5CCS2INT - Introduction to Artificial Intelligence

EU Economics domain – modelling a basic economic environment with PDDL

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**Description**

Maintaining good quality of life amongst their members is a tough task for the EU. ‘Quality of life index’ is the quantifier for countries to keep track of how well their citizens live. We want a more unified and happier EU, so we have modelled a domain and problem file to uncover EU’s problems for computer scientist around the world. This problem is modelled for a simplified version of the early EU, which at that stage, had a slightly different economical structure. We have assumed however that every country is cooperative and eager to contribute for the greater good of the EU.

The goal state of each object doesn’t actually depend only on the country, it depends on the other countries resources at that point in time so our model is time and resource dependent at the same time.

**Economic sectors**

Our planning divides EU economy into three sectors: Resources, Industry and Services. Each country in the EU has a specific economic bias. Having an economic bias, as a country, means to be economically inclined towards growing and keeping more resources from that sector.

**Trading**

Countries can trade each other resources for funds. They can later use the funds to increase their quality of life. Internally, a country can grow resources by investing their funds into resources. Afterwards they can either trade their resources with other countries (for money – a.k.a. funds) or use their resources to enhance the ‘quality of like index’. The ultimate goal is to reach a state where the country has surpassed a certain threshold for the ‘quality of life index’. At this moment, the country is considered to have come along with the EU standards of living. It is possible to trade multiple economy batches at the same time. That would be equivalent to sending multiple shipments from one country to the other, which is equivalent with what is actually happening in the real life.

**The flow is the following:**

*Funds (money) 🡨🡪 Economic sectors (resources, industry, services) 🡪 Quality of life*

**Resources**

Numbeo: <https://www.numbeo.com/cost-of-living/>

Wikipedia: <https://en.wikipedia.org/wiki/List_of_sovereign_states_in_Europe_by_GDP_(nominal)>

Every economic sector is parametrised and every biased is taking care of a specific country’s trading habit. For instance, if Germany is services biased, it is considered that it has enough services internally and doesn’t need to buy services from another country. In this case Germany can only sell services to other countries. As for the other economic sectors, it can buy and sell as much as it wishes.

Each country has different prices for their resources and also has different taxes for increasing the ‘quality of life index’. There are parameters for how much of each resource is reduced by increasing the life quality in a country.

**Appendix: Domain file**

;domain file

(define (domain EU\_economics)

(:requirements :equality :typing :fluents :durative-actions)

(:types Country)

;fluents

(:functions

(resources-sector ?c - Country)

(industry-sector ?c - Country)

(services-sector ?c - Country)

(funds ?c - Country)

(quality-of-life-index ?c - Country)

(resources-price ?c - Country)

(industry-price ?c - Country)

(services-price ?c - Country)

(economy-growth-price ?c - Country)

(resources-growth ?c - Country)

(industry-growth ?c - Country)

(services-growth ?c - Country)

(quality-index-resources-cost ?c - Country)

(quality-index-industry-cost ?c - Country)

(quality-index-services-cost ?c - Country))

;predicates

(:predicates

(is-not-resources-biased ?c - Country)

(is-not-industry-biased ?c - Country)

(is-not-services-biased ?c - Country)

(is-not-growing-economy ?c - Country)

(is-not-growing-quality-of-life ?c - Country))

;predicates

(:predicates

(is-not-resources-biased ?c - Country)

(is-not-industry-biased ?c - Country)

(is-not-services-biased ?c - Country)

(is-not-growing-economy ?c - Country)

(is-not-growing-quality-of-life ?c - Country))

; c1 buys from c2

; RESOURCES

(:durative-action trade-resources

:parameters(?c1 ?c2 - Country)

:duration (= ?duration 1)

:condition(and(at start(is-not-resources-biased ?c1))

(at start(>= (funds ?c1) (\* 50 (resources-price ?c2))))

(at start(>= (resources-sector ?c2) 50))

(over all (not (= ?c1 ?c2))))

:effect(and(at start(decrease(funds ?c1) (\* 50 (resources-price ?c2))))

(at start(decrease(resources-sector ?c2) 50))

(at end(increase(funds ?c2) (\* 50 (resources-price ?c2))))

(at end(increase (resources-sector ?c1) 50))

