Modeling workforce demand in North Dakota: a System Dynamics approach

By

Adiba Muminova

Thesis submitted in partial fulfillment of the requirements of
Master of Philosophy in System Dynamics (Universitetet i Bergen),
Master of Science in System Dynamics (Universidade Nova de Lisboa)
and Master of Science in Business Administration
(Radboud Universiteit Nijmegen)

Supervised by: Associate Professor David I. Wheat

Second reader: Dr. H.P.L.M. Korzilius

August, 2015

System Dynamics Group
Department of Geography
University of Bergen

Contents

Abstract 3
List of abbreviations 4
Introduction 5
Background information 5
Problem description 6
Research objective and research questions 7
Reference mode 7
Stakeholders 11
Literature review 12
Research Methodology 15
Research design 15
Data collection and analysis 17
Model description 21
Sub-models description 21
Feedback analysis 30
Model validation 32
The of concept validation 32
Structure validity 33
Behavior validity 39
Model runs 41
Base run 41
Scenario runs 46
Concluding remarks 53
Addressing the research questions 53
Limitations and further research 54
References 55
Appendices 58

Abstract

This study investigates the dynamics behind the workforce demand and attempts to predict the potential effects of future changes in oil prices on workforce demand in North Dakota. The study attempts to join System Dynamics and Input-Output models in order to overcome shortcomings in both of the approaches and gain a more complete understanding of the issue of workforce demand. A system dynamics simulation of workforce demand within different economic sectors of North Dakota is conducted for the period of 1997-2015 and test scenarios for the period of 2015-2020 are run with the help of the iThink software by isee Systems. IO technical coefficients are calculated to create linkages between eight aggregated industry sectors and incorporated into the system dynamics model.

Increased demands for inputs to the oil industry from other industries are shown to be the drivers of workforce demand in North Dakota. The model scenario runs demonstrate that the increased demands for inputs are driven by oil price changes and oil production volume changes.

The workforce demand is shown to exhibit differential sensitivity to the above two factors. The dynamic hypothesis that the oil boom has created a 'ripple effect' throughout other industries, causing an increase in demand for workforce throughout the state of North Dakota, is investigated and proven. The research is of high importance to North Dakota, as well as to other regions and communities with boom-and-bust economic cycles.

List of abbreviations

AG – Agriculture

BLS - Bureau of Labor Statistics

CES – Current Employment Statistics

EIA - Energy Information Administration

EIU – Economist Intelligence Unit

GDP – Gross Domestic Product

GSP – Gross State Product

AD - Aggregated Demand

IO - Input-Output

MNF - Manufacturing

NAICS - North American Industry Classification System

ND – North Dakota

NDSU - North Dakota State University

OS – Other Services

PPI – Producer's Price Index

QCEW – Quarterly Census of Employment and Wages

RFL – Retail Food and Lodging

SIC – Standard Industrial Classification

SD – System Dynamics

UI- Unemployment Insurance

UR – Unemployment Rate

UND – University of North Dakota

WTI - Western Texas Intermediate

US(A)- United States (of America)

Introduction

Background information

Since 2006, the state of North Dakota has been experiencing unprecedented economic expansion brought on by an oil boom in the state, with thousands of new job openings created throughout the state's economy and the state's government budget surplus growing due to improved revenues from the oil production industry (Weber, Geigle, & Barkdull, 2014). The revolution in oil and gas industry resulted from a combination of new technological developments and high energy prices that allowed 'unconventional' oil and gas drilling to flourish. Successfully combining horizontal drilling with hydraulic fracturing, or 'fracking', first in Texas in 2000 and then in North Dakota in 2004, allowed tapping into large, once barely reachable reservoirs of shale oil and made North Dakota one of the leading oil-producing states in the US (Vachon, 2014), turning the state from one of the poorest in the US into one of the most prosperous ones (American Enterprise Institute, 2015).

The boom-and-bust scenario the state of North Dakota has already been through several times in the past, the latest being in 1980s, has taught the communities valuable lessons about both benefits and downsides of booms (Weber et al., 2014; Baxter, 2015).

