GWS SPECIALISTS IN EMPIRICAL ECONOMIC RESEARCH

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COFORCE - COPPER FORECASTING CHILE

Methodology and Design of a Macro-Econometric Input-Output Model for the Chilean Economy

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1. Background

Background

- Joint research project
  „Development of sustainable strategies in the Chilean mining sector through a regionalized national model“
- Overall aim: Analysis of socio-economic impact of copper on the Chilean economy
- Choice of instrument: macro-econometric input-output model (INFORUM type) of Chile
  - ⇨ national level – completed 2018
  - ⇨ regional level – upcoming work in 2018/2019

2. Methodology Overview

- **Comparison INFORUM type and CGE type of models**

Methodology Overview

- **INFORUM** type of models
  - http://www.inforum.umd.edu/
  - INFORUM - Interindustry Forecasting at the University of Maryland
  - Founded 1967 by **Dr. Clopper Almon**
  - Dedicated to improve **business planning**, **government policy** analysis, and the general understanding of the economic environment
  - Building and using **dynamic interindustry-macroeconomic models** that portray the economy in a "**bottom-up**" fashion.
  - **World-wide network** of research associates, each of which **uses INFORUM modeling methods** and software.

Methodology Overview

- CGE and INFORUM type of models are similar
- But differ in some features.

- Sources for the following comparison:
  - ⇨ Almon, C. (1991) The INFORUM Approach to Interindustry Modeling. Economic Systems Research, 3 (1), 1-7.
  - ⇨ Grassini, M. (2003) Computable General Equilibrium Modelling Approach. Does it make any sense? Paper presented at the 11th Inforum World Conference Suzdal. September 8-10, 2003.
  - ⇨ Grassini, M. (2005) CGE versus Inforum Modelling Approach. Paper presented at the 15th International Conference on Input Output Techniques. June 27 – July 1, 2015. Beijing, China.

Methodology Overview

	INFORUM type of model	CGE type of model
Behavior function	Bounded rationality of economic actors Imperfect markets	Optimization assumption: Households as utility maximizers Enterprises as profit maximizers
Price setting	Price rigidities	Market equilibrium assumption: Flexible prices to employ market equilibrium
Level of detail	Meso – industry level	Meso – industry level
Modelling approach	Bottom-up Total integration („closed system“; double accounting; intersectoral dependencies)	Top-down Total integration („closed system“; double accounting; intersectoral dependencies)
Database	Input-Output Tables + National Accounts No adjustment of original data	Input-Output Tables + National Accounts Calibration of base year data to equilibrium
Time	Dynamic Path dependency, irreversible	Dynamic; but comparison of steady state solutions: what happens outside the equilibrium is not explained Timeless (no calender time)
Implementation of modelling	Regression analysis of time-series	Parameters values taken from literature
Paradigm	Keynsian, Synthesis	Neo-classical
Degree of endogenization	High	Low

Methodology Overview

	Characteristics of COFORCE
Type	INFORUM type of model
Focus	Macro / meso economy
Derived assumptions	Bounded rationality of economic actors Imperfect markets Price rigidities Equal importance of supply and use
Implementation of modelling	Econometric estimation of parameters and their elasticity values using OLS
Technology	Variable input coefficient
Basic dataset	IO Tables + National Accounts
Modelling approach	Bottom-up (73 products and industries) Total integration („closed system“; double accounting; intersectoral dependencies)
Solution procedure	Iterative; simultanous solution of total system
Time	Irreversible; path dependency; dynamic (until 2035)

Methodology Overview

Strength and Weeknesses

Analysis of **complex socio-economic structures**.

Identification of **direct and indirect** impacts.

Low sectoral aggregation level by goods and industries

Differentiation of **institutional sectors** according to SNA

Amplification of model is possible („**modularization**“)