)

)

; c1 buys from c2

; INDUSTRY

(:durative-action trade-industry

:parameters(?c1 ?c2 - Country)

:duration (= ?duration 1)

:condition(and (at start(is-not-industry-biased ?c1))

(at start(>= (funds ?c1) (\* 50 (industry-price ?c2))))

(at start(>= (industry-sector ?c2) 50))

(over all (not (= ?c1 ?c2)))

)

:effect(and(at start(decrease(funds ?c1) (\* 50 (industry-price ?c2))))

(at start(decrease(industry-sector ?c2) 50))

(at end(increase(funds ?c2) (\* 50 (industry-price ?c2))))

(at end(increase(industry-sector ?c1) 50))))

; c1 buys from c2

;SERVICES

(:durative-action trade-services

:parameters(?c1 ?c2 - Country)

:duration (= ?duration 1)

:condition(and (at start(is-not-services-biased ?c1))

(at start(>= (funds ?c1) (\* 50 (services-price ?c2) )))

(at start(>= (services-sector ?c2) 50))

(over all (not (= ?c1 ?c2)))

)

:effect(and(at start(decrease(funds ?c1) (\* 50 (services-price ?c2))))

(at start(decrease(services-sector ?c2) 50))

(at end(increase(funds ?c2) (\* 50 (services-price ?c2))))

(at end(increase(services-sector ?c1) 50))

)

)

; grow economy

(:durative-action grow-economy

:parameters(?c - Country)

:duration (= ?duration 1)

:condition(and(at start(>= (funds ?c) (economy-growth-price ?c)))

(at start(is-not-growing-economy ?c)))

:effect(and(at start(decrease(funds ?c) (economy-growth-price ?c)))

(at start(not(is-not-growing-economy ?c)))

(at end(increase(resources-sector ?c) (resources-growth ?c)))

(at end(increase(industry-sector ?c) (industry-growth ?c)))

(at end(increase(services-sector ?c) (services-growth ?c)))

(at end(is-not-growing-economy ?c))))

; grow quality of life

(:durative-action grow-quality-of-life

:parameters(?c - Country)

:duration(= ?duration 1)

:condition(and(at start(<= (quality-index-resources-cost ?c) (resources-sector ?c)))

(at start(<= (quality-index-industry-cost ?c) (industry-sector ?c)))

(at start(<= (quality-index-services-cost ?c) (services-sector ?c)))

(at start(is-not-growing-quality-of-life ?c)))

:effect(and(at start(not(is-not-growing-quality-of-life ?c)))

(at start(decrease(resources-sector ?c) (quality-index-resources-cost ?c)))

(at start(decrease(industry-sector ?c) (quality-index-industry-cost ?c)))

(at start(decrease(services-sector ?c) (quality-index-services-cost ?c)))

(at end(increase(quality-of-life-index ?c) 1))

(at end(is-not-growing-quality-of-life ?c))))

)

**Code: Problem file**

; problem file -- includes only a template for

; how countries are going to be represented in

; their initial state.

(define (problem problem1)

(:domain EU\_economics)

(:objects Belgium Germany France Italy Luxembourg Netherlands - Country) ; "name": "Belgium"

