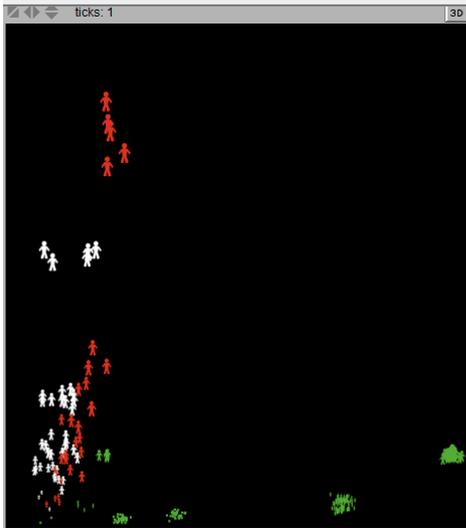
In this simulation we focus on the button “No-duty probability”.

When the slider is set to be equal to one no duty should be introduced in the economy, even if the probabilities of introducing a new duty are positive.

Hence we expect consumers not to change their consumption (i.e. no movement of agents).

This is the setup:

In this setup we set “No-duty probability” equal to one and the probabilities of introducing a new duty equal to 0.5.

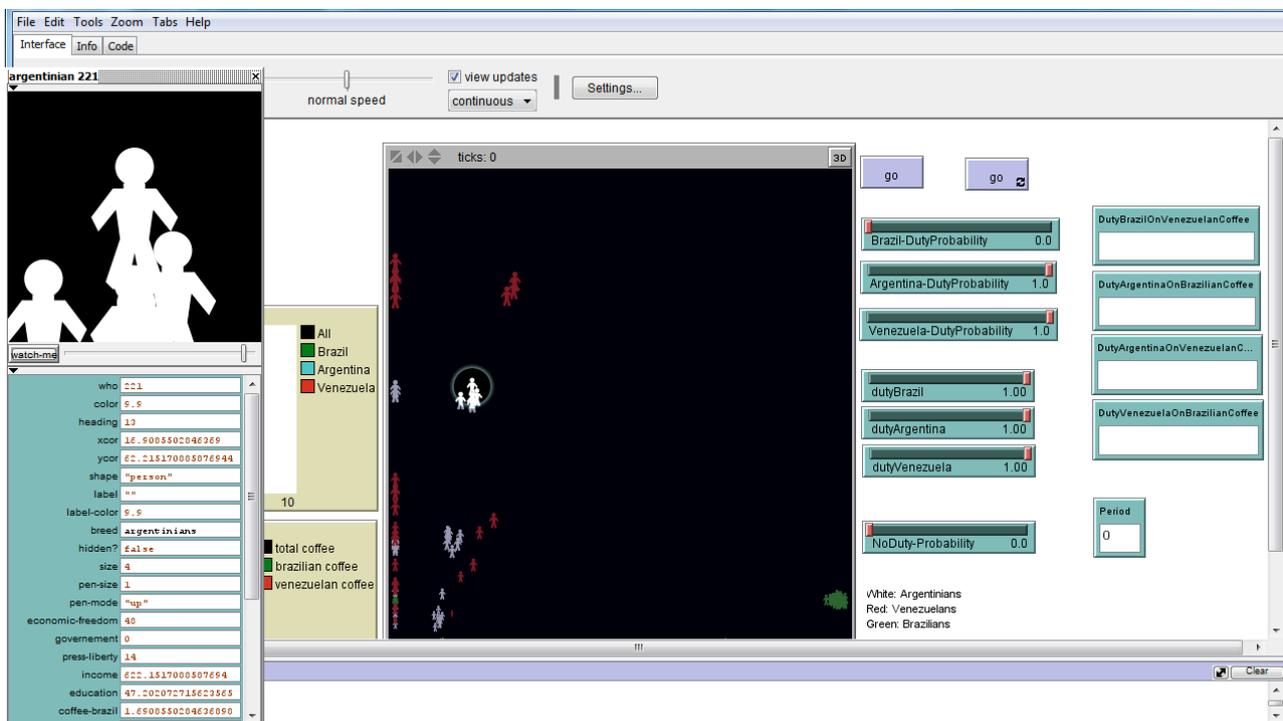
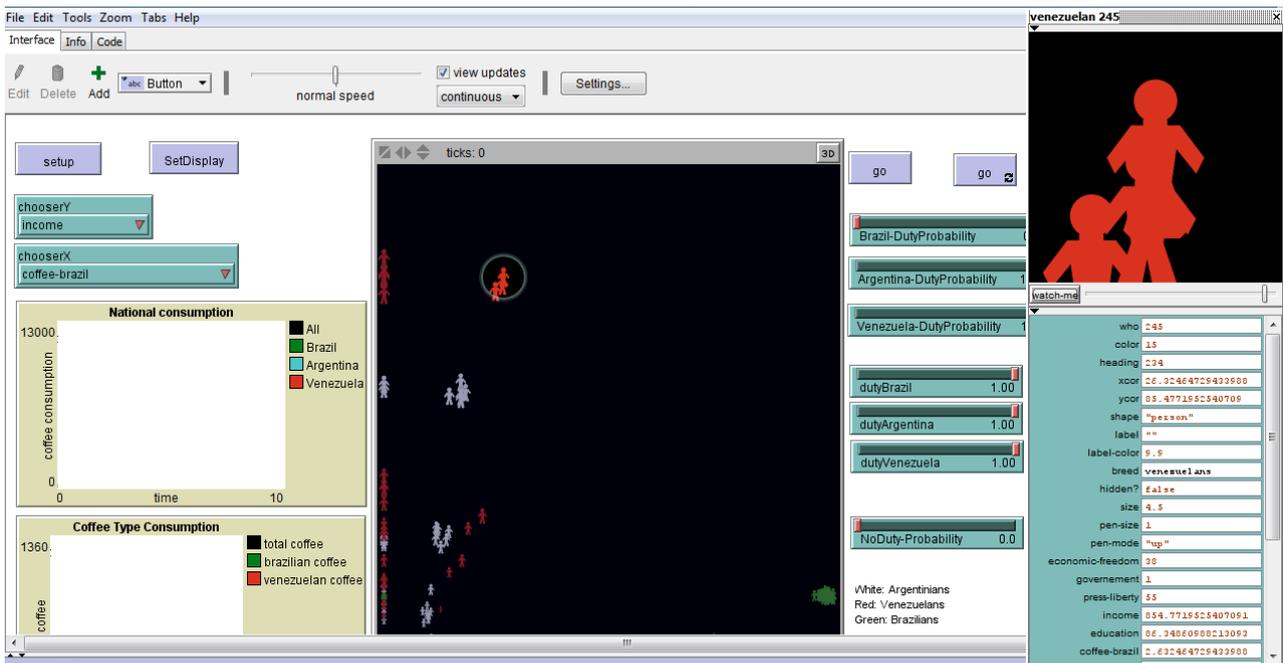


We can see that in ticks two and three (lag 2 and lag 3) some agents change their consumption. A possible explanation could be that agents first perceive the positive probability and thus they expect that the duty will be actually introduced; then they accordingly adapt their consumption. At the beginning of the next cycle they realize that the duty has not been effectively introduced and they return to the initial consumption levels.