Update on yearly basis

Well-suited for **scenario analysis** and **forecasts**

Large and **complex system**; „black box“

Quality of historical dataset is decisive

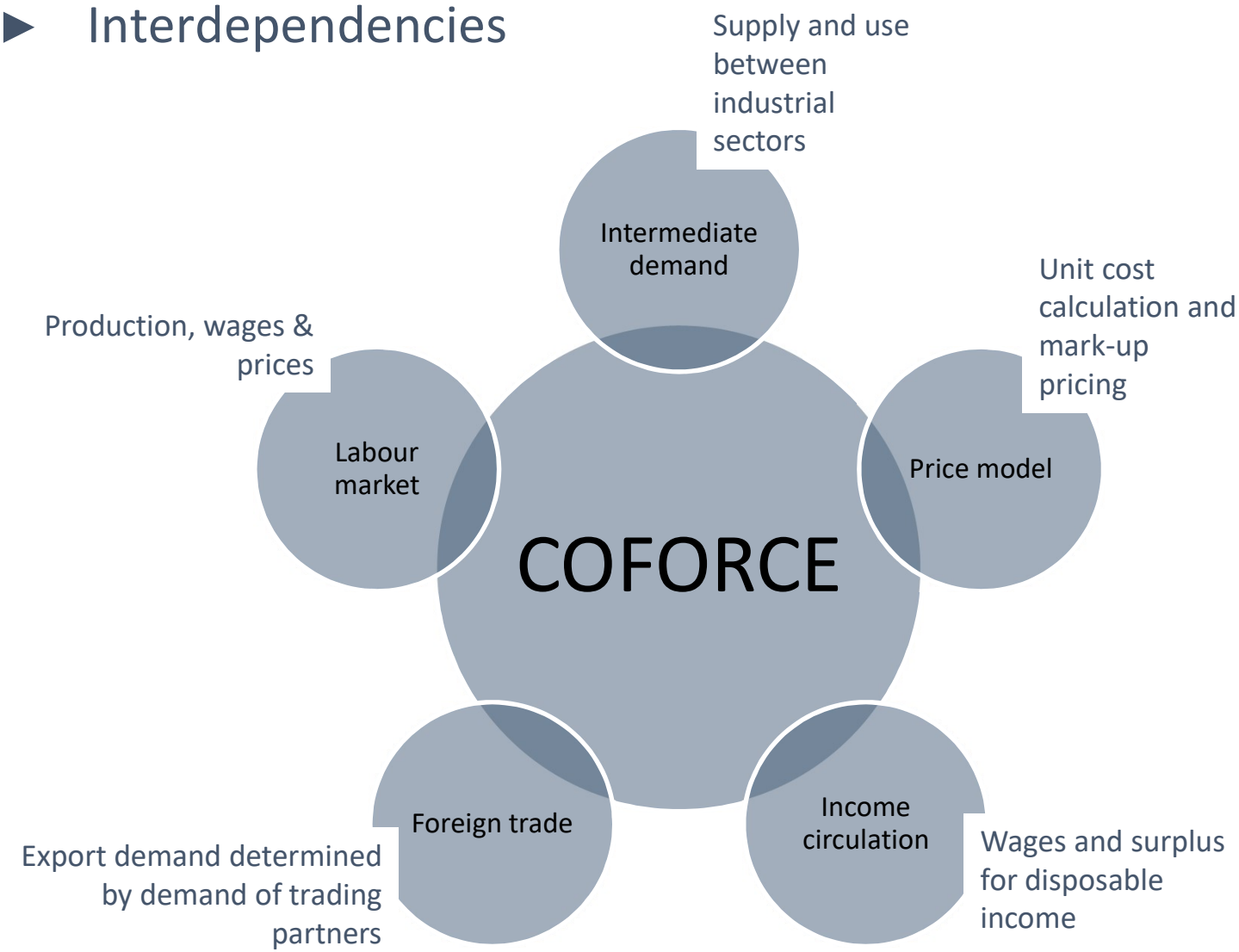
Making-off is **time-intense**

High number of interdependencies and the interrelation between definition and regression functions constitute a **sensitive system.**

Excellent regression test values do not mean automatically a good forecasting performance.

