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Copper Forecasting Chile – COFORCE

Methodology Report.

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1 INTRODUCTION

The research project "Development of sustainable strategies in the Chilean mining sector through a regionalized national model" will analyse the socio-economic impacts of copper on the Chilean economy. For this, a regionalized national model was developed from scratch. It is based on the modelling philosophy of the INFORUM group and characterized as a macro-econometric input-output-model.

The analysis of copper and mining sectors is a major issue in Chile. Many studies have focused on this research area, but mainly do ex post analysis and use General Equilibrium Models. Different to these approaches, we built a dynamic input-output-model for the Chilean economy where parameters are estimated and the model equations are solved iteratively over time and no equilibrium conditions are met. That means for instance, that the labour market does not necessarily balance in the long run as well. The main features of the model are bottom-up modelling on 73 industry level, total integration of input-output-tables and national accounts that consider not only inter-industry relations but also income distribution and use. Further characteristics are bounded rationality of economic actors, imperfect markets as well as price rigidities. Demand and supply are both treated equally. The projection horizon of the model is 2035. The data used are official datasets compiled and provided by the Chilean project partners.

This paper is a methodology report on the construction of the model. It describes the general modelling concept and illustrates first results of the baseline scenario, which includes major indicators of the total economy and its sectors.

2 OTHER APPROACHES ON MODELLING IN CHILE

The research project "Development of sustainable strategies in the Chilean mining sector through a regionalized national model" enquires the socio-economic impacts of copper on the Chilean economy. The chosen quantitative method in this project is a macro-econometric input-output-model: Input-output-models are based on input-output-tables that represent the interdependencies between different branches of a national economy. They can show separately the direct, indirect and induced effects which are caused by economic changes and which are an important aspect for this project.

In contrast, Chilean research institutions have focused on using macroeconomic General Equilibrium Models[1], Computable General Equilibrium Models[2], Dynamic Stochastic General Equilibrium Models[3] and other quantitative methods to address topics concerning Chile.

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[1] Abbreviated GEM

[2] Abbreviated CGE

[3] Abbreviated DSGE: is an inter-temporal modelling approach.

The GEM is a system of equations that deals with interactions and outcomes of economic policies by diverse aggregations of agents and markets representing a dominant part of an economy (Chumacero & Schmidt-Hebbel 2005: p. 2). In Chile, modelling with GEM started in 1960s, addressing mainly historical macroeconomic policy concerns such as inflation. In those times, copper was an approached topic as well. The developed model focused on simulating counterfactual changes in copper market conditions and domestic policies in Chile during 1956-1968.

In the anthology of the Central Bank of Chile (Chumacero & Schmidt-Hebbel 2005) recent macroeconomic GEMs are compiled. They focus on assessing macroeconomic policy changes, on changes in trade and tax policy and on external shocks. Two developed GEMs are able to characterize short- and medium-term dynamics: Corbo and Tessada, as well as Garcia et al., measure the impact of external shocks on the Chilean economy (ib.: pp. 29-55; pp. 57-112). The researchers confirm the Chilean economy's strong dependence on the external environment. This dependence is to be expected given the high degree of openness of the Chilean economy, where international trade and external financing are relatively important to the size of the economy. A forward-looking behavior in fiscal and monetary policy can absorb shocks with significant transitory effects.

Five other modelling approaches in the previous mentioned anthology are dynamic GEM's grounded on microeconomic foundations which address macroeconomic policy changes such as identifying the determinants of Chilean economic growth for the period 1960-2000. All these models have in common to explain past economic phases of Chile and do not simulate forecasted scenarios for the future (cf. chapters 1-7, 10, 11 of Chumacero & Schmidt-Hebbel 2005).

However, two other modelling approaches address recent policy questions, simulate scenarios and make suggestions relating to policy reforms that are in general seriously considered by Chilean authorities. By using a CGE model, Harrison, Rutherford and Tarr highlight the importance of market access and lowering the tariff to six percent (ib.: pp. 303-343). CGE models serve to assess how the economy as a whole will react to any exogenous change. It is an analytical representation of all the transaction in a given economy in such a way that it is possible to connect each element of the model with some observed empirical data. O' Ryan, de Miguel and Miller measure with a multisector CGE termed ECOGEM and based on a Social Accounting Matrix[4] the economic, environmental and social impacts of an increase in fuel taxes of 100 % (ib.: pp. 345-373). They represent the result that sectors providing alternative energy products would benefit from the policy. The oil extraction, the production and the transport sector are the identified sectors, that are affected negatively.

Mardones Poblete (2010) generates six simulations for the period of 2003-2025 with a dynamic CGE to quantify the impacts of reforms to the Chilean tax system. In particular it concerns the effects on decreases in the value added tax (VAT) and on increases in income tax. Reforms of lowering the VAT and of raising the income tax of the richest quintile of the population have the advantage of increased salaries in different qualification levels and also of raising the income of the first four quintiles. Furthermore, a slight increase in exports and

[4] Abbreviated SAM: are very similar to IO and capable of measuring the different economic agents.

decrease in imports is observed.

All above mentioned equilibrium models (Chumacero & Schmidt-Hebbel 2005; Poblete 2010) evaluate taken measures in financial and economic policies but do not put a specific focus on the copper production. There are only a few economic analyses existing in Chile with a focus on sectors and on regions (cf. Poblete measuring the impact of a fishery crisis in the Region VIII). Pérez-Ruiz (2017) and Fuentes & García (2014) have analysed the mining sector and its impact on economy with a vector auto-regression[5] model respectively with a DSGE model.

Pérez-Ruiz studies with her developed VAR model data spanning from 1995 to 2016 for the mining, the manufacturing and the construction sector to make conclusions about how the production of these three stylized Chilean sectors relate each other in response to a copper shock. Main indicators for her research are the real copper prices, the real gross value added, the world real GDP, the U.S. consumer price index and the FED funds target rate. Pérez-Ruiz can confirm positive spillovers from commodity sector to the non-commodity tradable (manufacturing) and the non-tradable (construction) sector. However, the size of the spillovers seems to be modest, though shocks originating in copper prices have permanent effects on growth in the two other sectors. Large capital costs and long investment times prevent mining supply from responding quickly to a positive copper price shock. A related research was made in 2016 by Fornero, Kirchner & Yany: With a DSGE model they analysed the propagation channels of commodity price changes and the response of the Chilean economy to commodity price shocks affected by different types of fiscal rules. The results suggest the importance of flexible inflation targeting, floating exchange rates and structural fiscal rules to efficiently manage commodity price volatility. While different monetary and fiscal policy reactions have, in general, important implications for the response of the economy to commodity price shocks, the rules only have small impacts on investment decisions in the commodity sector that are mainly driven by sectoral productivity developments and commodity prices.

Fuentes & García (2014) used a DSGE model to measure the contribution of the mining sector in the economic cycle explaining the interconnections of this sector with the rest of the productive sectors. Macroeconomic information, as well as data of the mining sector, was received from the Central Bank of Chile. In quantitative terms results show, that an increase of 1 % of the copper price causes an accumulated increase of 0.16 % GDP in five years due to the low backward linkages of the mining sector with other productive sectors.

Data used in Chilean researches mainly comes from national authorities like the Central Bank of Chile, COCHILCO (Comisión Chilena del Cobre), INE (Instituto Nacional de Estadísticas) or the Dirección de Presupuestos de Chile. Many models also use information from the Encuesta Casen (de Caracterización Socioeconómica Nacional) mandated by the Chilean Ministry of Social Development and the FECU (Ficha Estadística Codificada Uniforme).

[5] Abbreviated VAR: is a stochastic process model for simultaneous estimations of multiple equations.

3 METHODOLOGY OVERVIEW

The macro-econometric IO model COFORCE (COpper FORcasting ChilE) was developed to analyse Chiles economy in general and its economic dependency on copper in specific for the long run. Its forecasting and scenario ability are both suitable for this task. Its dynamic construction allows to encounter adaptation processes. The current version of the model runs until 2035.

COFORCE goes in line with the model characteristics of the German forecasting model INFORGE (Interindustry Forecasting Germany), QINFORGE (Qube Interindustry Forecasting Germany), the Austrian and Russian model e3.at respectively e3.ru or GINFORS (Global Interindustry Forecasting System). These models have been developed by the Institute of Economic Structures Research (GWS) and have been tested in numerous application in the field of research and policy analysis (Maier et al 2017b, Maier et al. 2015, Maier et al. 2014b, Wiebe et al. 2012, Stocker et al. 2011, Großmann et al. 2011).

This type of model has many features in common with standard CGE models (Almon 1991). The data set (input-output tables and national accounts) as well as the non-linear functions are of similar nature. Both model types consider supply constraints, prices and the feedback loop between income and final demand. All equations are solved simultaneously. The theoretical foundation of the models differ, however. CGE models focus on equilibrium situations (West 1995) most often following neo-classical tradition. The applied model here, instead, borrows from evolutionary economics (Nelson and Winter 1982) and features technological change, imperfect competition, interdependencies, and partially sticky prices. Parameters and their elasticity values are estimated econometrically with given time series for a large number of variables, whereas most CGE models calibrate their parameters on a given benchmark or obtain elasticity value from literature (Peichl, 2005).

COFORCE belongs to the INFORUM modelling family (Almon 1991) that rest on two fundamentals: bottom-up construction and total integration. The former indicates that each industry respectively product is modeled individually and macroeconomic variables are calculated through explicit aggregation. This ensures that each single industry is embedded within the economic context. The latter describes a complex and simultaneous solution, which takes inter-industrial dependence as well as the complete economic circle from generation of income, distribution of income, the redistribution effects of the government and the usage of income for goods and services into consideration. Thus, the input-output-tables are fully integrated in the national accounts and each sector such as government, private households, companies and rest of world is treated individually (Ahlert et al. 2009). Due to its interdependent and detailed modelling structure this kind of model allows for in-depth analysis on industry and sectoral level. Winners and losers of different policy measures can be identified.

COFORCE is a single country forecasting and simulation model. At the expense of endogenous exports and import prices, a single country forecasting model has the advantage of being much more detailed and explicit.