(:init

; -- Variables --

(=(resources-sector Belgium) 4) ; "resources": 4

(=(industry-sector Belgium) 108) ; "industry": 108

(=(services-sector Belgium) 400) ; "services": 400

(=(funds Belgium) 536) ; "funds": 536

(=(quality-of-life-index Belgium) 162) ; "quality-of-life-index": 162

; -- Constants --

(=(resources-price Belgium) 20) ; "resources": 20

(=(industry-price Belgium) 4) ; "industry": 4

(=(services-price Belgium) 2) ; "services": 2

(=(economy-growth-price Belgium) 30) ; "economy growth: " : 30

; -- Economy growth --

(=(resources-growth Belgium) 5) ; "resources": 5

(=(industry-growth Belgium) 10) ; "industry": 10

(=(services-growth Belgium) 15) ; "services": s15

; -- Quality of life growth --

(=(quality-index-resources-cost Belgium) 2) ; "resources": 2

(=(quality-index-industry-cost Belgium) 8) ; "industry": 8

(=(quality-index-services-cost Belgium) 12) ; "services": 12

;predicates initialised ; -- Biases --

(is-not-resources-biased Belgium) ; resources: false

(is-not-industry-biased Belgium) ; industry: false

(not(is-not-services-biased Belgium)) ; services: true

; -- Technical --

(is-not-growing-economy Belgium) ; "growing-eco": false

(is-not-growing-quality-of-life Belgium) ; "growing-quality-of-life": false

; -- Variables --

(=(resources-sector Germany) 1856) ; "resources": 1856

(=(industry-sector Germany) 1622) ; "industry": 1622

(=(services-sector Germany) 885) ; "services": 885

(=(funds Germany) 4029) ; "funds": 4029

(=(quality-of-life-index Germany) 187) ; "quality-of-life-index": 187

; -- Constants --

(=(resources-price Germany) 2) ; "resources": 2

(=(industry-price Germany) 2) ; "industry": 2

(=(services-price Germany) 15) ; "services": 15

(=(economy-growth-price Germany) 377) ; "economy growth: " : 377

; -- Economy growth --

(=(resources-growth Germany) 150) ; "resources": 150

(=(industry-growth Germany) 150) ; "industry": 150

(=(services-growth Germany) 100) ; "services": s100

; -- Quality of life growth --

(=(quality-index-resources-cost Germany) 126) ; "resources": 126

(=(quality-index-industry-cost Germany) 114) ; "industry": 114

(=(quality-index-services-cost Germany) 155) ; "services": 155

;predicates initialised ; -- Biases --

(not(is-not-resources-biased Germany)) ; resources: true

(is-not-industry-biased Germany) ; industry: false

(is-not-services-biased Germany) ; services: false

; -- Technical --

(is-not-growing-economy Germany) ; "growing-eco": false

(is-not-growing-quality-of-life Germany) ; "growing-quality-of-life": false

; -- Variables --

(=(resources-sector France) 1254) ; "resources": 1254

(=(industry-sector France) 1126) ; "industry": 1126

(=(services-sector France) 809) ; "services": 809

(=(funds France) 2795) ; "funds": 2795

(=(quality-of-life-index France) 158) ; "quality-of-life-index": 158

; -- Constants --

(=(resources-price France) 2) ; "resources": 2

(=(industry-price France) 3) ; "industry": 3

(=(services-price France) 12) ; "services": 12

(=(economy-growth-price France) 154) ; "economy growth: " : 154

; -- Economy growth --

(=(resources-growth France) 100) ; "resources": 100

(=(industry-growth France) 100) ; "industry": 100

(=(services-growth France) 71) ; "services": s71

; -- Quality of life growth --

(=(quality-index-resources-cost France) 45) ; "resources": 45

(=(quality-index-industry-cost France) 55) ; "industry": 55

(=(quality-index-services-cost France) 62) ; "services": 62

;predicates initialised ; -- Biases --

(not(is-not-resources-biased France)) ; resources: true

(not(is-not-industry-biased France)) ; industry: true

(is-not-services-biased France) ; services: false

; -- Technical --

(is-not-growing-economy France) ; "growing-eco": false

(is-not-growing-quality-of-life France) ; "growing-quality-of-life": false

; -- Variables --

(=(resources-sector Italy) 703) ; "resources": 703

(=(industry-sector Italy) 1208) ; "industry": 1208

(=(services-sector Italy) 602) ; "services": 602