Methodology Overview

- Interdependencies

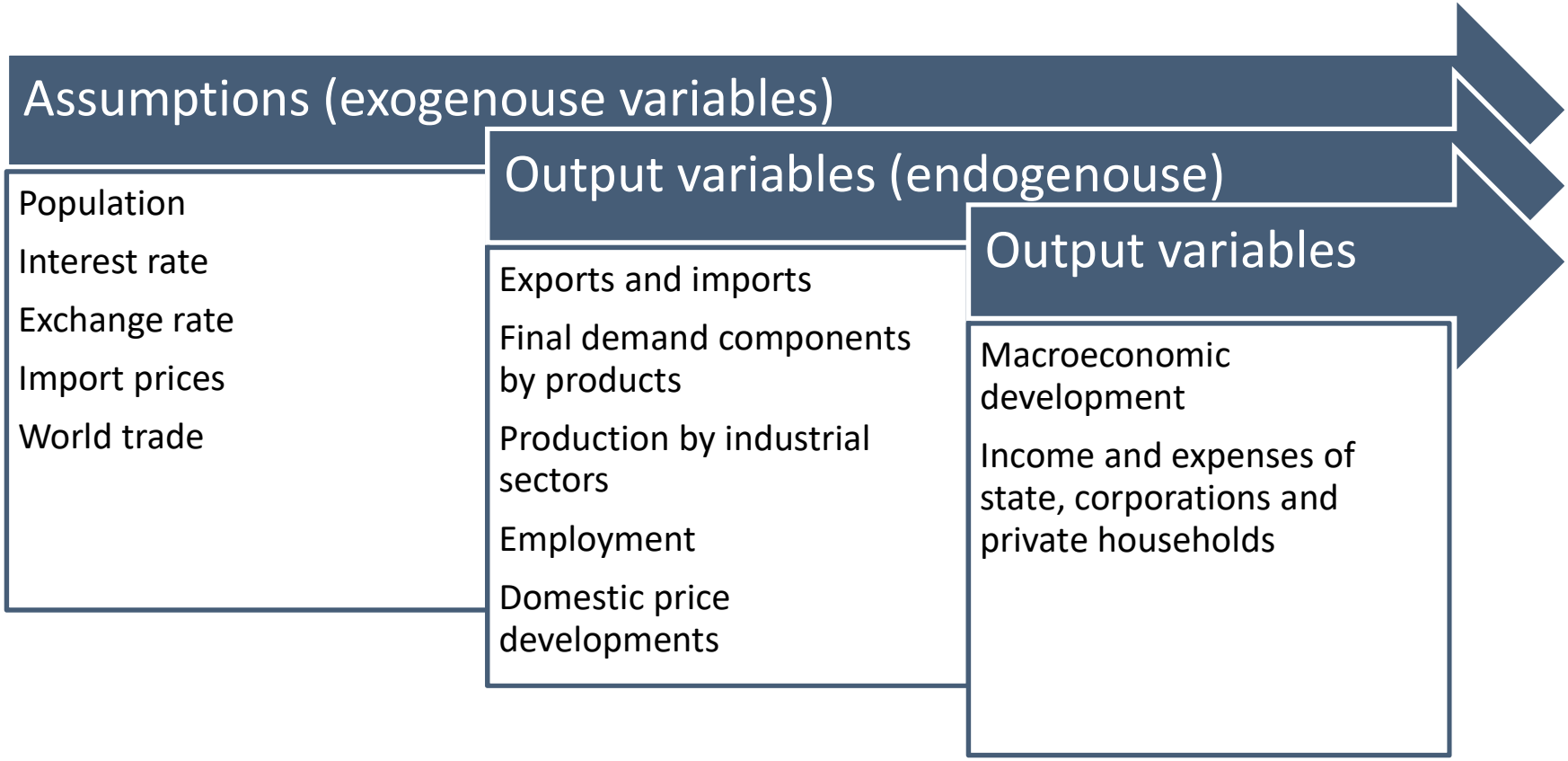


Methodology Overview

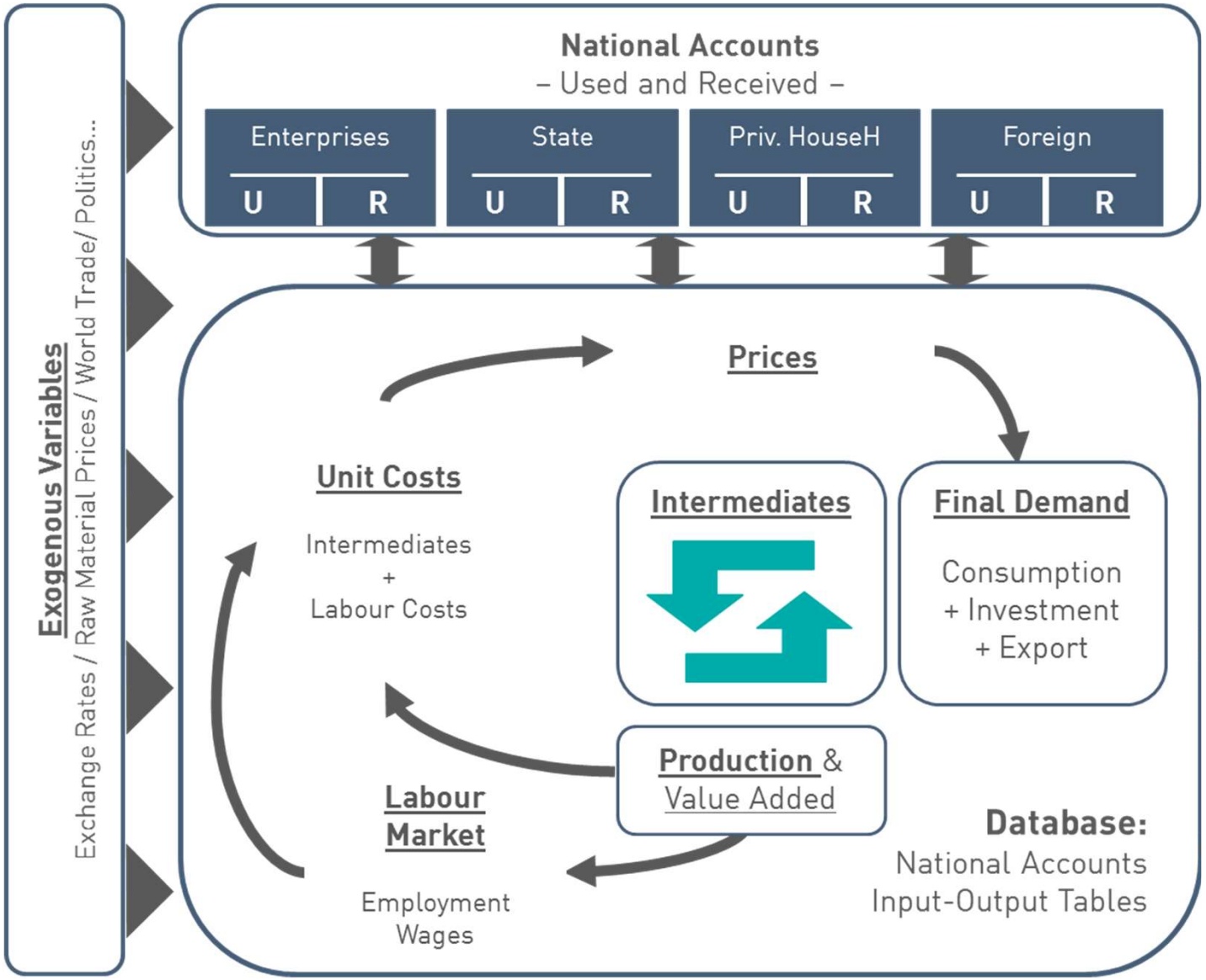
- Important output variables
  - ⇨ Foreign trade
  - ⇨ Final demand components by products
  - ⇨ Production by industrial sectors
  - ⇨ Employment by industrial sectors
  - ⇨ Price development
  - ⇨ Income and expenses of state, corporations and private households
  - ⇨ Macroeconomic development
- Important assumptions
  - ⇨ Population
  - ⇨ Interest rates
  - ⇨ Exchange rates
  - ⇨ Import prices
  - ⇨ World trade development (via world trade model)