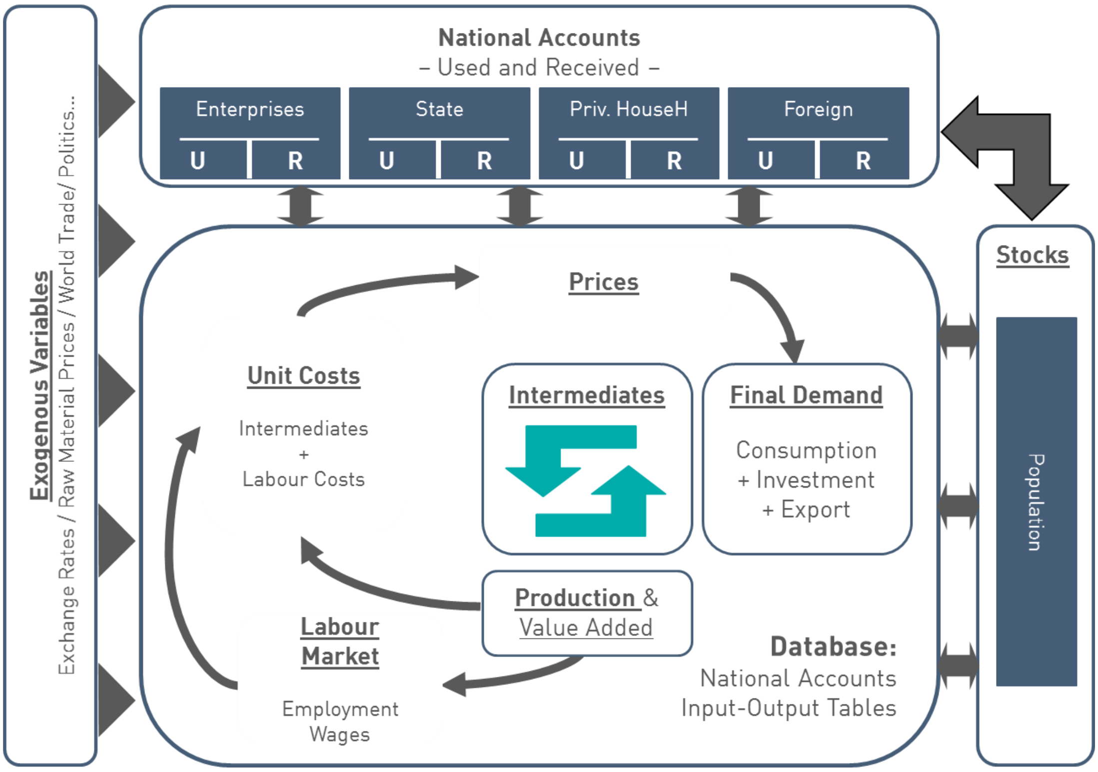
The model is based on a comprehensive data set using original Chilean data obtained from the project partners of University of Adolfo Ibañez. The dataset is retrieved by official data producers like the Chilean Central Bank or the National Statistical Bureau. The degree of detail is not limited by the modelling approach but only by its used statistics. For different variables different aggregation levels exist.

A prerequisite for econometric models is the availability of data as a time series. Most variables are modelled endogenously – either as behavioural equations or by definition – and are therefore dependent on each other. Only a few variables are given exogenously such as population forecasts or exchange rates.

4 THE ECONOMIC CORE OF COFORCE

Figure 1 shows a simplified illustration of the modelling framework of COFORCE. Positioned in its centre are input-output relations of intermediate demand, final demand components and primary inputs that define value added and production. National account data and stock data such as population are linked to the input-output world. Labour market variables such as employment and wages are related to production output. Prices are derived by using a unit cost approach. Amongst others, prices in turn affect price-adjusted final demand components. The complete economic circle is captured and many feedback loops are considered. However, some exogenous variables exist: Population forecast, central bank interest rates, raw material prices, world trade, exchange rate or politics are parameters that are not determined within the model but are given exogenously by either third party information or by setting own assumptions.

Figure 1: Simplified illustration of the modelling framework of COFORCE



Input-output tables and national account data are given from our Chilean partners for years 1996, 2003, 2008-2013. The industry detail corresponds to the information provided by these tables (73 industries and products – see Table 9 in the Appendix). All total values are derived by aggregation from sectoral information.

The system of national accounts is fully integrated into the model. Generally, "used" elements of national accounts are estimated, "received" items are defined according to the accounting system and under consideration of the rest of world.

Estimation equations are performed on industry level. All final demand components (private and non-profit institutions serving households, government consumption, equipment and building investment, exports and imports) and intermediate demand as well as wages, employment and prices are estimated. Regression functions are given in more detail in sections 4.1 and 4.2.

The ordinary least square (OLS) method is used for performing regressions. The regression equations are checked against common test statistics such as Durbin Watson, t-test, R^2. To the disadvantage of possible inconsistent estimation, the OLS method allows for controlling system stability. Excellent regression test values do not mean automatically a stable system or a good forecasting performance (Großmann & Hohmann 2016). This is often the case in comprehensive structural models that compute a high number of interconnections (Frohn et al. 2003: 195): Right-hand side variables of one equation are calculated as left-hand side variables within another equation.

Due to these many feedback effects the model has no explicit solution. The model equations are solved for each year iteratively. The iteration process ends once the convergence criteria is fulfilled. The convergence criterion is defined as percentage deviation of the previous iteration on nominal production by industries. When the difference is below 0.01 %, the iteration process stops and all equations for a given year are calculated. Afterwards, the iteration process starts again for the subsequent year.

4.1 FINAL DEMAND (AT PURCHASER PRICES)

4.1.1 PRIVATE HOUSEHOLD CONSUMPTION

Private household consumption expenditures are the most important contributor to economic growth in Chile. Its nominal growth impact is usually over 4 % and usually higher than the growth impact of foreign trade. The use tables provide information about the consumption sectors. The ten largest (nominal values) consumption sectors are listed in Table 1. Home ownership is outstanding the most important product consumed by private households. Followed by products used for health care, food, transport and communication.

Table 1: Ten most important private consumption sectors, 2013

	Share of total	Sector
1	9.8 %	Home ownership
2	4.8 %	Private health
3	4.5 %	Restaurants

4	4.2 %	Financial intermediation
5	4.0 %	Fuel production
6	4.0 %	Other land passenger transport
7	4.0 %	Meat production
8	3.6 %	Private education
9	3.4 %	Manufacture of clothing
10	3.3 %	Manufacture of machinery and electrical equipment

Source: COFORCE

Private household consumption is mostly based on the almost ideal demand system developed by Deaton and Muelbauer (1980) which assumes utility-maximizing consumption of a representative household. In COFORCE, however, neither an aggregate consumption function is used nor does it estimate a saving function for private households. Moreover, saving is a residual in COFORCE that is derived as the difference between disposable income and total consumption expenditures.

Real private household consumption expenditures $hcesr$ are estimated bottom-up on sector level i. It is a function of real personal income $\left({}^{DB6000RH}/_{HCPOP}\right)$ and relative prices $\left({}^{ppil_i}/_{HCPOP}\right)$. This approach considers overall price inflation as limitation for expanding consumption expenditures as well as relative product price shifts. If a specific sector price increases faster than the overall price level, the products of this sector are consumed less. Disposable income is determined in the system of national accounts (see sector 4.8).

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

[2] $HCESR = \sum hcesr$

Private household consumption expenditures in nominal terms $hcesn$ are derived by definition by multiplying the real consumption expenditures $hcesr$ with the overall price development $HCPOP$. The overall price development is estimated as an aggregate function influenced by the development of producer prices PS.

[3] $HCPOP = HCPOP(PS)$

[4] $hcesn = hcesr * HCPOP/100$

[5] $HCESN = \sum hcesn$

The aggregates of nominal and real private consumption expenditures are derived by definition.

4.1.2 CONSUMPTION EXPENDITURES OF PRIVATE INSTITUTION FOR NON-PROFIT

Non-profit organizations are for instance unions, parties, churches or associations. They only have a very small growth impact on both nominal or real gross domestic product. That is why often non-profit organisation consumption is combined with private household consumption expenditures. However, the Chilean use tables separate both consumption institutions. In Chile, non-profit organization consume 97 % from other service activities sector.

It is estimated in nominal terms by using disposable income of households $B6000RH$ as a proxy for non-profit organization's disposable income. This proxy is legitimate as the system of national accounts does not – different to the IO tables – differ between private households and non-profit organisation.

[6] $cpon_i = cpon(B6000RH)$
[7] $CPON = \sum cpon$

Real values of non-profit organization consumption expenditures uses the same aggregate price index as private households $HCPOP$.

[8] $cponr = cponr * HCPOP/100$
[9] $CPONR = \sum cponr$

Again, aggregate values are derived by definition.

4.1.3 GOVERNMENT CONSUMPTION EXPENDITURES

Compared to private household consumption expenditures, government consumption expenditures have a less strong growth impact on GDP. It contributes around 1.2 % to nominal GDP growth. Government expenditures are also more concentrated on specific sectors. In 2013, 94 % of total (nominal) government consumption expenditures were spent in the sectors public administration (48 %), public education (24 %) and public health (22 %).

Generally, the major driving force for **government expenditure** by products $gces$ is state disposable income $B6000RG$. Additionally, for some sectors an autonomous time trend was used due to the assumption, that certain government expenditures are independent of exogenous influences.

[10] $gces_i = gces_i(B6000RG),\ \ i \in (1,..,73)$

The aggregate price index for government expenditures GCESP is explained by producer prices.

[11] $GCESP = GCESP(PS)$

Price adjusted government expenditures as well as the corresponding aggregates are derived by definition.

[12] $gcesr_i = gcesr_i/GCESP * 100$
[13] $GCESR = \sum gcesr$
[14] $GCESN = \sum gcesn$

4.1.4 GROSS FIXED CAPITAL FORMATION

In COFORCE, gross fixed capital formation is not further split between investment in machinery and equipment and investment in buildings. However, building investments mainly refer to one sector alone: construction industry. Altogether, gross fixed capital formation's (without inventories) contribution to nominal GDP growth fluctuates yearly but in average amounts to around 2 %. Investments are therefore an important component for growth. Table 2 shows the five largest (nominal) shares of investment by industries.

Table 2: Five most important investment by industry, 2013

	Share of total	Product type
1	55.4 %	Construction
2	10.8 %	Manufacture of machinery and non-electrical equipment
3	8.8 %	Manufacture of machinery and electrical equipment
4	7.4 %	Manufacture of transportation equipment
5	6.1 %	Business service activities

Source: COFORCE

Corresponding to the determination of other demand components, gross fixed capital formation follows a bottom-up approach by differentiating on the level of investing industries.

Gross fixed capital formation is estimated in real terms by using real production by industries and by real disposable income of non-financial institutions ${}^{B6000RN}/_{PS}$. The higher the overall income of non-financial institutions the higher the demand for investment.

$$[15]\quad gicnr_i = gicnr_i\left(ysr_i, {}^{B6000RN}/_{PS}\right),\ i \in (1,..,73)$$

The aggregate price index for gross fixed capital formation $GFCFP$ depends on aggregate production price index PS.

$$[16]\quad GFCFP = GFCFP(PS)$$

Again, nominal investment and aggregate values are retrieved by definition.

$$[17]\quad gicn_i = gicnr_i * GFCFP/100$$
$$[18]\quad GICNR = \sum gicnr$$
$$[19]\quad GICN = \sum gicn$$

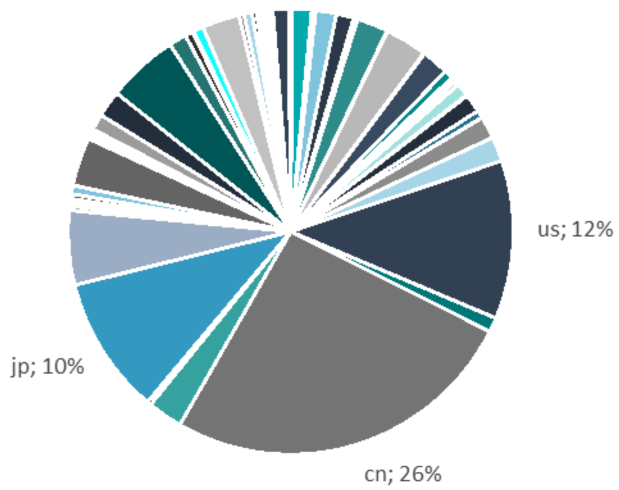
4.2 FOREIGN TRADE

Chile is an open economy that exports and imports different goods in different degrees with a wide range of trading partners all over the world. In 2015, the degree of openness amount to around 60 %. In the years before, the degree of openness has declined continuously. This is also reflected in a low to negative growth impact of foreign trade to GDP growth. Since 2007, import demand growth exceeded the growth of export demand regularly, except for year 2009.