4. EDUCATION AND GOVERNMENT EFFECT

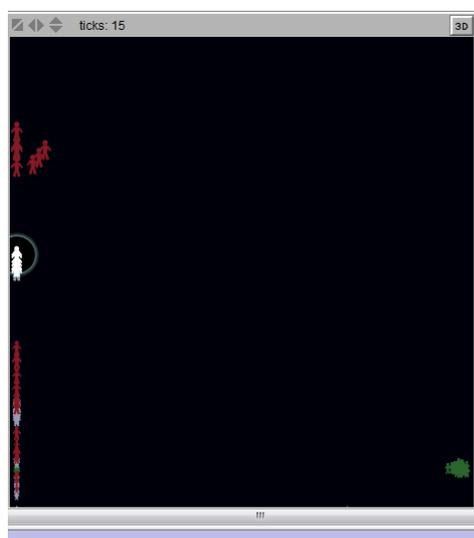
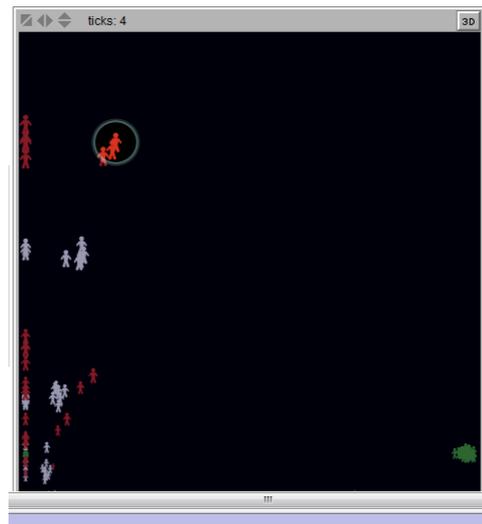
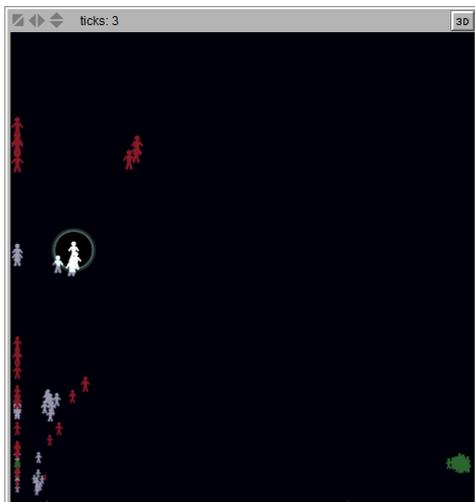
In this simulation we are interested in studying the effect of the variables *education*, *press liberty* and *government* on consumption. For this purpose we considered two individuals: Venezuelan 245 and Argentinian 221. They have the same level of income, in fact they belong to the richest class in their countries, but they are different from the education, press liberty and government point of view. Both of them are subject to duties of the same magnitude.

This is the setup:



We cannot predict the behavior of the two agents because there are opposite effects affecting their behavior. On the one hand Venezuelan 245 is much more educated than Argentinian 221 and this should imply that the Venezuelan changes his consumption faster. Anyway the non democratic Government of Chavez and the low level of press liberty in Venezuela may distort the public information about duties causing delays in changing consumption.

This is the go:



As we can see from the figures the result is that Argentinian 221 reduces his consumption faster than Venezuelan 245. This suggests that the variables *press liberty* and *government* together weight more than the variable *education*.

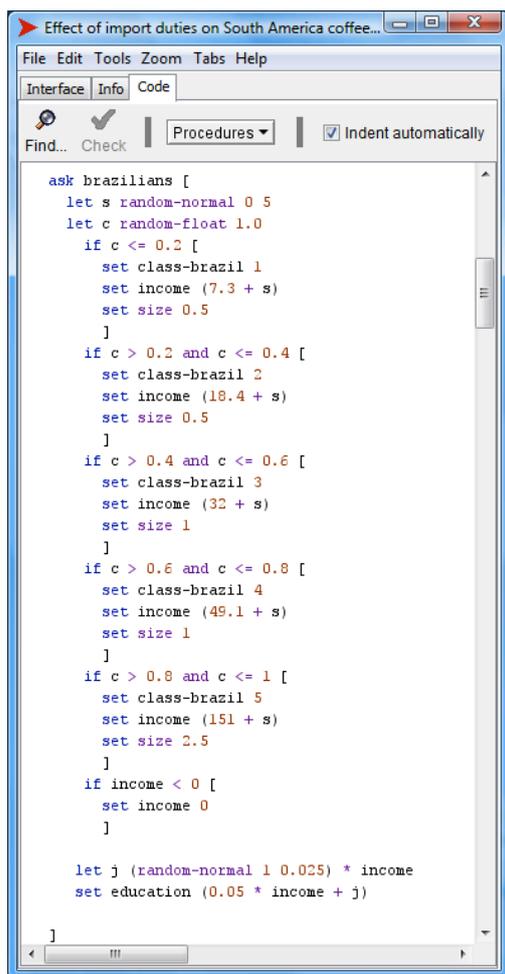
THE CODE

The innovative aspect of our simulation project is the use of real data in the setup. The description and the derivation of individual data can be found in the supporting information section. Here we analyse how we insert them in the code.