Methodology Overview

- Assumptions and output variables

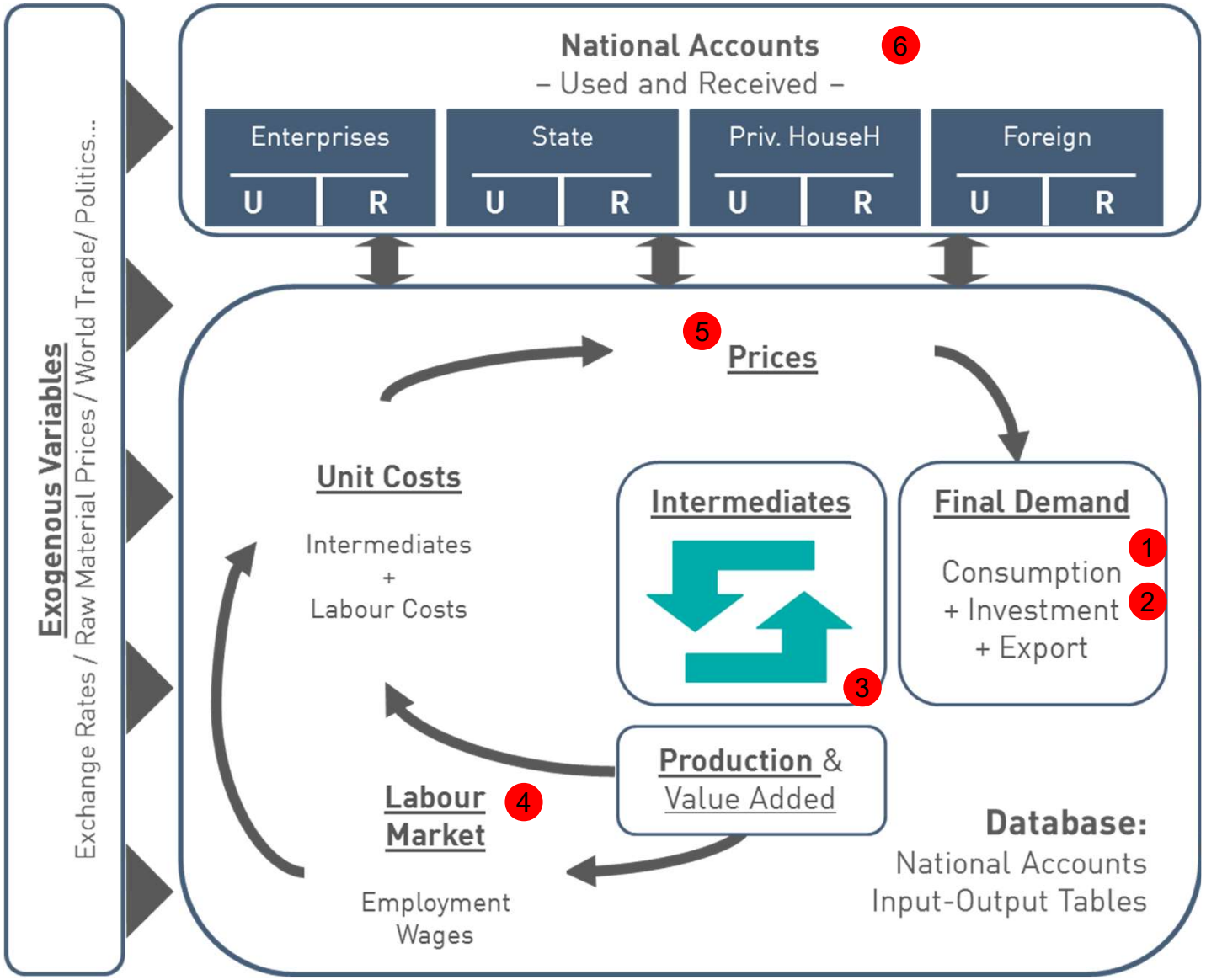


Methodology Overview



3. Selected Specification of COFORCE

Methodology Overview



1 Private household consumption $hcesr_i$

- Most important contributor to economic growth
- Estimated bottom-up on product level and in real terms as a function of
  - ⇨ real personal income $^{DB6000RH}/_{HCPOP}$ (+)
  - ⇨ relative commodity prices $^{ppil_i}/_{HCPOP}$ (-)

  - ⇨ $hcesr_i = hcesr\left(^{DB6000RH}/_{HCPOP}, ^{ppil_i}/_{HCPOP}\right),\ i \in (1,..,73)$

- Overall price inflation and relative price shifts as limitation for consumption expension
- Savings are a residual between disposable income and consumption expenditure

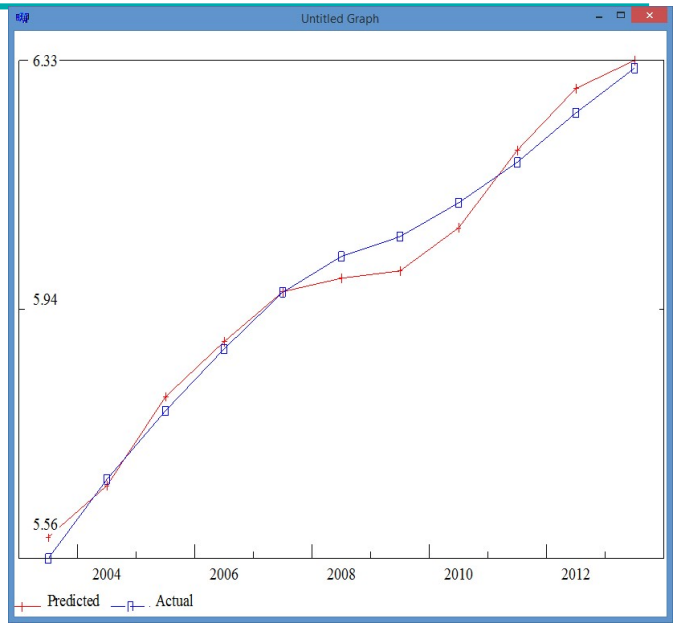
1 Private household consumption $hcesr_i$

▶ Example 1: Wine making

r @log(hcesr22) = @log(B6000RH/HCPOP), @log(ppil22/HCPOP)

RSQ	0.9837	Obser	11
RBSQ	0.9796	from	2003
DW	0.98	to	2013

Var name	Reg-Coef	Mexval	t-value
intercept	-2.76094	135.4	-6.027
@log(B6000RH/HCPOP)	1.34804	604.8	19.732
@log(ppil22/HCPOP)	-0.38659	31.2	-2.402