The export and import demand structure differs however considerably. While export demand is concentrated to 45 % on copper mining industry, import demand is much more diverse. 28 % of import demand is dedicated to three sectors: manufacture of machinery and non-electrical equipment (9.8 %), fuel production (9.5 %) and manufacture of machinery and electrical equipment (9,4 %).

Chiles main exporting countries are shown in Figure 2. It shows, that Chile highly concentrates on exports to China. Almost 50 % of all exports are destined to three countries alone: China (26 %), USA (12 %) and Japan (10 %). Related to copper exports, the main trading economies are China, Japan, Korea and India. The United States – although second largest trading partner in total – is not a big user of Chilean copper.

Figure 2: Main export destination of Chile's total exports, 2016



Source: OECD Bilateral trade matrices, 2016

4.2.1 EXPORT DEMAND

COFORCE is a national model for which foreign trade is an exogenous variable. However, in order not to depend on third parties judgement on future world trade development, the world trade model TINFORGE is used to estimate Chile's **export demand**. TINFORGE enhances the capacity of COFORCE to deliver information on Chilean international trade (Wolter et al 2014, Großmann et al. 2015). A simplified sketch of the world model is given in Figure 3.

TINFORGE computes bilateral trade by 155 countries and 33 industries (ISCID Rev. 4). Chilean export demand is determined by the import demand of 155 trading partners for 33 industries (see Table 11 and Table 12 in the Appendix for more detail). The trade matrices are connected to simple macroeconomic models of 80 major countries. Around 30 macroeconomic aggregates are estimated for each of these 80 national models. These include GDP and its components in price-adjusted and nominal values, the associated price indices and four key labour market indicators (economically active population, employment, unemployment and wages). The model also incorporates UN demographic projections. TINFORGE is primarily based on OECD data, complemented where necessary by EUROSTAT, UN and International Monetary Fund (IMF) data. Bilateral trade is modelled on the basis of the OECD's bilateral trade matrices.

Figure 3: Simplified sketch of the world trade model TINFORGE

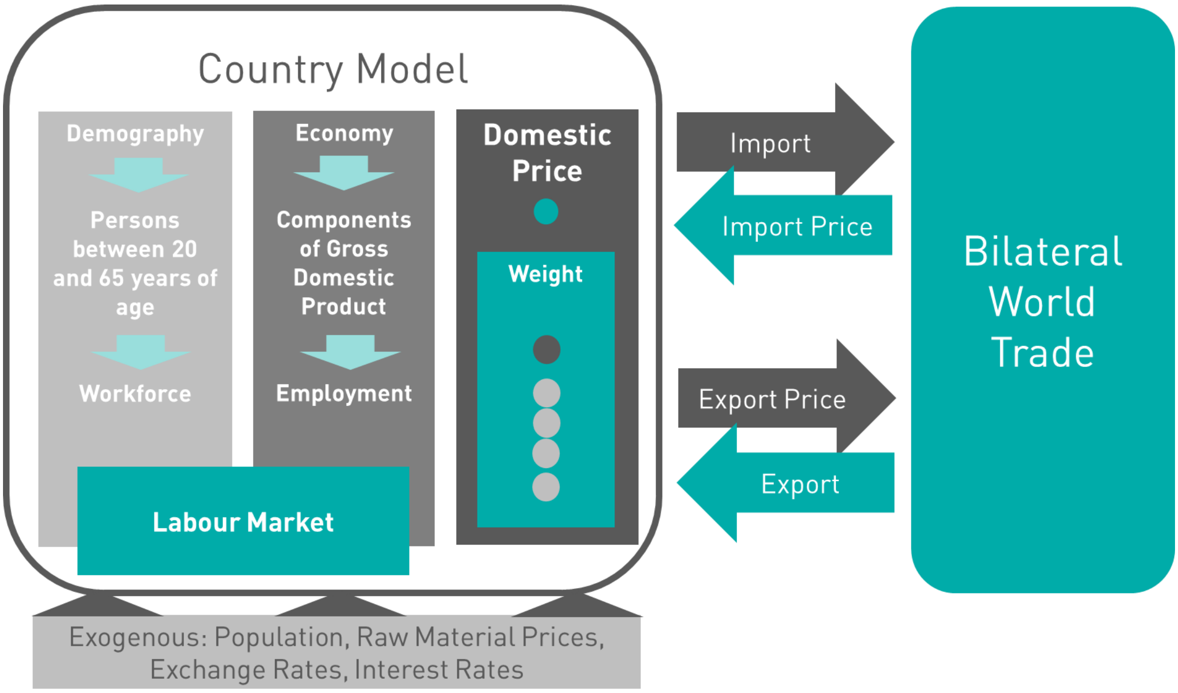
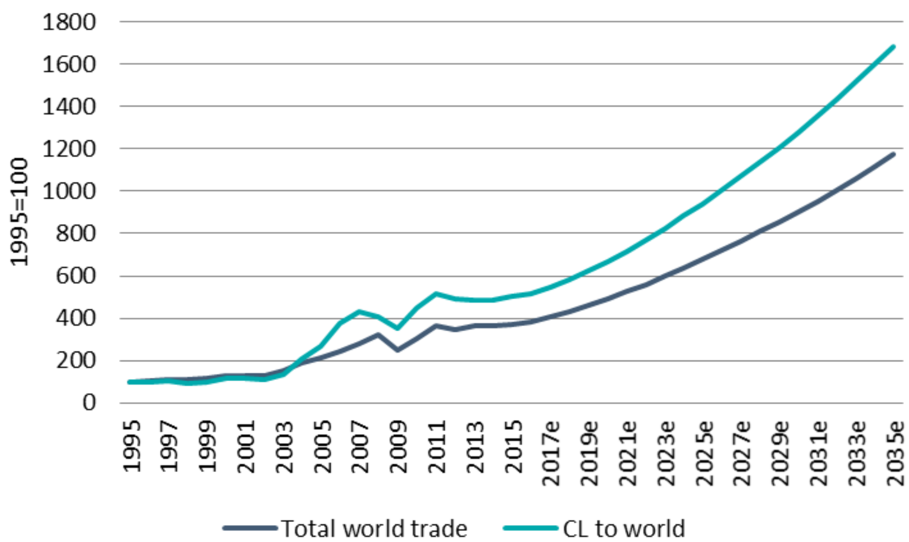


Figure 4 shows as index numbers the dynamics of total world trade as projected from TINFORGE and Chile's export dynamics. Chile has started to grow faster than total world trade in 2005 and continuous to do so until 2035. However, Chile's export share in total world trade remains low with roughly 0.5 %.

Figure 4: Development of total world trade and Chile's total export



Source: TINFORGE

Nominal export demand $eggs$ is deviated from the Chilean bilateral trade matrix BXTT in billion USD that holds information on export demand by 33 industries and by 155 trading partners. Aggregated over 155 trading partners computes the explanatory variable $exnev$

for Chilean exports by sectors. Bilateral exchange rate Chilean Peso to US Dollar $BEXR$ is considered in the estimation function.

[20] $eggs_i = eggs_i(exnev_k, BEXR)\ ,\ i \in (1,..,73), k\ \in (1,\ldots,33)$

In the history, information on export prices on production level were available, whereby structural price estimation instead of aggregate price estimation was possible. Export prices eggsp depend on domestic price developments ppil and import prices igssp. Both input factors influence export prices positively.

[21] $eggsp_i = eggsp_i(ppil_i, igssp_i)\ ,\ i \in (1,..,73)$

Real export demand and the corresponding aggregates are calculated by definition.

[22] $eggsr_i = eggs_i/eggsp_i * 100,\ \ i \in (1,..,73)$
[23] $EGGS = \sum eggs$
[24] $EGGSR = \sum eggsr$
[25] $EGGSP = 100 * EGGS/EGGSR$

4.2.2 IMPORT DEMAND

Import demand can be distinguished between industries that import final products and intermediate products. This information are provided by the input-output tables. COFORCE models this differentiation, however in a very simplified form.

Regression analysis are performed on the level of total imports $igss$. Imports are generally explained by nominal domestic production by industries ysn. However, for some sectors also final demand $fdnd$ can be well used as explanatory variables. Final demand is mostly used for sectors that produce products consumed predominantly by private households such as footwear.

[26] $igss_i = igss_i(ysn_i, fdnd_i)\ ,\ i \in (1,..,73)$

Total imports can be split into intermediate $iimnp$ and final $ifnd$ import demand. Chile imports predominantly intermediate goods. In 2013, 56 % of total nominal imports were intermediate goods. However, since 2008, final import demand increases faster than intermediate import demand (compare Figure 5).

Figure 5: Shares of intermediate and final imported goods to total import demand

Source: COFORCE

Nevertheless, in the long run, the distribution of total imports between final and intermediate demand is relatively stable which is why constant shares $qiimn$ are used to separate estimated total import demand in final and intermediate import demand. This approach denies shifts between the proportion of intermediate and final import demand. A more sophisticated approach would individually estimate final and intermediate import demand. Final and intermediate imports are separated as given in the following two equations:

[27] $iimnp_i = qiimn_i * igss_i/100, \;\; i \in (1,..,73)$
[28] $ifnd_i = qiimn_i * igss_i/100, \;\; i \in (1,..,73)$

Same as with export prices, information on import prices on production level are available and structural price estimations are possible. Import prices $igssp$ depend on world import price of raw materials $weoreptc$. Raw material prices are taken from the IMF World Economic Outlook (see Table 13 in the Appendix for more detail).

[29] $igssp_i = igssp_i(weoreptc_r) \, , \;\; i \in (1,..,73), \;\; r \in (1,..,76)$

Real import demand and the corresponding aggregates are calculated by definition.

[30] $igssr_i = igss_i/igssp_i * 100, \;\; i \in (1,..,73)$
[31] $IGSS = \sum igss$
[32] $IGSSR = \sum igssr$
[33] $IGSSP = 100 * IGSS/IGSSR$

4.3 FINAL DEMAND AND GROSS DOMESTIC PRODUCT

Final demand and gross domestic product are defined by definition. They both can be computed as a result of previous calculations.

Final demand at purchaser prices $fdnd$ is the result of adding up private $hces + cpon$ and state $gces$ consumption, investments $gicn$, inventories $cies$ and exports $eggs$. It represents total final demand in Chile. All components are not corrected by their import content.

$fdnd_i = hces_i + cpon_i + gces_i + gicn_i + cies_i + eggs_i,\ i \in (1,..,73)$

[34] $FDND = \sum fdnd$

Gross domestic product $gdpt$ represents total final demand corrected by import demand.