(=(funds Italy) 2087) ; "funds": 2087

(=(quality-of-life-index Italy) 146) ; "quality-of-life-index": 146

; -- Constants --

(=(resources-price Italy) 7) ; "resources": 7

(=(industry-price Italy) 2) ; "industry": 2

(=(services-price Italy) 8) ; "services": 8

(=(economy-growth-price Italy) 70) ; "economy growth: " : 70

; -- Economy growth --

(=(resources-growth Italy) 42) ; "resources": 42

(=(industry-growth Italy) 88) ; "industry": 88

(=(services-growth Italy) 23) ; "services": s23

; -- Quality of life growth --

(=(quality-index-resources-cost Italy) 40) ; "resources": 40

(=(quality-index-industry-cost Italy) 50) ; "industry": 50

(=(quality-index-services-cost Italy) 31) ; "services": 31

;predicates initialised ; -- Biases --

(is-not-resources-biased Italy) ; resources: false

(is-not-industry-biased Italy) ; industry: false

(not(is-not-services-biased Italy)) ; services: true

; -- Technical --

(is-not-growing-economy Italy) ; "growing-eco": false

(is-not-growing-quality-of-life Italy) ; "growing-quality-of-life": false

; -- Variables --

(=(resources-sector Luxembourg) 22) ; "resources": 22

(=(industry-sector Luxembourg) 28) ; "industry": 28

(=(services-sector Luxembourg) 46) ; "services": 46

(=(funds Luxembourg) 69) ; "funds": 69

(=(quality-of-life-index Luxembourg) 181) ; "quality-of-life-index": 181

; -- Constants --

(=(resources-price Luxembourg) 2) ; "resources": 2

(=(industry-price Luxembourg) 2) ; "industry": 2

(=(services-price Luxembourg) 2) ; "services": 2

(=(economy-growth-price Luxembourg) 5) ; "economy growth: " : 5

; -- Economy growth --

(=(resources-growth Luxembourg) 2) ; "resources": 2

(=(industry-growth Luxembourg) 3) ; "industry": 3

(=(services-growth Luxembourg) 2) ; "services": s2

; -- Quality of life growth --

(=(quality-index-resources-cost Luxembourg) 4) ; "resources": 4

(=(quality-index-industry-cost Luxembourg) 4) ; "industry": 4

(=(quality-index-services-cost Luxembourg) 4) ; "services": 4

;predicates initialised ; -- Biases --

(is-not-resources-biased Luxembourg) ; resources: false

(is-not-industry-biased Luxembourg) ; industry: false

(is-not-services-biased Luxembourg) ; services: false

; -- Technical --

(is-not-growing-economy Luxembourg) ; "growing-eco": false

(is-not-growing-quality-of-life Luxembourg) ; "growing-quality-of-life": false

; -- Variables --

(=(resources-sector Netherlands) 120) ; "resources": 120

(=(industry-sector Netherlands) 312) ; "industry": 312

(=(services-sector Netherlands) 540) ; "services": 540

(=(funds Netherlands) 910) ; "funds": 910

(=(quality-of-life-index Netherlands) 189) ; "quality-of-life-index": 189

; -- Constants --

(=(resources-price Netherlands) 11) ; "resources": 11

(=(industry-price Netherlands) 5) ; "industry": 5

(=(services-price Netherlands) 4) ; "services": 4

(=(economy-growth-price Netherlands) 25) ; "economy growth: " : 25

; -- Economy growth --

(=(resources-growth Netherlands) 3) ; "resources": 3

(=(industry-growth Netherlands) 10) ; "industry": 10

(=(services-growth Netherlands) 15) ; "services": s15

; -- Quality of life growth --

(=(quality-index-resources-cost Netherlands) 15) ; "resources": 15

(=(quality-index-industry-cost Netherlands) 57) ; "industry": 57

(=(quality-index-services-cost Netherlands) 225) ; "services": 225

;predicates initialised ; -- Biases --

(is-not-resources-biased Netherlands) ; resources: false

(is-not-industry-biased Netherlands) ; industry: false

(not(is-not-services-biased Netherlands)) ; services: true

; -- Technical --

(is-not-growing-economy Netherlands) ; "growing-eco": false

(is-not-growing-quality-of-life Netherlands) ; "growing-quality-of-life": false

)

(:goal (and

;todo: put the goal condition here

(>= (quality-of-life-index Belgium) 190)

(>= (quality-of-life-index Germany) 190)

(>= (quality-of-life-index France) 190)

(>= (quality-of-life-index Italy) 190)

(>= (quality-of-life-index Luxembourg) 190)

(>= (quality-of-life-index Netherlands) 190)

)

)

)