Among the obvious benefits to the communities' economies is increased employment occurring not only in extraction but in other industries such as retails and services (Weber et al., 2014), due to the spill-over effect. The program 'Find the Good Life in North Dakota', supported by the ND government, and many media sources position North Dakota as one of the best states for career opportunities with a great number of high-wage jobs and vacancies and second-highest per-capita income in the US. ND is one of the very few states with a government budget surplus and one with the lowest unemployment rate in the nation ('Find the Good Life in North Dakota', 2015).

However, the communities have learned that there are also downsides to booms. One of the primary problems that come along in every boom-community is housing issues, and ND is not immune to them (Conlin, 2014). Moreover, attracting workforce form outside of the state accelerates deterioration of existing infrastructure (Baxter, 2015). Being aware of the previous boom-followed-by-bust cycles that have left the state with not only job loss and decreased wages, but also with overcapitalized industries, the communities have developed a reluctance to construct, the private businesses and other industries of ND – to invest and to expand capacity (Weber et al., 2014).

Problem description

Along with obvious economic benefits, the state is facing a major workforce supply shortage, as indicated by 25-27 thousand job vacancies each year (Job Service North Dakota, 2013), which hardly can be filled with local workforce supply. ND has more job openings than job applicants. The media is filled with stories about great economic opportunities and descriptions of job vacancy programs promising a good life in North Dakota in hopes of getting more people to come to work and, more importantly, settle in the state. When workers do migrate and apply, they naturally prefer to work in an industry that offers a higher payment. The Fiscal Times listed 10 highest-paying North Dakota's oil boom jobs (Briody, 2013) outside of the usual lucrative fields such as medicine and law; all 10 are in the oil industry.

The high wages in oil-related industries are a major factor in workforce in-migration from other states. (Vachon, 2014) However, even though the oil boom has created jobs not only in energy-related industries, the non-energy-related vacancies are not getting filled because of the availability of better-paid jobs in energy-related industries. As Weber et al. (2014) quoted one of their interviewees, 'There are jobs and there are good, paying jobs'. With costs of living on the rise, which is a common phenomenon in boom-state communities, the workforce tends to head towards well-paid jobs (Blake, 2011)

The workforce shortage has driven the wages upwards in the rest of the industries as well in a bid to attract workers. However, there is a limit to how much a given industry can raise wages. The National Center for Policy Analysis (2014) reported that while oil workers command annual salaries in six figures, even fast-food workers receive hundreds of dollars in hiring bonuses. This shows that non-energy-related industries are trying to create incentives to apply for a job for potential employees

Another important concern is whether the jobs will still be there in case of another bust. The concern has existed ever since the global oil market, after 5 years of price stability, experienced a dramatic drop in prices, which have remained relatively low since June 2014 (E.L., 2014). As

USA Today reports (Davidson, 2015), the price drop caused mass layoffs in the oil industry. The question that needs to be answered is whether the rest of thousands of non-oil-related jobs would vanish as a result of a slump in the oil industry. In order to be able to answer that question, the dynamics of workforce demand and job openings in North Dakota should be studied first.

Research objective and research questions

The research objective is to predict the potential effects of future changes in oil prices on workforce demand in North Dakota through identifying key factors affecting the dynamics of workforce demand during the pre-boom period (1997-2006) and during the oil boom (2006-2015) by conducting a system dynamics simulation of workforce demand within different economic sectors of North Dakota and by running test scenarios for the period of 2015-2020. The terms 'industries' and 'sectors' are used interchangeably in this study.