[35] $gdptr_i = hces_i + cpon_i + gces_i + gicn_i + cies_i + eggs_i - igss_i,\ i \in (1,..,73)$

[36] $GDPT = \sum gdpt$

4.4 TRANSITION FROM PURCHASER TO BASIC PRICES

Chapters 4.1 and 4.2 have described the making-off final demand components at purchaser prices. Purchaser prices are prices relevant for final demand, because they do not only include production costs, but also taxes and subsidies.

However, for firms, purchaser prices are not the relevant price for production decision. On this level, basic prices are the relevant benchmark.

The share matrix $UAHQ$ describes the relation between final demand components at purchaser prices and basic prices. These informations are given from the IO-tables. While $FNDN$ is a matrix that describes nominal domestic final demand components and $FUNDI$ is a matrix of imported final demand components both at basic prices; the matrix FND represents total (domestic plus imported) final demand components at purchaser prices.

[37] $UAHQ_{i,j} = \left(FNDN_{i,j} + FUNDI_{i,j}\right) / FND_{i,j}\ , i \in (1, \ldots, 73), i \in (1, \ldots, 7)$

In the years after 2013, a relatively simple transition from purchaser prices to basic prices is performed. Domestic final demand at basic prices FNDN is retrieved by applying constant transition shares $UAHQ$. Final demand at purchaser price is the result of the regression analysis of chapter 4.1 and 4.2. Imported final demand at purchaser prices $FUNDI$ has to be substracted in order to obtain only domestic final demand at basic prices.

[38] $FNDN_{i,j} = \left(UAHQ_{i,j} * FND_{i,j}\right) - FUNDI_{i,j}, i \in (1, \ldots, 73), i \in (1, \ldots, 7)$

By adding-up across demand components j, total final demand at basic prices is computed.

[39] $fdnb_i = \sum_{j=1}^{7} FNDN_{i,j}\ , i \in (1, \ldots, 73), i \in (1, \ldots, 7)$

4.5 INTERMEDIATE TRANSACTION AND PRODUCTION

Input coefficients show the relation between intermediate demand and total production. Changes in these coefficients define technology change. In total, 5329 industry-by-industry-combinations exist. However, not all combinations are filled.

In COFORCE, the technical coefficients are dynamic over time and estimated with an autonomous time trend.

[40] $DINCT_{i,j} = DINCT_{i,j}(1/TIME), i \in (1, \ldots, 73), i \in (1, \ldots, 73), j \in (1, \ldots, 73)$

Due to the large number of input coefficient, only those 100 input coefficients are estimated that belong to the 100 largest intermediate demand combinations. In total, the top 100 combinations represent 45 % of all domestic inputs in year 2013. The twenty largest intermediate demand combinations are given in Table 3.

Table 3: Top 20 intermediate demand combinations (2013)

Industry		Product		input coefficient
Extractive Fishing	5	Fishing Industry	12	63
Farming	3	Meat Production	11	57
Copper Mining	9	Basic industries of non-ferrous metals	41	53
Electricity supply	48	Electricity supply	48	41
Manufacture of animal feed	17	Extractive Fishing	5	34
Agriculture	1	Milling	16	31
Commerce	52	Other manufacturing industries	47	29
Farming	3	Milk Industry	15	28
Gas supply	49	Gas supply	49	24
Fruit farming	2	Canning Processing	13	24
Business service activities	65	Manufacture of spirits and liqueurs	21	23
Manufacture of animal feed	17	Farming	3	21
Communications	61	Communications	61	21
Forestry	4	Forestry	4	20
Forestry	4	Production of wood and its products	30	19
Business service activities	65	Insurance companies	63	19
Business service activities	65	Oil Extraction	7	19
Business service activities	65	Manufacture of transportation equipment	45	18
Other Mining Activities	10	Manufacture of other non-metallic mineral products	39	16
Financial intermediation	62	Insurance companies	63	16

Source: COFORCE

Table 4 presents a comparison of other country's input shares. The sample shows that the share of the top 100 inputs in European countries is around 50 % and in the USA around 47 %. These shares are higher than in Chile, where the quota is 45 %, but they don`t differ significantly to other countries.

Table 4: Share of Top 100 inputs on total inputs (domestic)

Germany (2013)	50.6
France (2011)	50.2
France (2013)	49.1
Spain (2010)	54.9
USA (2010)	47.4
USA (2011)	47.9
USA (2012)	47.7
Chile (2013)	**45.2**

Source: Source: Eurostat, Banco de Chile; own calculation

Domestic intermediate demand $dimni$ is the sum over 73 products for each of 73 industries.

[1] $$dimni_j = \sum_{i=1}^{73} DINCT_{i,j}\, , i \in (1, \dots ,73), i \in (1, \dots ,7)$$

Production ygn is defined by using the Leontief multiplier $(IL - DINCT)^{-1}$that combines intermediate demand with domestic final demand $fdnb$. While A is the coefficient matrix for 73 categories of goods and industries and I is the identity matrix, $(IL - DICNT)^{-1}$ is the Leontief multiplier that gives domestic production by 73 industries when multiplied with domestic final demand.

[2] $$ygn_t = (IL - DINCT)^{-1} \cdot (fdnb_t)$$

4.6 VALUE ADDED

Value added is decomposed by labour compensation, profits and indirect taxes. Over 50 % of value added is dedicated to profits, 44 % to wages. Indirect taxes are a minor part of value added. Value added is computed according to its definition as production minus intermediate demand.

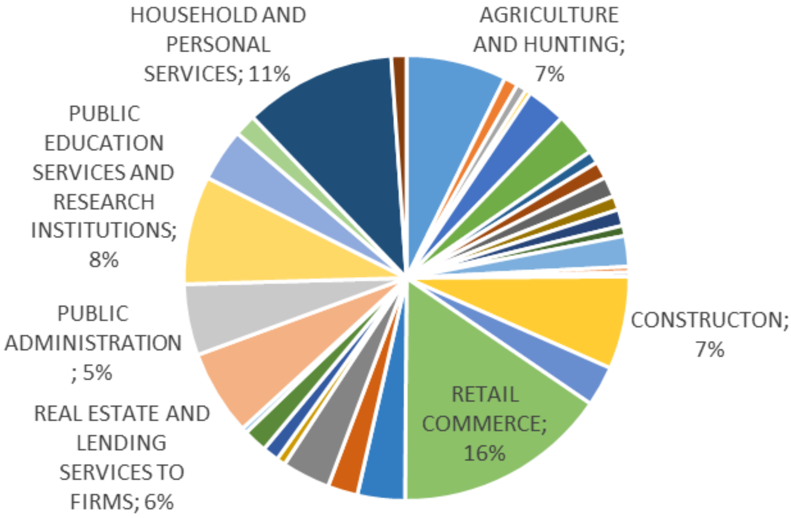
[3] $$vadd_i = ygn_i - dimni_i - iimn_i, i \in (1, \dots ,73)$$

Wages are determined on the labour market. In COFORCE, labour demand is determined by using a per-capita approach. The difference to a volume-based approach, that computes labour demand on the basis of hours worked, is that changing dynamics in full- or part-time work or annual working time are not explicitly modelled.

Employment $empll$ are estimated on a reduced sectoral level of 32 industries due to limited data availability (see Table 10 in the Appendix). Accordingly, adequate aggregation of 73 sectors to a level of 32 had to be computed in order to guarantee that all sectoral changes channel into employment estimation functions.

Total employment in Chile arose to 7.8 million persons in 2013. As shown in Figure 6, the fast majority (16 % of all employees) works in retail commerce. With 11 %, the household and personal service sector is the second largest labour-intensive sector in Chile. This is very different to other industrialized economies, where this personal service sector generally employs only very little people. Also, it is remarkable, that no manufacturing industry is listed among the ten top labour-intense sectors. Manufacturing food production (3.2 %) and copper and metallic mining extraction (2.8 %) are the two sectors with the most employees among manufacturing industries.

Figure 6: Employment by sectors, 2013



Source: COFORCE

Employment $empll$ depends positively on real production ysr and negatively on real wages $wage/ppil$. Estimated employment refers to employment demand by industries. That is, increasing real wages are increasing costs for firms. If nominal wages grow faster than producer prices, the wage increase goes to the disadvantage of firms. In tendency, this leads to job losses.

[1] $empll_k = empll_k(ysr_k, wage_k/ppil_k), k \in (1,..,32)$

[2] $EMPL = \sum empll$

Aggregate wage $WAGE$ is determined by using a Phillips curve approach. Accordingly, real GDP per capita inflated with consumer price ($\frac{GDPTR}{EMPL} * HCPOP$) and a scarcity factor between labour demand and supply (${}^{EMPL}/_{LFCE}$) are explenatory variables. Increasing real gross domestic product or increasing consumer prices induce wage increases as well as a growing scarcity of labour.

[3] $WAGE = WAGE\left({}^{GDPTR}/_{EMPL} * HCPOP, {}^{EMPL}/_{LFCE}\right)$

The overall wage level influences sectoral wages $wage$ together with sectoral nominal productivity $ysn/empll$. This allows to account for both, industry-specific business cycles as well as for general wage developments.

[4] $wage_i = wage_i\left(WAGE, {}^{ysn_i}/_{empll_i}\right)$, $i \in (1,..,73)$

Indirect taxes $idxn$ grow with real production. They are not estimated empirically. Moreover, it is assumed, that indirect taxes depend on real production dynamics with an elasticity of one.

[5] $$idxn_i = idxn_i[t-1] * {}^{(ysn_i/ppil_i)}\!\Big/_{(ysn_i[t-1]/ppil_i[t-1])}, \; i \in (1,..,73)$$

Profits $protn$ are the result of value added $vadd$ minus wages $wage$ and indirect taxes $idxn$.

[6] $$protn_i = vadd_i - wage_i - idxn_i, \; i \in (1,..,73)$$

4.7 UNIT COSTS, PRODUCTION PRICES

In COFORCE, production prices follow a unit cost approach. Unit costs are defined as costs per unit of real production. COFORCE differentiates between four different kinds of unit costs: unit labour costs $ulbt$, unit indirect tax costs $upit$, unit imported intermediate costs $uiite$ and unit domestic intermediate costs $udite$.

[1] $$uc_i = ulbt_i + upit_i + uiite_i + udite_i \, , \; i \in (1,..,73)$$

Production prices $ppil$ are basic prices and determined by unit costs uc and mark-up pricing. The magnitude of mark-up pricing depends on the prevailing industrial organization. Under monopolistic structures, mark-ups tend to be more generous than under competitive industrial structures. Price stickiness is signaled by an industry price elasticity that is lower than 1. Production prices influence price indices of final demand components and determine indirectly real final demand.

[2] $$ppil_i = ppil_i(uc_i) \, , \; i \in (1,..,73)$$

4.8 SYSTEM OF NATIONAL ACCOUNTS

The system of national accounts (SNA) delivers a comprehensive and quantitative image of economic activity within a nation. Where input-output tables represent a highly disaggregated account of production interdependencies of the total economy, the SNA shows the origin, its reallocation and use of income by institutional sectors. The SNA records economic activities according to national concept. This accounts for all economic activity that are permanently located in Chile. Activities, that take place within the national boundaries but by foreigners are therefore not considered, or more precisely, are part of the rest of world accounting.