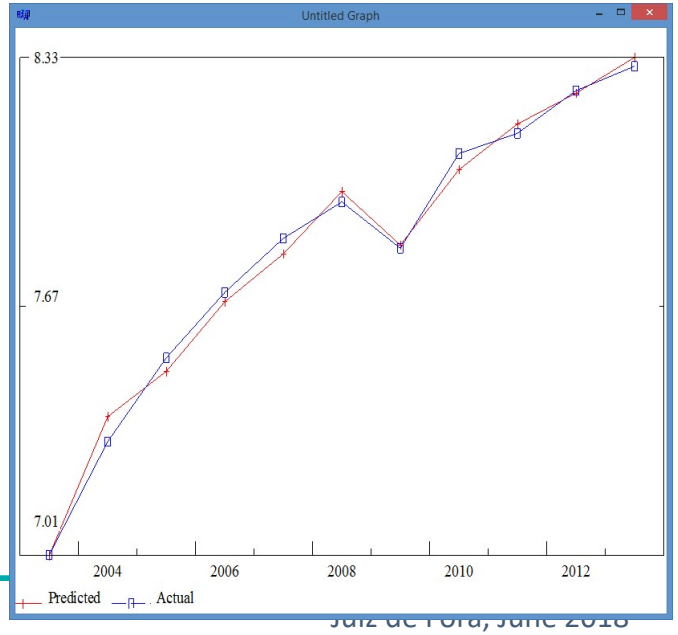


▶ Example 2: Manufacture of machinery and electrical equipment

r @log(hcesr44) = @log(B6000RH/HCPOP), @log(ppil44/HCPOP), D103, D110FF

RSQ	0.9926	Obser	11
RBSQ	0.9876	from	2003
DW	2.48	to	2013

Var name	Reg-Coef	Mexval	t-value
intercept	-4.91964	111.2	-4.558
@log(B6000RH/HCPOP)	1.94921	379.5	11.486
@log(ppil44/HCPOP)	-0.97737	114.3	-4.642
D103			
D110FF			



2 Gross fixed capital formation $gicnr_i$

- No differentiation between investment in machinery and equipment and investment in buildings
- Bottom-up estimation on the level of investment products (!= investing industries)
  - ⇨ production groups either total production YSR or production of manufacturing industry $YSRMI$(+)
  - ⇨ real disposable income of non-financial institutions ${}^{B6000RN}/_{PS}$ (+)

  - ⇨ $gicnr_i = gicnr_i(YSR, YSRMI, {}^{B6000RN}/_{PS})\ ,\ i \in (1,..,73)$

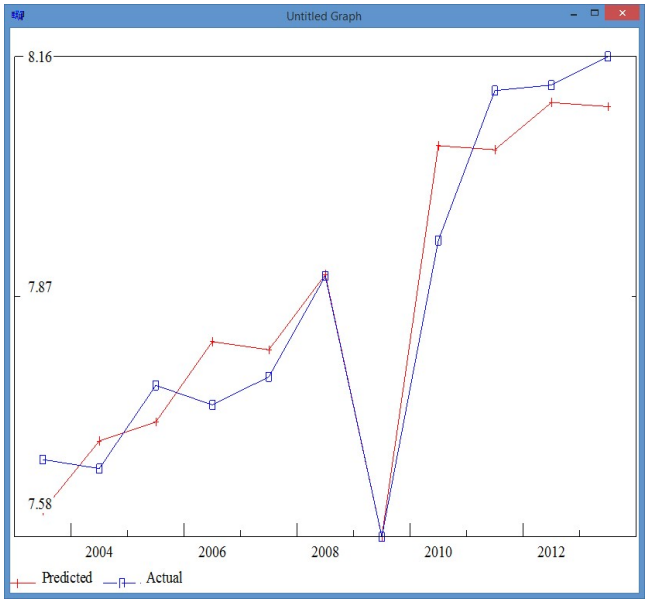
2 Gross fixed capital formation $gicnr_i$

- Example 1: Manufacture of machinery and non-electrical equipment

r @log(gicnr43) = @log(YSRMI), @log(B6000RN/PS), D109

RSQ	0.9139	Obser	11
RBSQ	0.8769	from	2003
DW	2.33	to	2013

Var name	Reg-Coef	Mexval	t-value
intercept	-2.16640	12.4	-1.358
@log(YSRMI)	0.84166	132.8	5.563
@log(B6000RN/PS)	0.27363	110.8	4.910
D109			



3 Intermediate transaction and production

- (Domestic) real input coefficient $DINCTR_{i,j}$ are estimated with an autonomous time trend
  - ⇨ 5329 coefficients exist
  - ⇨ Only those coefficients are estimated that belong to the 100 largest intermediate input combination
  - ⇨ They represent 45% of all domestic input in year 2013
  - ⇨ $DINCTR_{i,j} = DINCTR_{i,j}(1/TIME), i \in (1, \dots, 73), j \in (1, \dots, 73)$
- Production ygn via Leontief equation
  - ⇨ $ygn_t = (IL - DINCT)^{-1} \cdot (fdnb_t)$

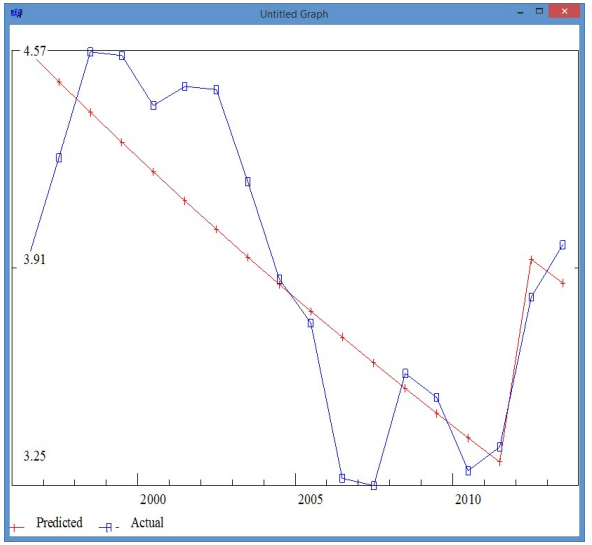
3 Intermediate transaction

- Example 1: Copper Mining | Basic industries of non-ferrous metals

r @log(dinct100zs003) = @log(1/(TIME-50)), D112FF

RSQ	0.6401	Obser	18
RBSQ	0.5921	from	1996
DW	0.69	to	2013

Var name	Reg-Coef	Mexval	t-value
intercept	21.57970	91.1	6.308
@log(1/(TIME-50))	4.44257	66.7	5.164
D112FF			