; -- Variables --

(=(resources-sector Germany) 1856) ; "resources": 1856

(=(industry-sector Germany) 1622) ; "industry": 1622

(=(services-sector Germany) 885) ; "services": 885

(=(funds Germany) 4029) ; "funds": 4029

(=(quality-of-life-index Germany) 187) ; "quality-of-life-index": 187

; -- Constants --

(=(resources-price Germany) 2) ; "resources": 2

(=(industry-price Germany) 2) ; "industry": 2

(=(services-price Germany) 15) ; "services": 15

(=(economy-growth-price Germany) 377) ; "economy growth: " : 377

; -- Economy growth --

(=(resources-growth Germany) 150) ; "resources": 150

(=(industry-growth Germany) 150) ; "industry": 150

(=(services-growth Germany) 100) ; "services": s100

; -- Quality of life growth --

(=(quality-index-resources-cost Germany) 126) ; "resources": 126

(=(quality-index-industry-cost Germany) 114) ; "industry": 114

(=(quality-index-services-cost Germany) 155) ; "services": 155

;predicates initialised ; -- Biases --

(not(is-not-resources-biased Germany)) ; resources: true

(is-not-industry-biased Germany) ; industry: false

(is-not-services-biased Germany) ; services: false

; -- Technical --

(is-not-growing-economy Germany) ; "growing-eco": false

(is-not-growing-quality-of-life Germany) ; "growing-quality-of-life": false

; -- Variables --

(=(resources-sector Germany) 1856) ; "resources": 1856

(=(industry-sector Germany) 1622) ; "industry": 1622

(=(services-sector Germany) 885) ; "services": 885

(=(funds Germany) 4029) ; "funds": 4029

(=(quality-of-life-index Germany) 187) ; "quality-of-life-index": 187

; -- Constants --

(=(resources-price Germany) 2) ; "resources": 2

(=(industry-price Germany) 2) ; "industry": 2

(=(services-price Germany) 15) ; "services": 15

(=(economy-growth-price Germany) 377) ; "economy growth: " : 377

; -- Economy growth --

(=(resources-growth Germany) 150) ; "resources": 150

(=(industry-growth Germany) 150) ; "industry": 150

(=(services-growth Germany) 100) ; "services": s100

; -- Quality of life growth --

(=(quality-index-resources-cost Germany) 126) ; "resources": 126

(=(quality-index-industry-cost Germany) 114) ; "industry": 114

(=(quality-index-services-cost Germany) 155) ; "services": 155

;predicates initialised ; -- Biases --

(not(is-not-resources-biased Germany)) ; resources: true

(is-not-industry-biased Germany) ; industry: false

(is-not-services-biased Germany) ; services: false

; -- Technical --

(is-not-growing-economy Germany) ; "growing-eco": false

(is-not-growing-quality-of-life Germany) ; "growing-quality-of-life": false

; -- Variables --

(=(resources-sector France) 1254) ; "resources": 1254

(=(industry-sector France) 1126) ; "industry": 1126

(=(services-sector France) 809) ; "services": 809

(=(funds France) 2795) ; "funds": 2795

(=(quality-of-life-index France) 158) ; "quality-of-life-index": 158

; -- Constants --

(=(resources-price France) 2) ; "resources": 2

(=(industry-price France) 3) ; "industry": 3

(=(services-price France) 12) ; "services": 12

(=(economy-growth-price France) 154) ; "economy growth: " : 154

; -- Economy growth --

(=(resources-growth France) 100) ; "resources": 100

(=(industry-growth France) 100) ; "industry": 100

(=(services-growth France) 71) ; "services": s71

; -- Quality of life growth --

(=(quality-index-resources-cost France) 45) ; "resources": 45

(=(quality-index-industry-cost France) 55) ; "industry": 55

(=(quality-index-services-cost France) 62) ; "services": 62

;predicates initialised ; -- Biases --

(not(is-not-resources-biased France)) ; resources: true

(not(is-not-industry-biased France)) ; industry: true

(is-not-services-biased France) ; services: false

; -- Technical --

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(=(resources-sector Italy) 703) ; "resources": 703