Economic active units are separated into institutional sectors according to their kind and combination of activities, their financing opportunities as well as according to their position in the market: (i) non-financial enterprises, (ii) financial enterprises, (iii) state, (iv) private households and non-profit organization, (iv) rest of world.

Economic activities are dedicated to different phases of economic cycle (functional transaction). Each of these sub-accounts reproduce for each institutional sector their economic activity: (i) production, (ii) income generation, (iii) income distribution, (iv) use of income and (v) capital accumulation.

Table 5 shows the national accounts for 2013 for Chile. All sub-accounts needs to be balanced horizontally and vertically. The forecasting model combines input-output tables and system of national accounts to a consistent booking system. Their interface are among others production, value added, intermediate demand and income. They enter the system of national accounts. Due to the double accounting system, the results are always balanced.

Table 5: National account of Chile for 2013

2013		Total economy (S1)		Non-financial (S11)		Financial (S12)		State (S13)		Private HH (S14/S15)		Rest of world (S2)	
	BNo.	USED	RECEIVED	USED	RECEIVED	USED	RECEIVED	USED	RECEIVED	USED	RECEIVED	USED	RECEIVED
I. Production account													
Import	P7												45188
Export	P6											44319	
Production	P1		247403										
Intermediate	P2	121898											
Gross value added	B1B	125506											
Trade balance	B11											868	
II. Income generation and distribution account													
II.1 Income generation account													
Gross value added	B1		125506		84788		6469		13136		21113		
Compensation of employees	D1	54020		36892		2557		11641		2931			
Other taxes on production - other subsidies	D29-D39	3340		2637		97		20		586			
Bruttobetriebsüberschuss / Bruttoeinkommen	**B2B/B3B**	**68146**		**45260**		**3815**		**1475,34**		**17596**			
II.1 Primary income distribution account													
Gross operating surplus / gross income	B2B/B3B		68146		45260		3815		1475		17596		
Gross income	B3												
Compensation of employees received	D1		53934								53934		153
Compensation paid to employees	D1											68	
Other taxes on production received - other subsidies	D2D3		15064						15064				
Other taxes on production paid - other subsidies	D2D3												
Property income paid	D4	50913		33867		12953		840		3253		4734	
Interest rates paid	D41	17790		6438		7259		840		3253		795	
Distributions and withdrawals made	D42	26608		24918		1690						2465	
Reinvested earnings from the rest of the world	D43	2956,75		2438,48		518,26						1474,07	
Other investment income	D44	3486				3486							
Lease income paid	D45	71,39		71									
Property income received	D4		45828		7486		12505		456,7		25380		9820
Interest rates received	D41		16633,3		3224,0		11511,9		303,3		1594,1		1952,2
Distributions and withdrawals received	D42		24162,4		2787,7		474,6		82,0		20818,0		4910,6
Reinvested profits received from the rest of the world	D43		1474,1		1474,1		518,3		0,0		-518,3		2956,7
Other investment income received	D44		3486								3486,5		
Lease income received	D45		71,4						71,4				
Primary income	**B5**	**132059**		**18878,7**		**3366,6**		**16155,8**		**93657,8**			
II.2 Secondary income distribution account													
Primary income	B5		132059		18879		3367		16156		93658		
Income and wealth taxes paid	D5	8602		5708		620				2274			
Net social security contributions paid	D61	11128								11128			
Monetary social security contributions paid	D62	8397				2986		5411					
Other current transfers made	D7	9646		1076		2761		2841		2969		2074	
Net premiums written for non-life insurance policies	D71												
Non-life insurance benefits paid	D72												
Other current transfers made	D75												
Income and wealth taxes received	D5		8602						8602				
Net social security contributions received	D61		11128				8578		2550				
Monetary social security contributions received	D62		8397								8397		
Other current transfers received	D7		10766		705		2762		2289		5009		955
Net premiums received for non-life insurance	D71												
Non-life insurance benefits received	D72												
Other current transfers received	D75												
Disposable income	**B6B**	**133179**		**12800**		**8339**		**21346**		**90693**			
II.3 Income distribution account in kind													
Disposable income	B6		133179		12800		8339		21346		90693		
Social transfers received in kind	D63		10055								10055		
Social transfers made in kind	D63	10055						8961		1093			
Balanced disposable income	**B7**	**133179**		**12800**		**8339**		**12384**		**99655**			
II.4 Use income account													
Balanced disposable income	B7		133179		12800		8339		12384		99655		
Effective final demand	P4	104759						8259		96500			
Consumption (expenditure concept)	P3	104759						17220		87539			
Consumption expenditure for individual consumption	P31	10055						8961		1093			
Consumption expenditure for collective consumption	P32	8259						8259					
Received increase in company pension entitlements	D8		5592								5592		
Increase in company pension claims	D8	5592				5592							
Savings	**B8**	**28420**		**12800**		**2747**		**4125**		**8747**			
Balance of current items with foreign countries	B12											4919	
Savings	**B8**	**28420**		**12800**		**2747**		**4125**		**8747**			
III. Assets account													
Savings	B8B		28420		12800		2747		4125		8747		
Balance of current items with foreign countries	B12												4919
Gross investment	P5	33339		25333		362		2851		4993			
Gross fixed capital formation	P51												
Change in inventories	P52												
Mergers and acquisitions	K21	0		-78				78					
Capital transfer received	D9		1896		524						1372		
Capital transfers made	D9	1890						1890				6	
Change in net assets due to savings and capital transfers	**B101**		**28425**		**13324**		**2747**		**2235**		**10119**		**4914**
Net lending/ net borrowing	**B9**	**-4914**		**-11931**		**2385**		**-694**		**5125**		**4914**	
check		-4914		-11931		2385		-694		5125		4914	
diff		0		0		0		0		0		0	

Source: COFORCE

5 OUTCOMES

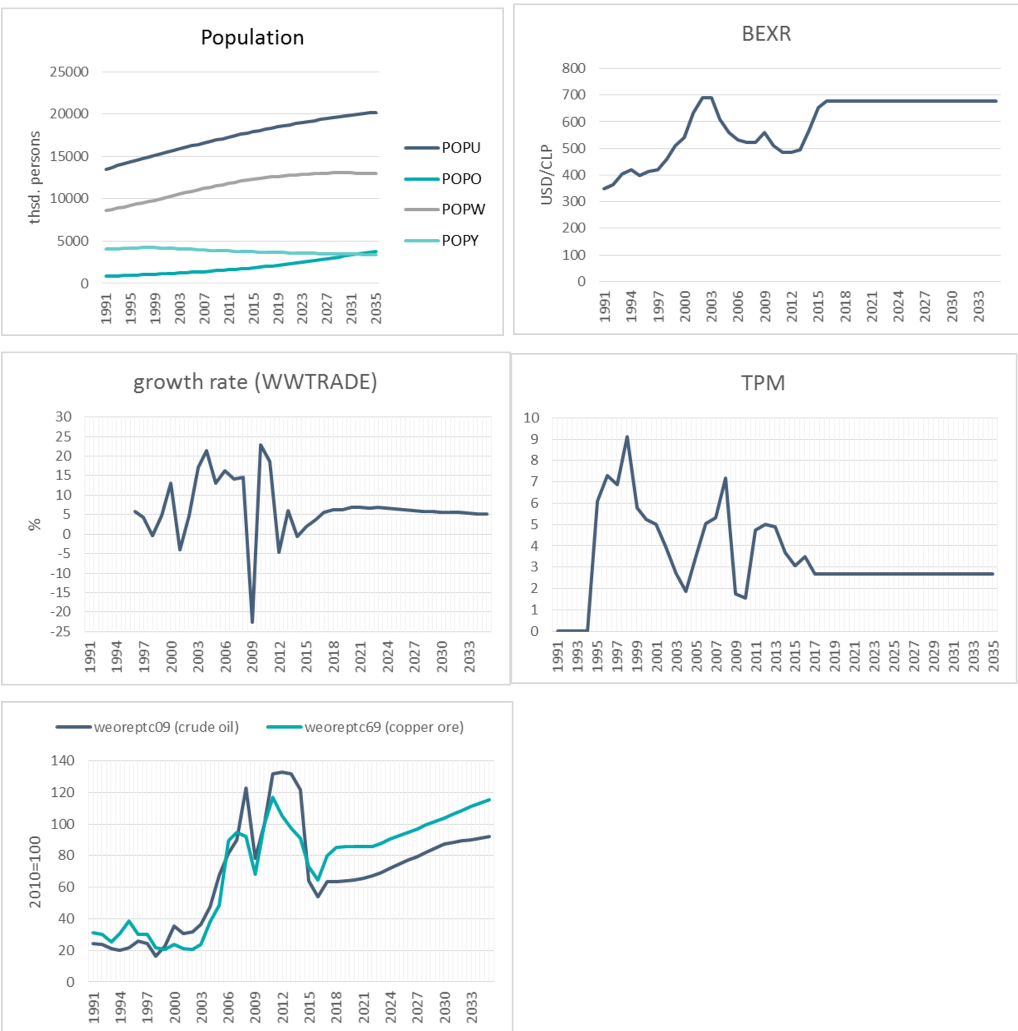
The described methodology has been applied and produces results until 2035. This chapter shows the empirical results for Chile (chapter 5.2) and describes the assumption for exogenous variables (chapter 5.1).

5.1 ASSUMPTIONS

Figure 7 gives an overview of main assumptions used in COFORCE. Population forecast is given from the Chilean authorities. It shows a constant increase of the population. However, the increase of older population ($POPO$) becomes significant in the long run. At the same time, population below year 15 ($POPY$) decline constantly.

Exchange rate ($BEXR$) of the US Dollar to the Chilean Peso remains constant in the projection horizon.

Figure 7: Overview of main assumption indicator



Source: COFORCE

World trade ($WWTRADE$) as driver of the Chilean exports show high growth rates of above

5 %. However, world trade's dynamic slows down in the long run.

TPM is the main refinancing rate of Chilean central bank. It remains constant until 2035.

Import prices are mainly influenced by crude oil ($weoreptc09$) and copper ore ($weoreptc63$) price developments. The projection are taken from the IMF. Both import prices increase constantly in the long run.

5.2 MACROECONOMIC RESULTS

The aggregate results on real gross domestic product and its components are summarized in Table 6. The growth path of Chile is in general positive. However, until 2035, the average growth rates are constantly declining, which is a normal phenomenon of a newly industrialized economy such as Chile. Growth is mainly driven by a constantly high demand of private households. This can be explained by the growing population.

Chile will be turning (again) into an export driven economy. Chile's foreign trade balance will be increasing until 2035. Nominal exports will then be accountable for 35 % of nominal GDP.