1. Income

We assign to each agent one of the five classes and the relative income of her country. How? We generate a random number c in $[0,1]$ for each agent; if this number is between the thresholds the agent is associated to the relative class, where the thresholds are 0.2, 0.4, 0.6, 0.8 (Remember that each class is 20% of the population).

Depending on the class we assign to agents the average individual income of the class plus a noise.



```
ask brazilians [
  let s random-normal 0 5
  let c random-float 1.0
  if c <= 0.2 [
    set class-brazil 1
    set income (7.3 + s)
    set size 0.5
  ]
  if c > 0.2 and c <= 0.4 [
    set class-brazil 2
    set income (18.4 + s)
    set size 0.5
  ]
  if c > 0.4 and c <= 0.6 [
    set class-brazil 3
    set income (32 + s)
    set size 1
  ]
  if c > 0.6 and c <= 0.8 [
    set class-brazil 4
    set income (49.1 + s)
    set size 1
  ]
  if c > 0.8 and c <= 1 [
    set class-brazil 5
    set income (151 + s)
    set size 2.5
  ]
  if income < 0 [
    set income 0
  ]

  let j (random-normal 1 0.025) * income
  set education (0.05 * income + j)
]
```

2. Coffee quantity

We distinguish among every nation people who consume Brazilian coffee or Venezuelan coffee.

```

ask n-of 184 brazilians [
  if class-brazil = 1 [set coffee-brazil 1.2 + (222.44 / 184 + random-normal 0 0.1)]
  if class-brazil = 2 [set coffee-brazil 2.417 + (222.44 / 184 + random-normal 0 0.1)]
  if class-brazil = 3 [set coffee-brazil 6.044 + (222.44 / 184 + random-normal 0 0.1)]
  if class-brazil = 4 [set coffee-brazil 6.044 + (222.44 / 184 + random-normal 0 0.1)]
  if class-brazil = 5 [set coffee-brazil 8.462 + (222.44 / 184 + random-normal 0 0.1)]
]

```

The program identifies randomly the 184 Brazilians who consume Brazilian coffee

```

ask brazilians with [coffee-brazil = 0] [
  if class-brazil = 1 [set coffee-venezuela 0.26 + (2.6 / 10 + random-normal 0 0.1)]
  if class-brazil = 2 [set coffee-venezuela 0.52 + (2.6 / 10 + random-normal 0 0.1)]
  if class-brazil = 3 [set coffee-venezuela 1.3 + (2.6 / 10 + random-normal 0 0.1)]
  if class-brazil = 4 [set coffee-venezuela 1.3 + (2.6 / 10 + random-normal 0 0.1)]
  if class-brazil = 5 [set coffee-venezuela 1.82 + (2.6 / 10 + random-normal 0 0.1)]
]

```

The program identifies the other 10 Brazilians who consume Venezuelan coffee and not Brazilian coffee

if class-brazil = 1 [set coffee-brazil 1.2 + (222.44 / 184 + random-normal 0 0.1)]

The quantity assigned depends partially on the average consumption of the class (which depends on income) and partially on tastes (part of the total consumption is distributed randomly among people with a remainder procedure).