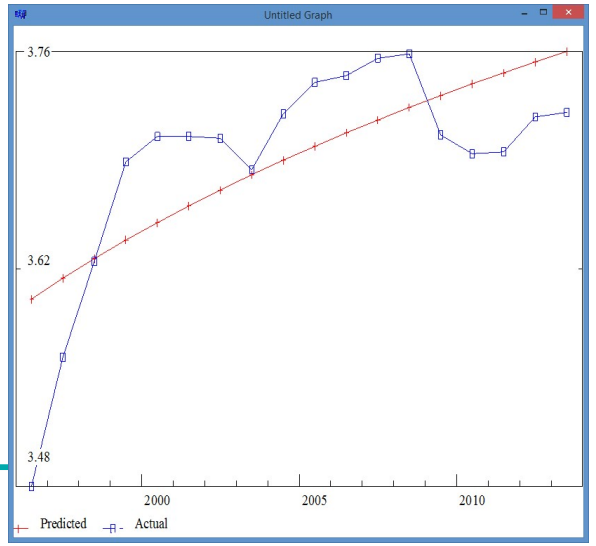


- Example 2: Electricity supply | Electricity supply

r @log(dinct100zs004) = @log(1/(TIME-80))

RSQ	0.5068	Obser	18
RBSQ	0.4759	from	1996
DW	0.40	to	2013

Var name	Reg-Coef	Mexval	t-value
intercept	2.98250	337.1	17.020
@log(1/(TIME-50))	-0.22323	42.4	-4.054



4 Labour market

- **Aggregate Wages** $wage_i$ determined on the labour market
  - ⇨ Average wage level estimated according to Philip curve approach: real GDP per capita ${}^{GDPTR}/_{EMPL}$ (+), labour scarcity factor ${}^{EMPL}/_{LFCE}$ (+), copper price $weoreptc$ (+)
  - ⇨ $WAGE = WAGE({}^{GDPTR}/_{EMPL} * HCPOP, {}^{EMPL}/_{LFCE}, weoreptc)$

- **Sectoral wages** influenced by overall wage level (+) and sectoral productivity ${}^{ysn_i}/_{empll_i}$ (+)
  - ⇨ $wage_i = wage_i\left(WAGE, {}^{ysn_i}/_{empll_k}\right),\ i \in (1,..,73), k \in (1,..,32)$

- **Employment** depends on real production ysr (+) and real wages $wage/ppil$ (-)
  - ⇨ $empl_k = empl_k\left(ysr_k, {}^{wage_i}/_{ppil_i}\right),\ i \in (1,..,73), k \in (1,..,32)$

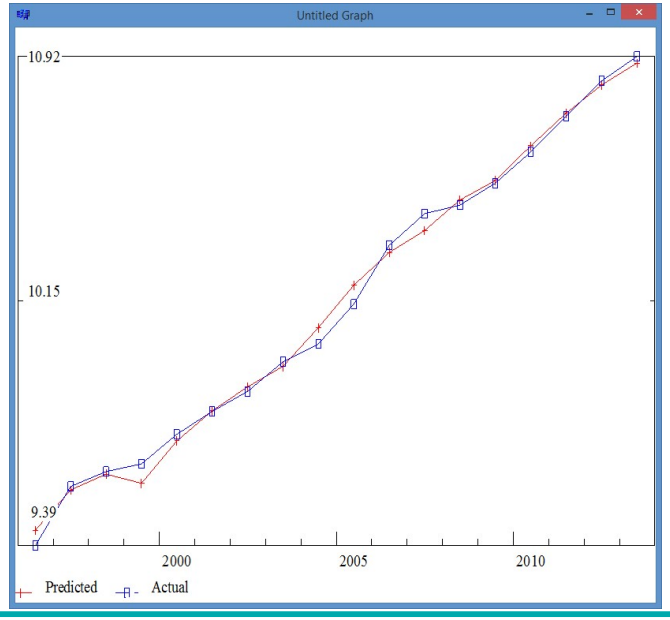
4 Labour market

► Example 1: Aggregate wage function

r @log(WAGE) = @log(GDPTR/EMPL*HCPOP), @log(EMPL/LFCE), @log(weoreptc69), D109FF

RSQ	0.9954	Obser	18
RBSQ	0.9939	from	1996
DW	1.49	to	2013

Var name	Reg-Coef	Mexval	t-value
intercept	9.74133'	1617.6	61.822
@log(GDPTR/EMPL*HCPOP)	1.32221	395.5	17.498
@log(EMPL/LFCE)	1.83214	23.0	2.581
@log(weoreptc69)	0.07766	21.6	2.496
D109FF			