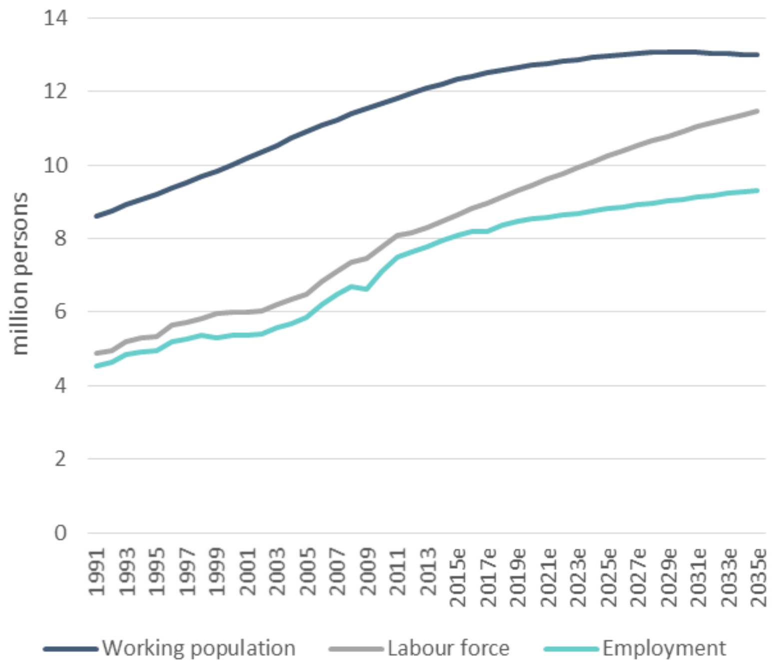
Table 6: Real average growth rates of GDP components, in %

	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035
Gross domestic product	3.7	3.9	2.6	1.8	1.4	1.3
Private consumption	5.8	4.9	3.1	2.0	1.8	1.6
State consumption	5.4	3.7	3.2	0.5	0.2	0.2
Investment	5.7	4.6	1.6	0.9	1.0	0.9
Exports	0.6	1.7	2.1	3.1	2.2	2.0
Imports	6.6	2.9	3.3	2.1	1.9	2.2

Source: COFORCE

The positive but slower growth perspective are transmitted on the labour market. In the long run, the gap between labour force and labour demand increases. Labour supply will be exceeding labour demand by over 2 million people in 2035 (compare Figure 8).

Figure 8: Population, labour force and employment

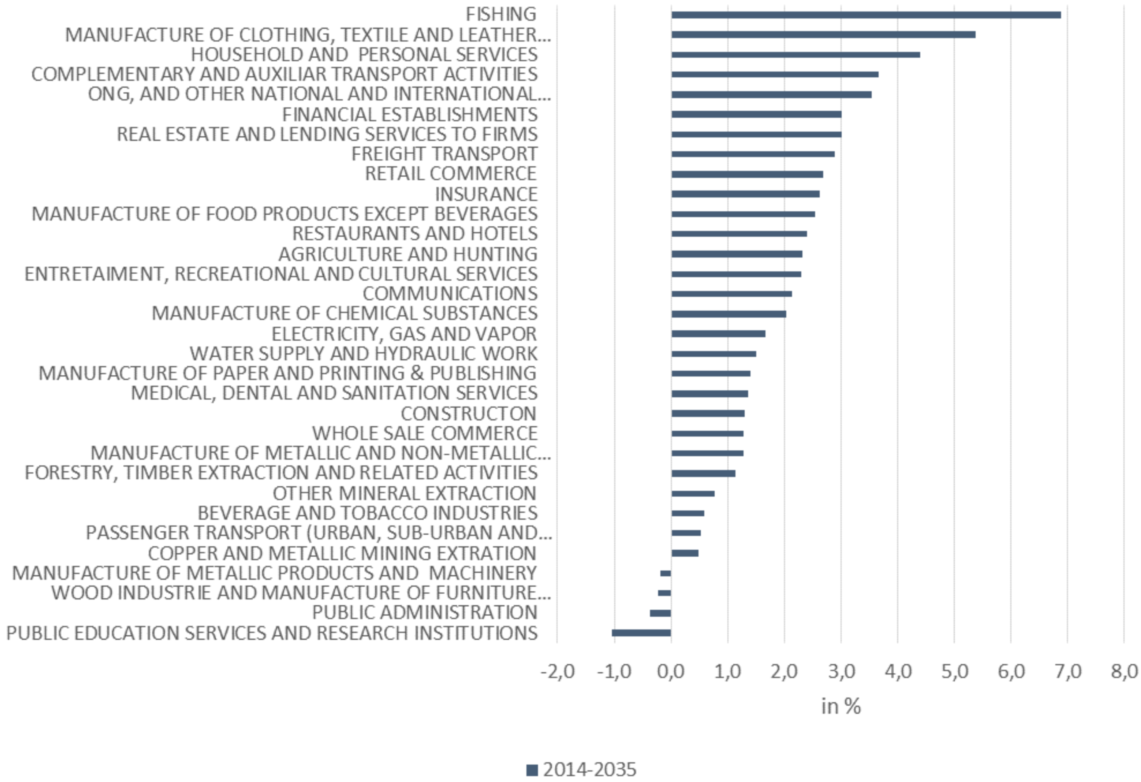


Source: COFORCE

5.3 RESULTS ON SECTORAL LEVEL

The macroeconomic results shown in chapter 5.2 are the results of sector-specific developments. Figure 9 shows on a 32 sector aggregation the average growth rate of real production. It is striking, that the highest average growth rates are especially expected in service industries. Manufacturing industries are also increasing in average but to a much lower extent. In contrary, the public sector — is expected to decline in real production. The shift between industry and service sector is a typical characteristic of industrialized economies. However, the still comparably strong influence of the agricultural sector – as fishing, agriculture and hunting – shows that Chile just recently shifted into an industrialized economy.

Figure 9: Real average growth rate of production by 32 sectors



Source: COFORCE

The impact on employment can be observed in Figure 10. Similar to production, employment grows especially in the labour-intensive sectors of the service industries. Again, the manufacturing industry also increases its number of employees, however in a less dynamic way. Apart from fishing, the agricultural industry can increase its productivity considerably. In average, employment increases much slower or even declines, despite growing real production. Similar is the case for many manufacturing industries, as well as for the copper mining industry. Technological change may be the major driving force here.

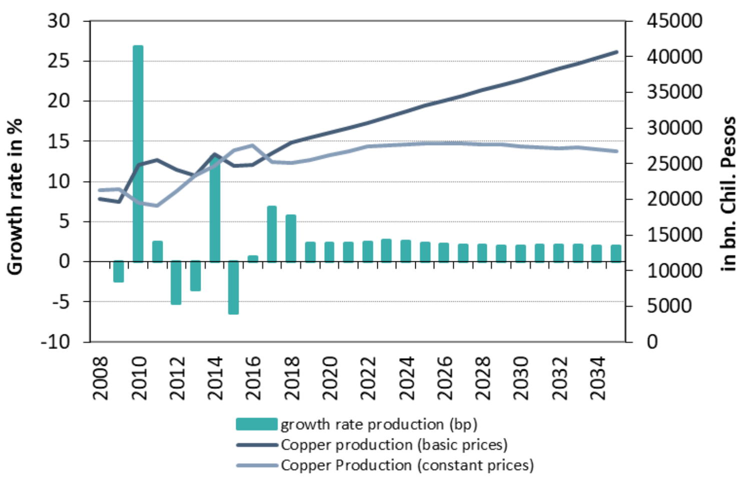
Figure 10: Average growth rate of employment by sectors

Source: COFORCE

5.4 THE COPPER INDUSTRY

The copper industry is a major pillar of Chiles economy. In the baseline, copper mining industry continuous to grow in nominal terms, but to a slower extent than in the past (see Figure 11). - In real terms, production of the copper industry declines from 2027 on by 3.6 % until 2035.

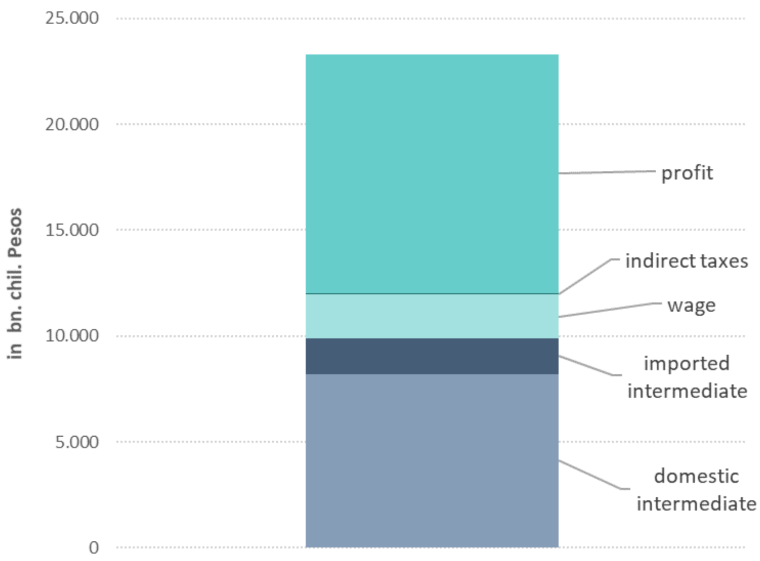
Figure 11: Development of Copper Production (2008 – 2035)



Source: COFORCE

Rising unit costs are the reason for the decline of production in real terms. Especially, the rise of the share of the costs for domestic and imported intermediates cause this increase. In total, the intermediates have a quota of 42.4 % in production, whereas the domestic intermediates are five times higher than the imported ones. Regarding the production components (see Figure 12) the share of profits of 48.5 % on production is remarkable. Wage has a share of less than one-tenth. This indicates, that copper production is getting more expensive the deeper the mining companies have to dig to extract copper. The shift towards underground copper extraction e. g. in the world largest copper mine Chuquicamata implies high investment.

Figure 12: Production components of the copper industry (2013)



Source: COFORCE

The domestic intermediate demand at basic prices of the copper industry is based mainly on the copper mining industry itself and on business service activities (see Table 7). The copper industry demands more than 15 % of the electricity industry and nearly 10 % of Commerce.

Table 7: Top 10 important suppliers to copper industry (2013)

industry	share in %
Copper Mining	23,4
Business service activities	22,6
Electricity supply	15,5
Commerce	9,4
Manufacture of machinery and non-electrical equipment	5,9
Fuel production	3,2
Manufacture of metallic products	3,0
Transporte camionero carga	2,1
Manufacture of basic chemical substances	1,9
Manufacture of other chemical products	1,4

Source: COFORCE

Turning from the use to the demand side, the intermediate demand for copper products originates by a quota of nearly 70 % by the copper industry. The basic industries of non-ferrous metals, business services, construction and commerce are the following most important purchasers of copper products (see Table 8).

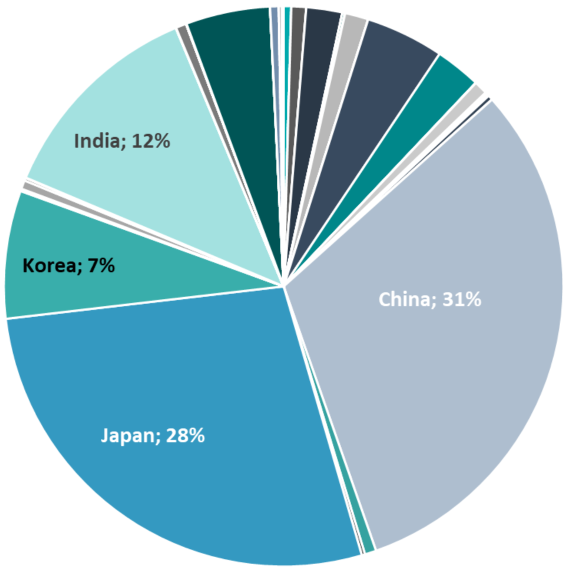
Table 8: Top 10 important demanders of copper industry (2013)

industry	share in %
Copper Mining	69,1
Basic industries of non-ferrous metals	10,9
Business service activities	3,5
Construction	2,1
Commerce	2,0
Agriculture	0,9
manufacturing of plastic products	0,8
Iron Mining	0,8
Manufacture of paper	0,7
Basic industries of iron and steel	0,6

Source: COFORCE

The final demand is mainly concentrated on the exports as they sum up to 97 %. The copper industry is consequently strongly linked to the world market. The main trading partners for copper of Chile are China, Japan, India and Korea (see Figure 13). Together, these four Asian countries demand nearly 80 % of Chilean copper. Especially China and Japan are a strong importers of Chilean copper with a demand of around 30 % each. India imports nearly an eights part of Chilean copper exports and Korea 7 %. In the long run, mainly India`s and China`s importance as importers is growing constantly while Japan imports a weaker share of Chilean copper.