The main **research question**:
How will possible future changes in oil prices affect workforce demand in the state of North Dakota? The research objective and the question will be addressed by answering the following **research sub-questions:**

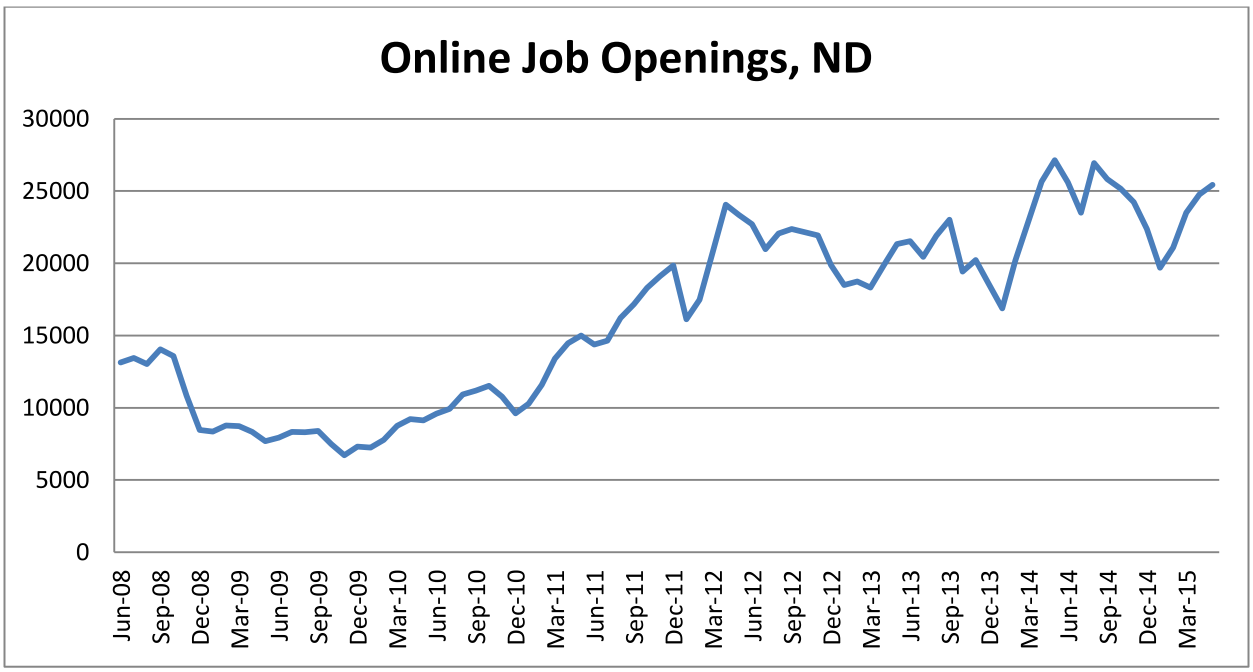
- What is the dynamics of the workforce demand in North Dakota during the pre-boom period of 1997-2006 and during the boom period of 2006-2015?
- What are the drivers of workforce demand in North Dakota?
- What are the effects of oil price changes on workforce demand in North Dakota?

To build a system dynamics model that addresses the research objective, a dynamic hypothesis is required. The dynamic hypothesis is that the oil-boom created a 'ripple effect' in other industries, causing an increase in demand for workforce throughout the state of North Dakota. The research is of high importance to North Dakota, as well as to other regions and communities with boom-and-bust economic cycles.

Reference mode

In order to address the first sub-question of the research, the study needs a reference mode, i.e. a historical behavior of workforce demand. The reference mode for the present study is based on calculations and estimates of desired employment in ND representing total demand for labor. In this paper the terms workforce and labor are used interchangeably. Demand for labor as used in the present research includes the total employment in ND and the unfilled vacancies, which represent an increase in labor demand. Figure 1 includes the latest available data for online job openings in North Dakota and covers the period from June 2008 to March 2015. The 'Online job openings' is the closest indicator of increased demand for workforce in the state of North Dakota. The graph represents only the job openings that were posted online, which means that the real number of job openings was almost certainly greater than the number used to calculate the reference mode in this research. However, neither the actual number of job openings nor an estimate thereof is available for the present research.