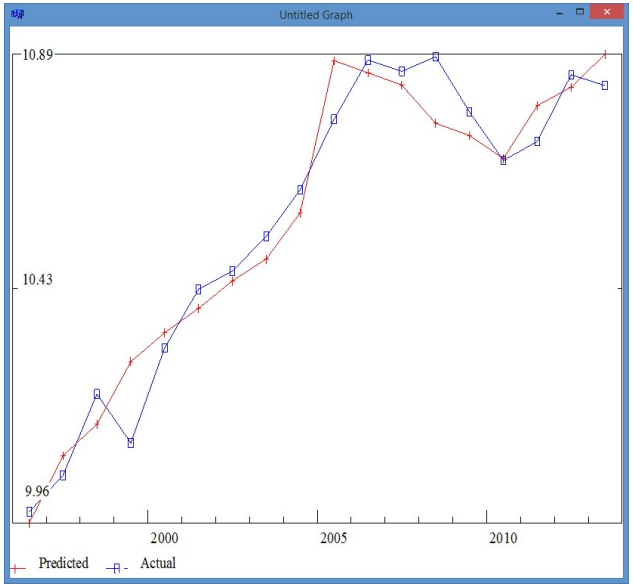
4 Labour market

- Example employment: Complementary and auxiliar transport activities

r @log(empll22) = @log(ysr_32c22), @log(wage60/ppil60), D105FF

RSQ	0.9473	Obser	18
RBSQ	0.9360	from	1996
DW	2.11	to	2013

Var name	Reg-Coef	Mexval	t-value
intercept	4.05776	58.1	4.580
@log(ysr_32c22)	0.93647	127.2	7.634
@log(wage60/ppil60)	-0.46035	29.1	-3.056
D105FF			



5 Modelling prices

- Production prices follow a unit cost approach
  - ⇨ Unit costs = cost per unit of real production

- COFORCE differentiates between 4 unit costs:
  - ⇨ unit labour costs,
  - ⇨ unit indirect tax costs,
  - ⇨ unit imported intermediate costs
  - ⇨ unit domestic intermediate costs

- Production prices $ppil_i$ determined by unit costs uc_i (+) and mark-up pricing
  - ⇨ Price stickiness is signaled by an elasticity <1
  - ⇨ $ppil_i = ppil_i(uc_i)\ ,\ i \in (1,..,73)$

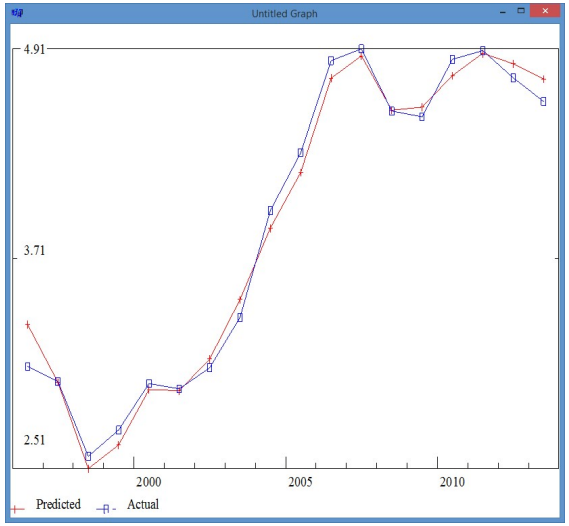
5 Modelling prices

► Example 1: Copper mining

r @log(ppil09) = @log(uc09)

RSQ	0.9883	Obser	18
RBSQ	0.9876	from	1996
DW	1.06	to	2013

Var name	Reg-Coef	Mexval	t-value
intercept	0.27782	21.5	2.757
@log(uc09)	1.14899	825.9	36.820

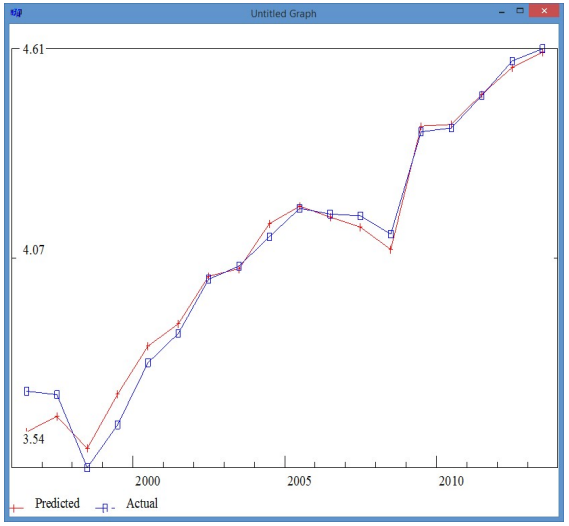


► Example 2: Furniture manufacturing

r @log(ppil46) = @log(uc46), D109FF

RSQ	0.9837	Obser	18
RBSQ	0.9815	from	1996
DW	0.77	to	2013

Var name	Reg-Coef	Mexval	t-value
intercept	0.68625	40.7	3.833
@log(uc46)	0.86496	381.1	18.226
D109FF			



6 System of National Accounts

- SNA shows the origin, its reallocation and use of income by institutional sectors
- Economic activities are dedicated to different phases of economic cycle (functional tansaction)
  - ⇨ (i) production,
  - ⇨ (ii) income generation,
  - ⇨ (iii) income distribution,
  - ⇨ (iv) use of income
  - ⇨ (v) capital accumulation.
- The forecasting modell combines IOT and SNA to a consistent booking system
  - ⇨ The linkages are among others **production, value added, intermediate demand and income**
  - ⇨ “Used” elements of SNA are estimated, “received” items are defined according to the accounting system and under consideration of the rest of world

4. Outcome

Main assumptions

- Population increases constantly.
- Accelerating increase of older population *POPO*
- Exchange rate remains constant
- World trade growth in average 5%
- Main refinancing interest rate remains constant
- Raw material prices increase constantly