Figure 13: Main copper importers of Chilean Copper (2013)

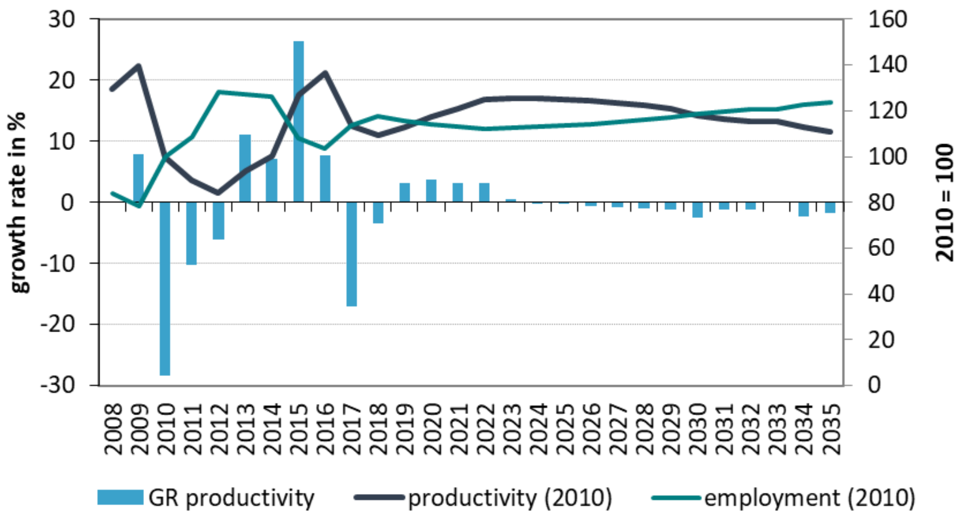


Source: COFORCE

The copper export itself has a share of around 45 % of the total Chilean exports. Therefore, they have a crucial role in the economic system of the country. Chile also imports copper products but in a very low degree. Actually the import competition, that is the ratio of imports to final demand at purchaser prices, has a share of 3.7 % and is getting weaker in the projection time.

In the copper and mining extraction sector more than 220.000 people were employed in 2013. The number of employees shows a constant rise (see green line in Figure 14). As the production in constant prices declines from 2027 on, the productivity of the copper mining industry – calculated as the ratio of production in real terms and employment - weakens constantly (see dark grey line and blue bars in Figure 14).

Figure 14: Productivity of the copper industry (2008 - 2035)



Source: COFORCE

6 SUMMARY

This paper is a methodology report on the construction of the model. It describes the general modelling concept and illustrates first results of the baseline scenario, which includes major indicators of the total economy and its sectors.

For Chile, such a dynamic, macro-econometric input-output model is a novelty. Other economic models have been developed and applied in Chile for different research questions, but these models belong to the CGE-type of models. Although similar, COFORCE – which belongs to the INFORUM type of models – differs from CGE models with respect to its theoretical foundation, the existence of equilibrium position, and the setting of elasticity values. COFORCE has been developed to analyse the economic impact of copper on Chile but can be used for general forecasting and simulation purposes for a battery of research questions. COFORCE can be updated and maintained very easily. Due to its modular construction, the model can be extended to more detailed features of the economy. For instance, the employment market can be extended by occupation and qualification levels or energy balances can be implemented for further investigation of the production, distribution and use of energy. The bottom-up construction of COFORCE implies, that all aggregates are the result of its components. Via simultaneous solution the input-output tables are fully implemented in the system of national accounts. A high number of feedback loops are considered.

The regression model COFORCE in its current version forecasts until 2035 on a yearly basis. The forecast assumes a continuous growth path for Chile in the long run, albeit with declining growth rates. The slowing increase of the national economy is the consequence of the industrialization process of Chile`s economy. However, the labour market is expected to get more under pressure as a growing labour force is facing a weaker growing demand of labour. In consequence, unemployment is expected to rise in the long run with increasing pressure on the social system of the economy.

From sectoral perspective, Chile’s transmission into an industrialized economy is observed by the faster growing service sector relative to the manufacturing industries. This leads to a growing demand for labour by the labour-intensive service industries. But in general, employment increases much slower in most industries despite growing real production. Technological change may be the major driving force here. The copper industry – as one of the most important industries of the country – is facing major shifts in the future. Although it is still an important growth engine, increasing prices in extraction or energy leads to a declining growth rate in real terms. The baseline scenario as introduced in this paper is the starting point for further studies on the vulnerability of Chile’s economy to copper. Two scenarios have been formulated by the Chilean project partners to further investigate the copper dependencies. One scenario on energy, addresses the energy-intense production of copper and the likely consequences if a shift to renewable energy would take place. The other scenario is a counterfactual scenario that discusses the impact of the special mining tax on the economy. A third scenario, formulated by the German project team, analyses the macroeconomic and sectoral effects of an export-demand shift of copper to another copper exporting country like Peru.

Until now, COFORCE is a national model without regional differentiation. However, analysis on copper needs to address the regional aspect as well, because copper mining is concentrated to the northern regions in Chile but its profits are spread nationwide. To capture regional impacts, COFORCE needs to be extended to regional developments by using a top-down approach that transmits national effects to its 15 regions. This work is currently in progress. Results are expected by end of 2019.

Appendix

Table 9: IO categories by 73 industries / products

1	Agriculture
2	Fruit farming
3	Farming
4	Forestry
5	Extractive Fishing
6	Coal Extraction
7	Oil Extraction
8	Iron Mining
9	Copper Mining
10	Other Mining Activities
11	Meat Production
12	Fishing Industry
13	Canning Processing
14	Oil Production
15	Milk Industry
16	Milling
17	Manufacture of animal feed
18	Bakeries
19	Sugar
20	Manufacture of other food products
21	Manufacture of spirits and liqueurs
22	Wine making
23	Beer making
24	Manufacture of non-alcoholic beverages
25	Manufacture of tobacco products
26	Manufacture of textiles
27	Manufacture of clothing
28	Manufacture of leather and its products
29	Manufacture of footwear
30	Production of wood and its products
31	Manufacture of paper
32	Printing and publishing
33	Fuel production
34	Manufacture of basic chemical substances
35	Manufacture of other chemical products
36	Manufacture of rubber products
37	Manufacture of plastic products
38	Glass manufacture and its products
39	Manufacture of other non-metallic mineral products
40	Basic industries of iron and steel
41	Basic industries of non-ferrous metals

42	Manufacture of metallic products
43	Manufacture of machinery and non-electrical equipment
44	Manufacture of machinery and electrical equipment
45	Manufacture of transportation equipment
46	Furniture manufacturing
47	Other manufacturing industries
48	Electricity supply
49	Gas supply
50	Water supply
51	Construction
52	Commerce
53	Hotels
54	Restaurants
55	Railway transport
56	Other land passenger transport
57	Land transport of freight
58	Marine transport
59	Air transport
60	Related transport activities
61	Communications
62	Financial intermediation
63	Insurance companies
64	Real estate activities
65	Business service activities
66	Home ownership
67	Public administration
68	Public education
69	Private education
70	Public health
71	Private health
72	Recreational activities
73	Other service activities

Table 10: Employment category by 32 sectors

1	AGRICULTURE AND HUNTING
2	FORESTRY, TIMBER EXTRACTION AND RELATED ACTIVITIES
3	FISHING
4	OTHER MINERAL EXTRACTION
5	COPPER AND METALLIC MINING EXTRATION
6	MANUFACTURE OF FOOD PRODUCTS EXCEPT BEVERAGES
7	BEVERAGE AND TOBACCO INDUSTRIES
8	MANUFACTURE OF CLOTHING, TEXTILE AND LEATHER PRODUCTS
9	WOOD INDUSTRIE AND MANUFACTURE OF FURNITURE AND ACCESSORIES

10	MANUFACTURE OF PAPER AND PRINTING & PUBLISHING
11	MANUFACTURE OF CHEMICAL SUBSTANCES
12	MANUFACTURE OF METALLIC AND NON-METALLIC PRODUCTS
13	MANUFACTURE OF METALLIC PRODUCTS AND MACHINERY
14	ELECTRICITY, GAS AND VAPOR
15	WATER SUPPLY AND HYDRAULIC WORK
16	CONSTRUCTON
17	WHOLE SALE COMMERCE
18	RETAIL COMMERCE
19	RESTAURANTS AND HOTELS
20	FREIGHT TRANSPORT
21	PASSENGER TRANSPORT (URBAN, SUB-URBAN AND INTERURBAN)
22	COMPLEMENTARY AND AUXILIAR TRANSPORT ACTIVITIES
23	COMMUNICATIONS
24	FINANCIAL ESTABLISHMENTS
25	INSURANCE
26	REAL ESTATE AND LENDING SERVICES TO FIRMS
27	PUBLIC ADMINISTRATION
28	PUBLIC EDUCATION SERVICES AND RESEARCH INSTITUTIONS
29	MEDICAL, DENTAL AND SANITATION SERVICES
30	ENTRETAIMENT, RECREATIONAL AND CULTURAL SERVICES
31	HOUSEHOLD AND PERSONAL SERVICES
32	ONG, AND OTHER NATIONAL AND INTERNATIONAL ORGANIZATIONS

Table 11: Trade categories in TINFORGE by 33 sectors

1	D01: Crop and animal production, hunting and related service activities
2	D02: Forestry and logging
3	D03: Fishing and aquaculture
4	D05: Mining of coal and lignite
5	D06: Extraction of crude petroleum and natural gas
6	D07: Mining of metal ores
7	D08: Other mining and quarrying
8	D10: Food products
9	D11: Beverages
10	D12: Tobacco products
11	D13: Textiles
12	D14: Wearing apparel
13	D15: Leather and related products
14	D16: Wood and products of wood and cork, except furniture, articles of straw and plaiting materials
15	D17: Paper and paper products
16	D18: Printing and reproduction of recorded media
17	D19: Coke and refined petroleum products
18	D20: Chemicals and chemical products