Figure 1.Online job openings in North Dakota (June, 2008 - March 2015)



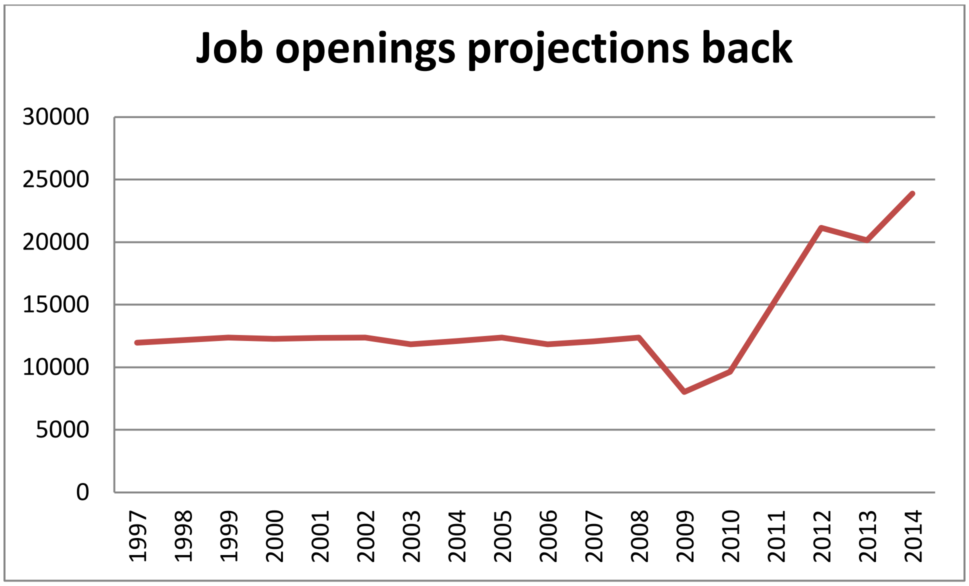
Source: North Dakota Workforce Intelligence, 2015

Another limitation of this indicator is that the starting date of availability of data for online job openings is June 2008. In order to find reference points for an earlier period, backward projections were made based on the growth rate of total employment[1] in North Dakota[2].

[1] The data source of Total employment: https://www.ndworkforceintelligence.com

Figure 2 shows the online job openings for the period 1997–2014. Although the previous figure contained data for several months of 2015, yearly data is the average values for the year, so the data for 2015 is not sufficient to produce a good estimate of the average and is therefore excluded from the reference mode. Job openings and employment are assumed to have shared the growth trend over the period from 1997 to 2008.

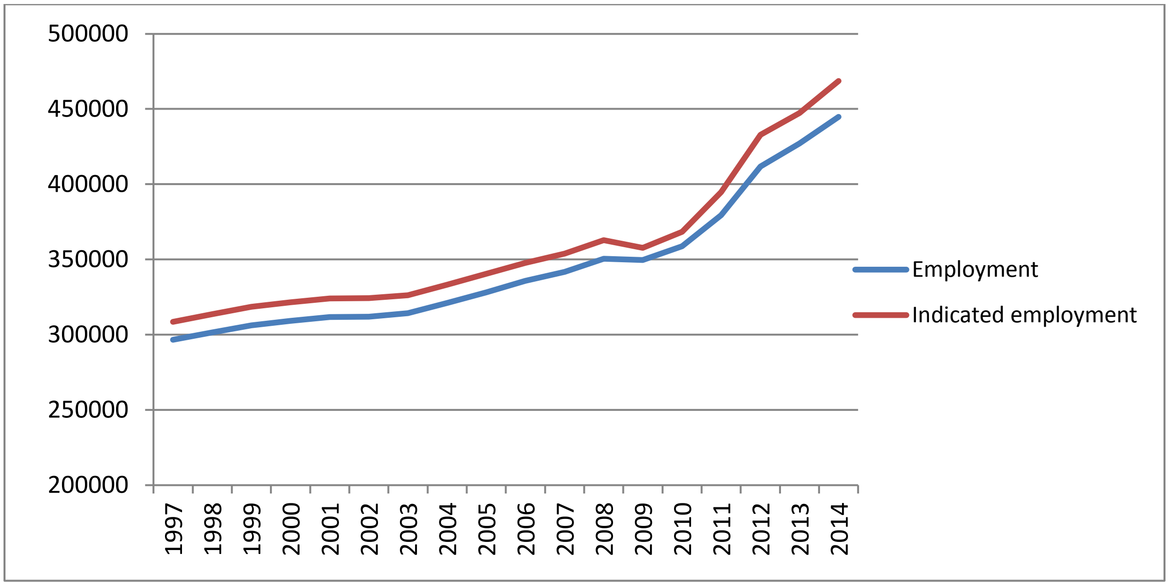
Figure 2. Online job openings in ND (1997-2014), with backward projections (1997-2008)