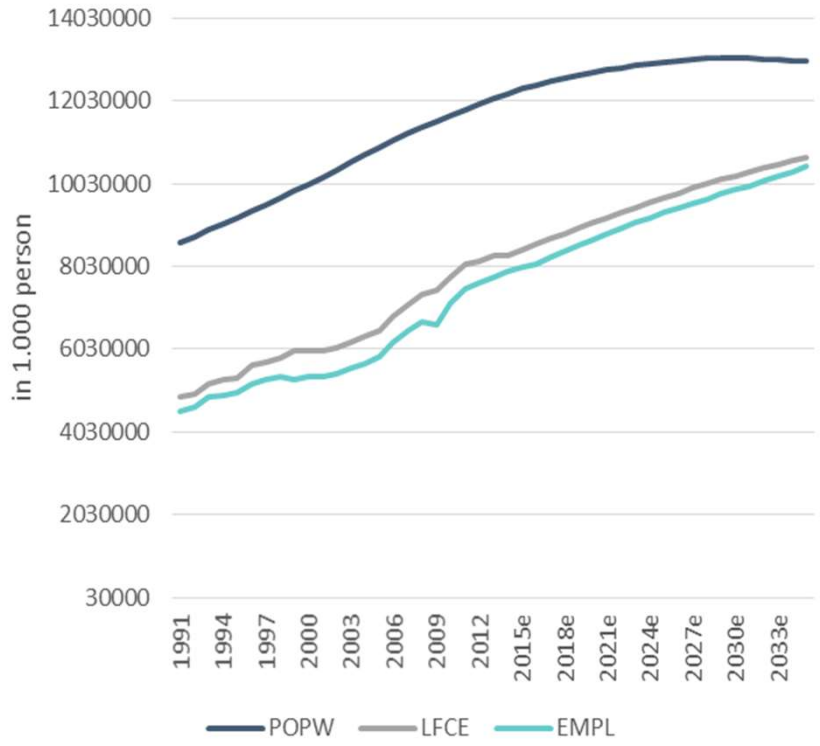
GDP and components

Price-adjusted	2005-2010	2010-2015	2015-2020e	2020-2025e	2025-2030e	2030-2035e
Gross domestic product	3,8	3,9	2,2	2,6	2,2	1,7
Private consumption	5,6	4,7	3,8	3,4	2,8	2,4
State consumption	5,2	3,5	3,2	2,1	1,7	1,1
Investment	6,4	4,9	2,1	3,3	2,9	2,6
Exports	0,9	1,8	2,7	3,7	3,0	2,9
Imports	7,9	3,0	4,1	4,1	4,0	4,1

- ⇨ Until 2025, average growth rate can be increased, than, declining average growth
- ⇨ Mainly driven by a **constantly high demand of private households**. This can be explaned by the **growing population**.
- ⇨ Chile's foreign real **trade balance** will remain **negative.**

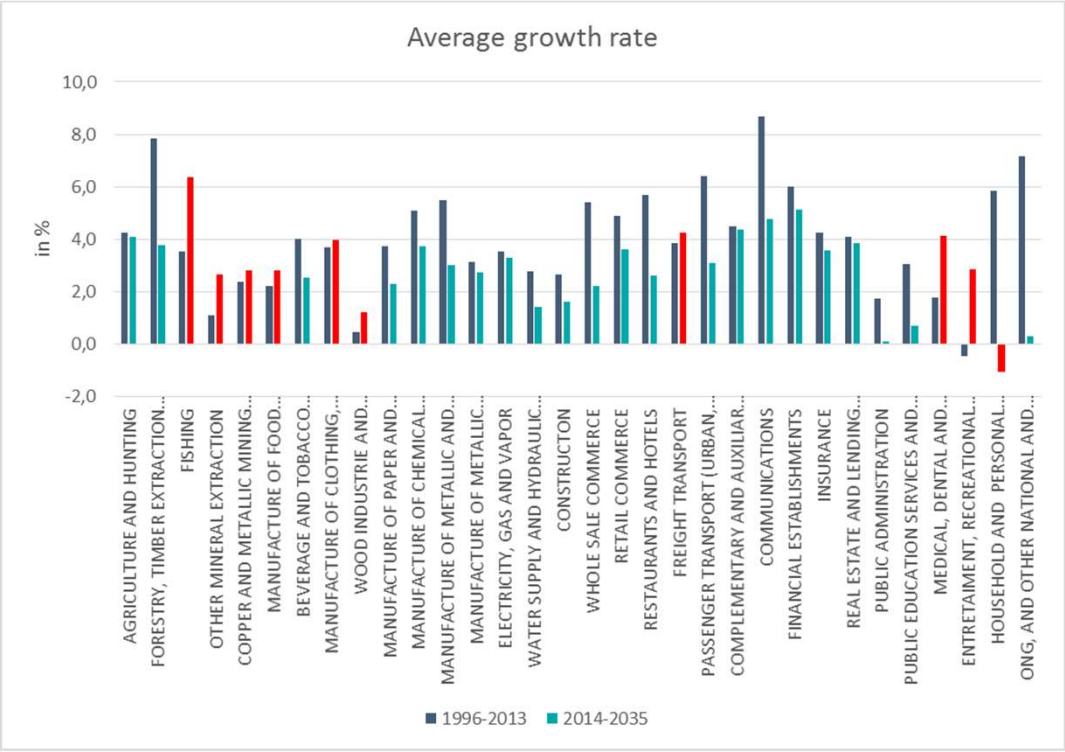
Labour market

- Positive growth perspective are transmitted to the labour market
- Gap between labour force and labour demand declines → labour becomes more scarce



Structural development

- Real production
  - ⇨ In average, growth is slower than in the past



⇨ Except for some sectors; especially for „medical, dental and sanitation services" a much higher growth path is expected

⇨ Also: copper production will increase slightly faster than in the future

5. Next steps adhead

Next steps ahead

- COFORCE on national level finalized
  - ⇨ but: update on new data possible
  - ⇨ depends on resources (personel, time) but may be sensible
  - ⇨ some improvements in modelling approach to be considered
    - include volume of work on labour market to account better for part-time work
    - include capital stocks

- Next step ahead: regionalization of COFORCE

Methodology Overview

No Inforum model has ever been completed, finished, and totally satisfactory. Building and working with them is a continuous adventure. It is, in our slightly immodest opinion, the most extensive effort in the world today to understand how modern economies work, to record that understanding in a form which makes it applicable and testable, and then to apply it to questions of policy and forecasting.

(Clopper Almon 1996)

Thank you for your attention.

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