3. Time

```

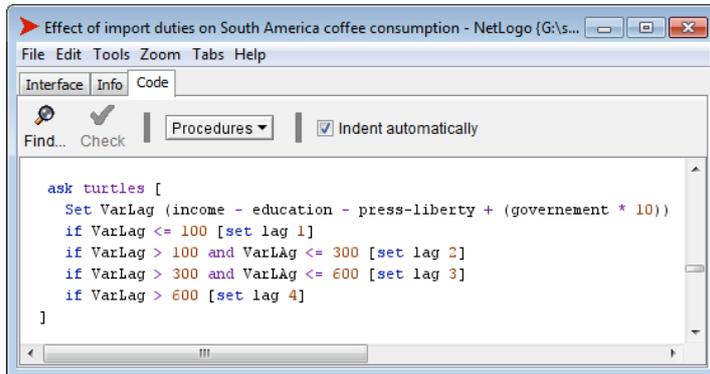
ask turtles [
  if time < 5 [set time (time + 1)]
  if time = 5 [set time 1]
]

```

We link time with ticks making agents count the four periods (lag) of each cycle.

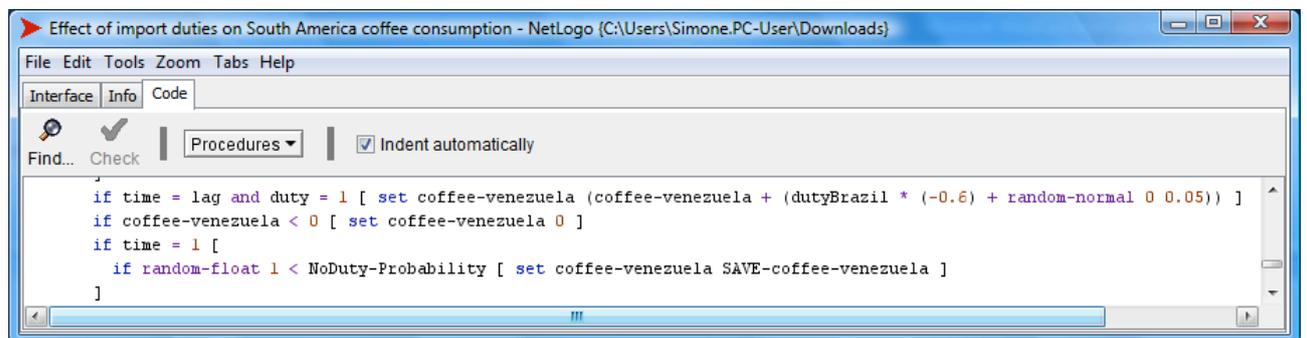
4. Lag

Depending on their personal characteristics, we assign to each agent a lag in reaction to the duty.



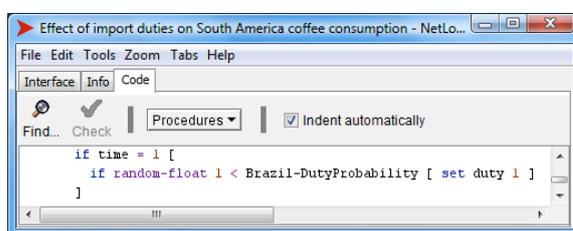
```
ask turtles [  
  set VarLag (income - education - press-liberty + (government * 10))  
  if VarLag <= 100 [set lag 1]  
  if VarLag > 100 and VarLag <= 300 [set lag 2]  
  if VarLag > 300 and VarLag <= 600 [set lag 3]  
  if VarLag > 600 [set lag 4]  
]
```

If the duty has been introduced, each agent reacts after the lags we have calculated for her.



```
if time = lag and duty = 1 [ set coffee-venezuela (coffee-venezuela + (dutyBrazil * (-0.6) + random-normal 0 0.05)) ]  
if coffee-venezuela < 0 [ set coffee-venezuela 0 ]  
if time = 1 [  
  if random-float 1 < NoDuty-Probability [ set coffee-venezuela SAVE-coffee-venezuela ]  
]
```