The reference mode is the sum of job openings and employment that comprises the total demand for labor. Figure 3 shows both employment and desired employment. The gap between the two is unfilled vacancies, i.e. online job openings. Thus, the reference mode for this research is the indicated employment (the red line in figure 3).

[2] The formula for the back projections of Online Job Openings was based on the growth rate of the 'Total' employment" in North Dakota: $Value\ (Previous\ year) = \frac{Value\ (Present\ year)}{(1+growth\ rate)}$

Figure 3.The reference mode, indicated employment.



Source: North Dakota Workforce Intelligence, 2015

The Bureau of Labor Statistics (BLS, 2015) informs that there are two employment measures that provide data by US states – the Quarterly Census of Employment and Wages (QCEW) and the Current Statistics Employment (CES) - with somewhat different estimation procedures. The data for employment included in the reference mode for the present research is taken from QCEW. The QCEW data was chosen for the reference mode because it is based on an actual count of establishments covered by Unemployment Insurance (UI)[3] and is the data most commonly quoted by statistical agencies and surveys in their publications and statistics reports.

The differences in employment estimation procedures have translated into significant differences between the estimates. The difference between estimates of employment by QCEW and CES averages approximately 20,000 jobs.

The data from QCEW includes all covered workers regardless of age, counting workers by place of work rather than residence and counting separately each job held by multiple job holders.. The data excludes unpaid workers, the self-employed, certain farm and domestic workers, workers on temporary layoff or unpaid vacation, or those absent due to illness. QCEW serves as a benchmark information source for CES.

[3] Federal-State Unemployment Insurance Program provides benefits to workers who are unemployed through no fault of their own and meet certain eligibility criteria. For more information on eligibility see http://www.dol.gov/dol/topic/unemployment-insurance/

The QCEW data is based on UI-covered count of administrative records collected from establishments. CES – includes non-UI covered jobs. BLS (2015) in its Technical note points it out, QCEW covers 98% of the jobs by quarterly count while the CES is based on the sample surveys of 588 000 establishments on monthly basis. The QCEW wages include total compensation, including bonuses.

Stakeholders

The people and institutions mentioned in this section of the paper are considered to be the stakeholders of the present research. The research adapts the definition of stakeholders from Elias et al. (2001) to state that *a stakeholder is any group or individual who can affect and be affected by the outcome of the present research*.

The research was conducted at the University of North Dakota (UND), located in Grand Forks, ND, USA, under the supervision of Associate Professor at the University of Bergen David Wheat and the project coordinator at UND Scott Johnson. The present research is part of the Project 'Labor market in North Dakota'. While the present research focuses on labor demand, labor supply is the main focus of research carried out by Babette Bakker. Her research studies local and out-of-state additions to workforce in North Dakota and the job-matching process taking place between employers and employees.

The present research is practice-oriented. A report on the results of the research will be presented in Bismarck, North Dakota, to our main client, the representatives of the government of North Dakota: commissioner and representative of the ND Department of Commerce Al Anderson, representative of the department of Economic Development and Commerce Paul Lucy, Director of the Workforce Development Division of the Department of Commerce Wayde Sick, and North Dakota job services market information manager Michael Ziesch.

This academic paper presenting the research is oriented towards an audience familiar with System Dynamics concepts. The research is especially timely because of the presently falling oil prices.

Literature review

There is abundant system dynamics literature on models related to labor market, focusing on it extensively and exclusively (Skribans, 2014; Soto Torres & Fernandes Lechon, 1995; Sterman, 2000) or dealing with structures of labor demand and supply within wider contexts such as bigger macroeconomic models showing the interrelationships among different economic sectors (Forrester, Mass, & Ryan, 1976; Wheat, 2007).