19	D21: Basic pharmaceutical products and pharmaceutical preparations
20	D22: Rubber and plastics products
21	D23: Other non-metallic mineral products
22	D24: Basic metals
23	D25: Fabricated metal products except machinery and equipment
24	D26: Computer, electronic and optical products
25	D27: Electrical equipment
26	D28: Machinery and equipment n.e.c.
27	D29: Motor vehicles, trailers and semi-trailers
28	D30: Other transport equipment
29	D31T32: Furniture, Other manufacturing
30	D35: Electricity and gas
31	D36T99: Other activities
32	DWASTE: Total Waste
33	UNALLOCATED: Unallocated

Table 12: Countries in bilateral trade in TINFORGE

1	Austria
2	Belgium
3	Cyprus
4	Estonia
5	Finland
6	France
7	Germany
8	Greece
9	Ireland
10	Italy
11	Latvia
12	Lithuania
13	Luxembourg
14	Malta
15	Netherlands
16	Portugal
17	Slovak Republic
18	Slovenia
19	Spain
20	Bulgaria
21	Croatia
22	Czech Republic
23	Denmark
24	Hungary
25	Poland
26	Romania

27	Sweden
28	United Kingdom
29	Iceland
30	Norway
31	Switzerland
32	Albania
33	Macedonia
34	Montenegro
35	Serbia
36	Turkey
37	Bosnia & Herzegovina
38	Moldova
39	Belarus
40	Ukraine
41	Canada
42	Mexico
43	United States
44	Russian (Federation of)
45	China
46	Chinese Taipei
47	Hong Kong, China
48	Japan
49	Korea
50	Macau
51	Brunei
52	Cambodia
53	Indonesia
54	Malaysia
55	Myanmar
56	Mongolia
57	Philippines
58	Singapore
59	Thailand
60	Viet Nam
61	Bangladesh
62	Bhutan
63	India
64	Maldives
65	Nepal
66	Pakistan
67	Sri Lanka
68	Georgia
69	Kazakhstan
70	Kyrgyzstan

71	Bahrein
72	Iran
73	Israel
74	Jordan
75	Kuwait
76	Lebanon
77	Oman
78	Qatar
79	Saudi Arabia
80	Syria
81	United Arab Emirates
82	Yemen
83	Argentina
84	Aruba
85	Bolivia
86	Brazil
87	Chile
88	Colombia
89	Ecuador
90	Guyana
91	Paraguay
92	Peru
93	Suriname
94	Uruguay
95	Venezuela
96	Costa Rica
97	El Salvador
98	Guatemala
99	Honduras
100	Nicaragua
101	Panama
102	Algeria
103	Egypt
104	Morocco
105	Sudan
106	Tunisia
107	Mauritania
108	Benin
109	Burkina Faso
110	Cameroun
111	Cape Verde
112	Côte d'Ivoire
113	Ghana
114	Guinea

115	Mali
116	Niger
117	Nigeria
118	Senegal
119	The Gambia
120	Togo
121	Burundi
122	Central African Republic
123	Gabon
124	Republic of the Congo
125	Ethiopia
126	Kenia
127	Madagascar
128	Mauritius
129	Rwanda
130	Seychelles
131	Tanzania
132	Uganda
133	Malawi
134	Mozambique
135	Namibia
136	Botswana
137	South Africa
138	Zambia
139	Zimbabwe
140	Sao Tome und Principe
141	Cuba
142	Dominican Republic
143	Dominica
144	Jamaica
145	Montserrat
146	Saint Vincent and the Grenadines
147	Saint Kitts and Nevis
148	Trinidad and Tobago
149	Fiji
150	New Caledonia
151	Australia
152	New Zealand
153	Papua New Guinea
154	Tonga
155	Rest of the world

Table 13: Categories of 76 raw material prices

1	Commodity Price Index includes both Fuel and Non-Fuel Price Indices
2	Commodity Non-Fuel Price Index includes Food and Beverages and Industrial Inputs Price Indices
3	Commodity Industrial Inputs Price Index includes Agricultural Raw Materials and Metals Price Indices
4	Crude Oil (petroleum), simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh, US$ per barrel
5	Crude Oil (petroleum), Dated Brent, light blend 38 API, fob U.K., US$ per barrel
6	Oil; Dubai, medium, Fateh 32 API, fob Dubai Crude Oil (petroleum), Dubai Fateh Fateh 32 API, US$ per barrel
7	Crude Oil (petroleum), West Texas Intermediate 40 API, Midland Texas, US$ per barrel
8	Commodity Fuel (energy) Index includes Crude oil (petroleum), Natural Gas, and Coal Price Indices
9	Crude Oil (petroleum), Price index simple average of three spot prices (APSP); Dated Brent, West Texas Intermediate, and the Dubai Fateh
10	Commodity Natural Gas Price Index includes European, Japanese, and American Natural Gas Price Indices
11	Natural Gas, Russian Natural Gas border price in Germany, US$ per million metric British thermal units of gas
12	Natural Gas, Indonesian Liquified Natural Gas in Japan, US$ per million metric British thermal units of liquid
13	Natural Gas, Natural Gas spot price at the Henry Hub terminal in Louisiana, US$ per million metric British thermal units of gas
14	Commodity Coal Price Index includes Australian and South African Coal
15	Coal, Australian thermal coal, 1200- btu /pound, less than 1 % sulfur, 14 % ash, FOB Newcastle/Port Kembla, US$ per metric tonne
16	Coal, South African export price, US$ per metric tonne
17	Commodity Food and Beverage Price Index includes Food and Beverage Price Indices
18	Commodity Food Price Index includes Cereal, Vegetable Oils, Meat, Seafood, Sugar, Bananas, and Oranges Price Indices
19	Commodity Cereals Price Index includes Wheat, Maize (Corn), Rice, and Barley
20	Wheat, No.1 Hard Red Winter, ordinary protein, FOB Gulf of Mexico, US$ per metric tonne
21	Maize (corn), U.S. No.2 Yellow, FOB Gulf of Mexico, U.S. price, US$ per metric tonne
22	Rice, 5 percent broken milled white rice, Thailand nominal price quote, US$ per metric tonne
23	Barley, Canadian no.1 Western Barley, spot price, US$ per metric tonne
24	Commodity Vegetable Oil Index includes Soybean, Soybean Meal, Soybean Oil, Rapeseed Oil, Palm Oil, Sunflower Oil, Olive Oil, Fishmeal, and Groundnut Price Indices
25	Soybeans, U.S. soybeans, Chicago Soybean futures contract (first contract forward) No. 2 yellow and par, US$ per metric tonne
26	Soybean Meal, Chicago Soybean Meal Futures (first contract forward) Minimum 48 percent protein, US$ per metric tonne
27	Soybean Oil, Chicago Soybean Oil Futures (first contract forward) exchange approved grades, US$ per metric tonne
28	Rapeseed oil, crude, FOB Rotterdam, US$ per metric ton
29	Palm oil, Malaysia Palm Oil Futures (first contract forward) 4-5 percent FFA, US$ per metric tonne

30	Sunflower Oil, US export price from Gulf of Mexico, US$ per metric tonne
31	Olive Oil, extra virgin less than 1 % free fatty acid, ex-tanker price U.K., US$ per metric tonne
32	Fishmeal, Peru Fish meal/pellets 65 % % protein, CIF, US$ per metric tonne
33	Groundnuts (peanuts), 40/50 (40 to 50 count per ounce), cif Argentina, US$ per metric tonne
34	Commodity Meat Price Index includes Beef, Lamb, Swine (pork), and Poultry Price Indices
35	Beef, Australian and New Zealand 85 % lean fores, FOB U.S. import price, US cents per pound
36	Lamb, frozen carcass Smithfield London, US cents per pound
37	Swine (pork), 51-52 % lean Hogs, U.S. price, US cents per pound
38	Poultry (chicken), Whole bird spot price, Georgia docks, US cents per pound
39	Commodity Seafood Index includes Fish (salmon) and Shrimp Price Indices
40	Fish (salmon), Farm Bred Norwegian Salmon, export price, US$ per kilogram
41	Shrimp, Frozen shell-on headless, block 16/20 count, Indian origin, C&F Japan, US$ per kil-ogram
42	Commodity Sugar Index includes European, Free market, and U.S. Price Indices
43	Sugar, Free Market, Coffee Sugar and Cocoa Exchange (CSCE) contract no.11 nearest fu-ture position, US cents per pound
44	Sugar, U.S. import price, contract no.14 nearest futures position, US cents per pound
45	Sugar, European import price, CIF Europe, US cents per pound
46	Bananas, Central American and Ecuador, FOB U.S. Ports, US$ per metric tonne
47	Oranges, miscellaneous oranges French import price, US$ per metric tonne
48	Commodity Beverage Price Index includes Coffee, Tea, and Cocoa
49	Commodity Coffee Price Index includes Other Mild Arabicas and Robusta
50	Coffee, Other Mild Arabicas, International Coffee Organization New York cash price, ex-dock New York, US cents per pound
51	Coffee, Robusta, International Coffee Organization New York cash price, ex-dock New York, US cents per pound
52	Cocoa beans, International Cocoa Organization cash price, CIF US and European ports, US$ per metric tonne
53	Tea, Mombasa, Kenya, Auction Price, US cents per kilogram
54	Commodity Agricultural Raw Materials Index includes Timber, Cotton, Wool, Rubber, and Hides Price Indices
55	Commodity Timber Index includes Hardwood and Softwood Price Indices
56	Commodity Hardwood Price Index includes Hardwood Logs and Hardwood Sawn Price In-dices
57	Hard Logs, Best quality Malaysian meranti, import price Japan, US$ per cubic meter
58	Hard Sawnwood, Dark Red Meranti, select and better quality, C&F U.K port, US$ per cubic meter
59	Commodity Softwood Index includes Softwood Sawn and Softwood Logs Price Indices
60	Soft Logs, Average Export price from the U.S. for Douglas Fir, US$ per cubic meter
61	Soft Sawnwood, average export price of Douglas Fir, U.S. Price, US$ per cubic meter
62	Cotton, Cotton Outlook \`A Index\`, Middling 1-3/32 inch staple, CIF Liverpool, US cents per pound
63	Commodity Wool Index includes Coarse and Fine Wool Price Indices
64	Wool, fine, 19 micron, Australian Wool Exchange spot quote, US cents per kilogram

65	Wool, coarse, 23 micron, Australian Wool Exchange spot quote, US cents per kilogram
66	Rubber, No.1 Rubber Smoked Sheet, FOB Malaysian/Singapore, US cents per pound
67	Hides, Heavy native steers, over 53 pounds, wholesale dealer`s price, US cents per pound
68	Commodity Metals Price Index includes Copper, Aluminium, Iron Ore, Tin, Nickel, Zinc, Lead, and Uranium Price Indices
69	Copper, grade A cathode, LME spot price, CIF European ports, US$ per metric tonne
70	Aluminium, 99.5 % minimum purity, LME spot price, CIF UK ports, US$ per metric tonne
71	Iron Ore, China import Iron Ore Fines 62 % FE spot (CFR Tianjin port) US$ per metric ton
72	Tin, standard grade, LME spot price, US$ per metric tonne
73	Nickel, melting grade, LME spot price, CIF European ports, US$ per metric tonne
74	Zinc, high grade 98 % pure, US$ per metric tonne
75	Lead, 99.97 % pure, LME spot price, CIF European Ports, US$ per metric tonne
76	Uranium, u3o8 restricted price, Nuexco exchange spot, US$ per pound

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