(=(industry-sector Italy) 1208) ; "industry": 1208

(=(services-sector Italy) 602) ; "services": 602

(=(funds Italy) 2087) ; "funds": 2087

(=(quality-of-life-index Italy) 146) ; "quality-of-life-index": 146

; -- Constants --

(=(resources-price Italy) 7) ; "resources": 7

(=(industry-price Italy) 2) ; "industry": 2

(=(services-price Italy) 8) ; "services": 8

(=(economy-growth-price Italy) 70) ; "economy growth: " : 70

; -- Economy growth --

(=(resources-growth Italy) 42) ; "resources": 42

(=(industry-growth Italy) 88) ; "industry": 88

(=(services-growth Italy) 23) ; "services": s23

; -- Quality of life growth --

(=(quality-index-resources-cost Italy) 40) ; "resources": 40

(=(quality-index-industry-cost Italy) 50) ; "industry": 50

(=(quality-index-services-cost Italy) 31) ; "services": 31

;predicates initialised ; -- Biases --

(is-not-resources-biased Italy) ; resources: false

(is-not-industry-biased Italy) ; industry: false

(not(is-not-services-biased Italy)) ; services: true

; -- Technical --

(is-not-growing-economy Italy) ; "growing-eco": false

(is-not-growing-quality-of-life Italy) ; "growing-quality-of-life": false

; -- Variables --

(=(resources-sector Luxembourg) 22) ; "resources": 22

(=(industry-sector Luxembourg) 28) ; "industry": 28

(=(services-sector Luxembourg) 46) ; "services": 46

(=(funds Luxembourg) 69) ; "funds": 69

(=(quality-of-life-index Luxembourg) 181) ; "quality-of-life-index": 181

; -- Constants --

(=(resources-price Luxembourg) 2) ; "resources": 2

(=(industry-price Luxembourg) 2) ; "industry": 2

(=(services-price Luxembourg) 2) ; "services": 2

(=(economy-growth-price Luxembourg) 5) ; "economy growth: " : 5

; -- Economy growth --

(=(resources-growth Luxembourg) 2) ; "resources": 2

(=(industry-growth Luxembourg) 3) ; "industry": 3

(=(services-growth Luxembourg) 2) ; "services": s2

; -- Quality of life growth --

(=(quality-index-resources-cost Luxembourg) 4) ; "resources": 4

(=(quality-index-industry-cost Luxembourg) 4) ; "industry": 4

(=(quality-index-services-cost Luxembourg) 4) ; "services": 4

;predicates initialised ; -- Biases --

(is-not-resources-biased Luxembourg) ; resources: false

(is-not-industry-biased Luxembourg) ; industry: false

(is-not-services-biased Luxembourg) ; services: false

; -- Technical --

(is-not-growing-economy Luxembourg) ; "growing-eco": false

(is-not-growing-quality-of-life Luxembourg) ; "growing-quality-of-life": false

; -- Variables --

(=(resources-sector Netherlands) 120) ; "resources": 120

(=(industry-sector Netherlands) 312) ; "industry": 312

(=(services-sector Netherlands) 540) ; "services": 540

(=(funds Netherlands) 910) ; "funds": 910

(=(quality-of-life-index Netherlands) 189) ; "quality-of-life-index": 189

; -- Constants --

(=(resources-price Netherlands) 11) ; "resources": 11

(=(industry-price Netherlands) 5) ; "industry": 5

(=(services-price Netherlands) 4) ; "services": 4

(=(economy-growth-price Netherlands) 25) ; "economy growth: " : 25

; -- Economy growth --

(=(resources-growth Netherlands) 3) ; "resources": 3

(=(industry-growth Netherlands) 10) ; "industry": 10

(=(services-growth Netherlands) 15) ; "services": s15

; -- Quality of life growth --

(=(quality-index-resources-cost Netherlands) 15) ; "resources": 15

(=(quality-index-industry-cost Netherlands) 57) ; "industry": 57

(=(quality-index-services-cost Netherlands) 225) ; "services": 225

;predicates initialised ; -- Biases --

(is-not-resources-biased Netherlands) ; resources: false

(is-not-industry-biased Netherlands) ; industry: false

(not(is-not-services-biased Netherlands)) ; services: true

; -- Technical --

(is-not-growing-economy Netherlands) ; "growing-eco": false

(is-not-growing-quality-of-life Netherlands) ; "growing-quality-of-life": false

)

(:goal (and

;todo: put the goal condition here

(>= (quality-of-life-index Belgium) 190)

(>= (quality-of-life-index Germany) 190)

(>= (quality-of-life-index France) 190)

(>= (quality-of-life-index Italy) 190)

(>= (quality-of-life-index Luxembourg) 190)

(>= (quality-of-life-index Netherlands) 190)

)

)

)