One of the earliest extensive SD models to include the labor sector as part of the national socio-economic model was the System Dynamics National Model developed by the System Dynamics Group at MIT Sloan School (Forrester, Mass and Ryan, 1976) and analyzed by Runge (1976). The purpose of the analysis was to increase understanding of labor-market dynamics and to suggest labor-market policies. According to the System Dynamics National Model, '*a higher demand for production increases the manpower required, leading to the creation of job vacancies and reduction of layoffs*' (Runge, 1976), which captures the basic structures of fundamental labor-market relationships relevant to this research. Moreover, the model embraced a multi-sector approach to production and hence to demand for workers within each sector, in that regard being similar to the North Dakota Labor Demand model developed within this research.

The North Dakota labor market has been undergoing significant growth in the boom-state context, which raises the importance of examining closely boom-and-bust cycles.

Boom-and-bust cycles attracted attention in 1970s, when boom towns commonly emerged near coal mines, oil and gas exploration and development areas, and other natural resource extraction regions. They were the focus of many studies(Gilmore, 1976; Markusen, 1978; Power, Gillespie, Wittkowski, & Rink, 1980), some of which resulted in development of impact models (Ford, 1976; Gilmore, 1976; Cortese and Jones, 1977) and set a conceptual framework for analysis of challenges faced by communities in or adjacent to areas of energy development. In 1980s and 1990s, when the prices of energy sources were low, the scientific interest diminished. However, the second half of 2000s, the era of new technological advances and high energy prices that gave a new boost to the hydrocarbons industry and produced a new wave of boom communities, saw reawakened interest in conducting new studies (Jacobsen & Parker, 2014; Jacquet, Kay, Ramsey, & Kay, 2014; Putz, Finken, & Goreham, 2011).

Although many studies scrutinized the changes that boom towns undergo as they respond to rapid and sudden economic growth, their approaches to analyzing the boom-town phenomenon varied. The 'Impact assessment model' developed by Cortese and Jones (1977) is a non-simulation model that analyzes social, economic, and environmental impacts of the boom-town phenomenon by incorporating a wide range of variables into the analysis. The variables comprised a long list of both positive and negative 'impacts', and, in order to mitigate the latter, 'propositions' were made. A study by Gilmore (1976) introduced the 'problem triangle', a concise feedback structure representing the interconnectedness of the problems resulting from an energy boom. The 'problem triangle' was among the first attempts at applying the systems thinking approach to the 'boom-town phenomenon'.

Many of the boom-town impact models, though utilizing a systems approach, were qualitative in nature and subject to criticism pointing out unmeasured impacts on boom-challenged communities (Jacquet and Kay, 2014). Among the few quantitative analyses of boom towns was an economic perspective taken by Jacobsen and Parker (2014), who studied short-term economic benefits and long-term detriments by means of a statistical analysis of the pre- and post-boom communities' historical data of different economic indicators, such as trends in population and employment, wages and income. Such quantitative studies are useful for gaining empirical evidence of dramatic changes that boom communities experience. However, these studies do not look into the structural mechanisms that make the changes occur. In order to do that, a systems approach with quantitative simulation models, such as the system dynamics approach, is needed.

There are few studies of boom towns in system dynamics literature. Ford's (1976) BOOM1 model appears to have been the first system dynamics simulation of a boom town, followed by the BOOMH model – a simulation model of a boom town's housing issues. Both models were later studied by Markusen (1978) and Power, Gillespie, Wittkowski (1980) to evaluate their usefulness to policy-makers. BOOM1 modeled the impacts of a large-scale energy facility construction on a small community. Under BOOM1, an influx of construction workers puts pressure on the local infrastructure facilities, leading to a decrease in the quality of life in the community. This compels the local government to start building up the infrastructure. However, after the energy facility project is complete and the construction workers have left the community, the community is left with the overbuilt public constructions – a classical boom-and-bust scenario. The BOOMH model is an extension of the BOOM1 model that includes the housing sector. The assumption is that construction workers, many of whom come with their families, put pressure on the availability of the vacant houses driving the housing prices up. As a result, the price-to-cost ratio impacts residential housing construction, increasing the stock of available houses, which grows even more once the construction workers leave the community.