5. Probability



```
if time = 1 [  
  if random-float 1 < Brazil-DutyProbability [ set duty 1 ]  
]
```

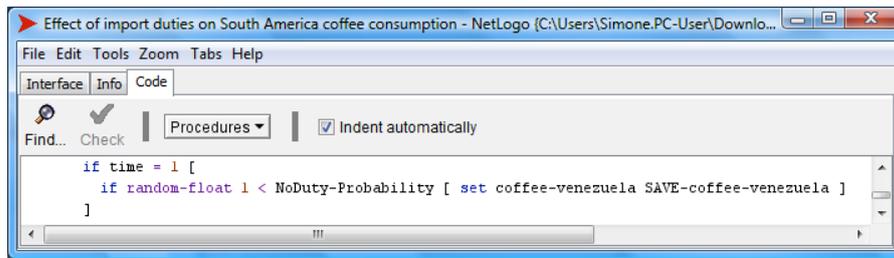
If time = 1 [

the probabilities can be activated only at the beginnings of each cycle

if random-float 1 < Brazil-DutyProbability [set duty 1]

to make the value of the slider a probability of introducing a duty.

Subsequent duties can be introduced in subsequent cycles



If this probability is activated, the duty is removed (no matter if also the previous probability was activated) and the consumption is set at the setup amount.

SUPPORTING INFORMATION

1. INDEXES

Index of economic freedom (www.heritage.org)

The *Index of Economic Freedom* is constructed through the analysis of 10 specific components of economic freedom, which are grouped for ease of reference into four key categories or pillars:

- **Rule of law** (property rights, freedom from corruption);
- **Limited government** (fiscal freedom, government spending);
- **Regulatory efficiency** (business freedom, labor freedom, monetary freedom);
- **Open markets** (trade freedom, investment freedom, financial freedom).

Some of the 10 components are themselves composites of additional quantifiable measures. Each of the 10 economic freedoms is graded on a scale from 0 to 100. The 10 component scores are equally weighted and averaged to get an overall economic freedom score for each economy.

- Brazil (mostly unfree)	57,9
- Argentina (repressed)	48
- Venezuela (repressed)	38,1

Index of press freedom (<http://en.rsf.org>)

The index is based on a questionnaire sent to partner organizations of Reporters Without Borders (14 freedom of expression groups in five continents) and its 130 correspondents around the world, as well as to journalists, researchers, jurists and human rights activists. The survey asks questions about direct attacks on journalists and media as well as other indirect sources of pressure against the free press. Due to the nature of the survey's methodology based on individual perceptions, there can be wide contrasts in a country's ranking from year to year.

- Argentina (48 in the ranking)	14,00
- Brazil (99 in the ranking)	35,00
- Venezuela (120 in the ranking)	55,00

1. DATA

Income (World Bank dataset)

ARGENTINA

Indicator Name		2010		
GNI per capita, PPP (current international \$)		15500		
Population, total		40412376		
GDP (current US\$)		3,6871E+11		
GDP growth (annual %)		9,16091692		
Life expectancy at birth, total (years)		75,6321463		
GINI index		44,49		
				AVG INC
Income share held by lowest 10%		1,46		
Income share held by lowest 20%		4,38		0,534146
Income share held by second 20%		9,31		1,135366
Income share held by third 20%		14,78		1,802439
Income share held by fourth 20%		22,17		2,703659
Income share held by highest 20%		49,36		6,019512
Income share held by highest 10%		32,3		

BRAZIL

Indicator Name		2010	2009		
GNI per capita, PPP (current international \$)		11000	10180		
Population, total		194946470	193246610		
GDP (current US\$)		2,143E+12	1,6217E+12		
			-		
GDP growth (annual %)		7,53361545	0,32824804		
Life expectancy at birth, total (years)		73,0995366	72,7598049		
GINI index			54,69		
					AVG INC
Income share held by lowest 10%			0,77		0,039691
Income share held by lowest 20%			2,85		0,073454
Income share held by second 20%			7,13		0,183763
Income share held by third 20%			12,41		0,319845
Income share held by fourth 20%			19,04		0,490722
Income share held by highest 20%			58,57		1,509536
Income share held by highest 10%			42,93		2,212887

2. PROCEDURES

INCOME: divide the population in 5 classes of income and assign to each individual the average level of income of its class (*100) that can be recovered from data; to create variability add a random normal shock.