The North Dakota oil boom was the subject of a system dynamics model developed by Bennich, Collste, & Bongers, (2014), which analyzed some unintended impacts of the oil boom on a North-Dakotan community, such as an increased pressure on the infrastructure due to labor in-migration from outside of the state and the consequent drop in the infrastructure performance. In terms of labor demand, the primary focus of the model was on energy sector, to the complete exclusion of other industries of North Dakota.

Jacquet and Kay (2014) contend that most of the boom-and-bust literature treats boom-town communities as rural and isolated: an approach that limits the analysis of booms' impacts to the immediately local communities, without considering impacts that might spread outside of the communities. In reality, 'globalization and financialization' broaden the scope of boom-related impacts beyond those small communities (Jacquet and Kay, 2014), which is more likely to be relevant in case of areas with unconventional energy developments such as those in the state of North Dakota.

Both Ford's BOOM models and the North Dakota oil boom model limit the analyses specifically to the boom communities. Besides, the models do not consider consequences of the energy boom on the local labor market other than the in-migration of construction or oil-field workers, nor the impact of the energy industry on increased local production of goods and services in other industries of North Dakota's economy. The present research attempts to close the gap.

The importance of this research is that the model focuses not just on a boom community in the context of the energy boom, but on the state-wide effects of the boom-and-bust cycle in North Dakota. The main emphasis is given to tracking the dynamics of workforce demand at a more disaggregated, multi-sector economic level, which allows to track the 'ripple effect' of the energy sector on other industries in North Dakota's economy.

Research Methodology

Research design

Based on the problem description in the introduction and the literature review on labor demand in the state of North Dakota, system dynamics modeling was established as one of the methods that can adequately deal with the complexity of the task. In terms of system dynamics modeling, the process proceeded according to the conceptualization, formulation and testing phases (Luna-Reyes, Andersen, 2003).

Since system dynamics models use people's mental models (mental representations of reality) as a source of data along with written data and numerical data (Forrester, 1994), the present research engaged both qualitative and quantitative research strategies. The qualitative strategy, since it involves an investigation of the topic within its context (Saunders and Lewis, 2012), was first conducted by reviewing literature and official government and media reports on the issue of workforce in North Dakota (as a secondary data collection method). Then research employed primary data collection based on semi-structured interviews with experts. The interviewees were Dwight Wendschlag, a consultant working for the oil industry, and Kevin Black, an entrepreneur providing transportation services to the oil industry. The interviews were conducted during a meeting on May 8, 2015. The primary context of the interview was 'hiring and firing processes', primarily in the oil industry but reflecting, to some extent, other industries as well. Although the interviews were conducted in order to elicit specific knowledge and obtain mental data which is required for a system dynamics model (Vennix, 1996), their semi-structured (not strictly framed) and open nature allowed bringing up new ideas into perspective and can provide new insights on the issues of the research interest. In addition, regular meetings and discussion with Scott Johnson were helpful in development of the model's structure. The answers by the interviewees and meetings' discussions were noted; however, no formal scripts are provided with the present paper. Together with literature review, the interviews and meetings contributed to the conceptualization and formulation phases (see chapter 'Model description') of the system dynamics modeling (Luna-Reyes and Andersen, 2003), while interviews with government officials contributed to the testing phase (see chapter Model validation).

The numerical data was obtained by secondary data collection methods, i.e. from statistical reports and other publications. Among the primary sources of data were the Bureau of Labor Statistics (BLS), North Dakota Workforce Intelligence, and IMPLAN.

As part of its quantitative research strategy, in order to analyze labor demand on a disaggregated, multi-sector economic level, this study combines System Dynamics (SD) with Input-Output (IO) modeling.