COFFEE

- Coffee production (annual production in kg)

Total (Brazil + Venezuela) = **2.676.000.000** Kg \rightarrow - 1.463.400.000 = **1.212.600.000** Kg

(we suppose that Brazil exports 1.463.400.000 kg of its production outside the 3 countries we are analyzing so that the total consumption of Bra+Arg+Ven is equal to the remaining production of Brazil plus the production of Argentina)

- Brazil	43,7	= 2.622.000.000 Kg	\rightarrow (-1.463.400.000) = 1.158.600.000
- Venezuela	0,9	= 54.000.000 Kg	
- Argentina	0	= 0 Kg	

- Coffee consumption (pro capite per year)

Total (Brazil + Venezuela + Argentina) = **1.212.600.000** Kg

- Brazil	5,8 kg	- 1.125.200.000 (total consumption)
- Venezuela	1,6 kg	- 46.400.000
- Argentina	1,0 kg	- 41.000.000

To assign coffee consumption

Rule:

Σ q(coffee) demanded by Brazilians = coffee consumption in Brazil (1)

Σ q(coffee) from Brazil demanded by all = coffee production in Brazil (2)

Coffee demanded by Brazilians: $Q_i(w) = a \cdot w_i + \text{shock}$ s.t. (1)

Coffe type: random st (2)

PROD

Bra: 1158,6

Ven: 54

Arg: 0

TOT: 1212,6

CONS

Bra: 1125,2 \rightarrow 13 (ven coffee) + 1112,2 (bra coffee)

Ven: 46,4 \rightarrow 30 (ven coffee) + 16,4 (bra coffee)

Arg: 41 \rightarrow 11 (ven coffee) + 30 (bra coffee)

TOT: 1212,6 \rightarrow 54 (tot ven coffee) + 1158,6 (tot bra coffee)

To assign consumption to each agent we decide for every Country how many people consume Brazilian coffee and how many people consume Venezuelan coffee.

In particular:

BRA: 184 people consume Brazilian coffee and 10 people consume Venezuelan coffee.

VEN: 9 people consume Brazilian coffee and 20 people consume Venezuelan coffee.

ARG: 25 people consume Brazilian coffee and 16 people consume Venezuelan coffee.

Then for every Country we assign an average consumption level for each class of income derived in the following way:

We take the 80% of total consumption of a type of coffee and we divide it for the 5 classes; then we divide these quantities by the number of people in each class (20% of the population) obtaining the average consumption in the class.

For Brazil

- 1st (richest) class: 35% (Bra: 8,462 – Ven: 1,82)
- 2nd class: 25% (Bra: 6,044 – Ven: 1,30)
- 3rd class: 25% (Bra: 6,044 – Ven: 1,30)
- 4th class: 10% (Bra: 2,417 – Ven: 0,52)
- 5th class: 5% (Bra: 1,200 – Ven: 0,26)

For Argentina

- 1st (richest) class: 30% (Bra: 1,44 – Ven: 0,825)
- 2nd class: 20% (Bra: 0,96 – Ven: 0,55)
- 3rd class: 20% (Bra: 0,96 – Ven: 0,55)
- 4th class: 15% (Bra: 0,72 – Ven: 0,412)
- 5th class: 15% (Bra: 0,72 – Ven: 0,412)

For Venezuela

- 1st (richest) class: 30% (Bra: 2,186 – Ven: 1,8)
- 2nd class: 25% (Bra: 1,822 – Ven: 1,5)
- 3rd class: 20% (Bra: 1,457 – Ven: 1,2)
- 4th class: 15% (Bra: 1,093 – Ven: 0,9)
- 5th class: 10% (Bra: 0,728 – Ven: 0,6)

We assign the remaining 20% randomly (as a shock) in order to differentiate for tastes of people.

REMAINDERS:

Brazil → Bra: 222,44 – Ven: 2.6

Argentina → Bra: 6 – Ven: 2,2

Venezuela → Bra: 3.28 – Ven: 6