In the past, there have been several studies incorporating SD models in IO analysis or, vise versa, IO models in SD analysis, in order to analyze economic systems (Braden, 1981; Diehl, 1985).

Braden used SD to explain how a dynamic analysis in the form of a system dynamics model, unlike the 'conventional dynamic analysis', can smoothly reach the results achieved by the static IO model. Similar to Braden, Diehl (1985) incorporated an SD model so that it allows observing how economic systems achieve equilibria instead of being confined to an IO model's standard static equilibrium. By using an SD model, the author studies disequilibrium, 'a transitory path' between equilibria, in models, inferring that demand and supply of goods are not always in equilibrium. The important insight gained was that, before reaching an economic equilibrium, an economic system goes through a disequilibrium path, probably with oscillations, awareness of which might be of a primary importance to a decision maker.

The most recent of the studies that combined IO and SD models was a study by Wheat and Pawluzcuk (2014). In the study, an IO model was part of an SD macroeconomic regional model. The study proved the mutual usefulness of integration of the methods. SD benefits from the 'disciplined disaggregation' of the SD-based macro-economic models allowing to analyze them on more detailed level, while the IO models benefit from dealing with the constraints usually encountered by the static models, such as fixed technology, capital and labor, etc.

The present research further increases the synergy between the two approaches. IO coefficients are incorporated in the SD model to observe the dynamics of labor demand within various economic sectors of North Dakota in the context of the oil boom. Disaggregating regional labor demand into separate industrial sectors helps reveal the industrial needs for labor.

The IO models represent static interrelationships among the different industries. The IO models assume that in a multi-sector economy a production output in one industry requires inputs from other industries. On the first stage, an IO model is expressed in a matrix form showing monetary transactions among sectors. The transaction matrix is then converted into a table of technical coefficients. These technical coefficients are used in the present research for the sectoral disaggregation of North Dakota's economy. The calculation process of the IO tables for North Dakota's economy is explained in the *Data collection and analysis* section of this chapter.

Data collection and analysis

To find the IO coefficients to input into the SD model, several sources were considered.

A team of scholars at North Dakota State University (NDSU) have been developing the IO models of the state of North Dakota since 1963 (Coon, Lelstrltz, Hertsgaard, & Leholm, 1985). Having been contacted, the team expressed readiness for collaboration and, subject to a data confidentiality agreement, agreed to share the results of their research. However, industry classification criteria used in their IO modeling were different from the North American Industry Classification System (NAICS), a standard classification system for collecting and analyzing statistical data of North American economies. NAICS is the classification system underlying the rest of the available statistical data converted into inputs to the SD model in this research or used for the validation of the model's simulation results. However, the NDSU scholars made available the crosswalk documentation between their classification and the Standard Industrial Classification (SIC), an old classification system that was eventually, in 1997, replaced by NAICS.

Therefore, a separate calculation of the IO model for the state of North Dakota was needed in order to obtain necessary inputs for the SD model. For this purpose, data was purchased from IMPLAN, the world leader in collecting and providing economic impact data (IMPLAN, LLC, 2015).

The data from IMPLAN was available for 5 non-consecutive years: 1997, 2001, 2006, 2009 and 2013. The data contained information about monetary transactions among industries made in North Dakota within the corresponding year. IMPLAN's data was used to construct a transaction table of the IO model. To strike a balance between detail complexity and inter-industry linkages, 20 initial NAICS industries were collapsed into 8 sectors of major industries of importance to the state of North Dakota by their economic size. These industries and sectors are presented in Table

1. On the right are listed the initial industries from IMPLAN's data, with the resulting industry sectors given on the left.

Table 1. The resulting industry sectors of North Dakota for the IO model

Resulting sectors	Initial industries
Agriculture	Agriculture, forestry, fishing & hunting
Mining	Mining
Utilities	Utilities
	Administrative & waste services
Construction	Construction
Manufacturing	Manufacturing
Wholesale trade and transportation	Wholesale trade
	Transportation & warehousing
Retail, food and lodging	Retail trade
	Accommodation & food services
Other services	Information
	Finance & insurance
	Real estate & rental
	Professional- Scientific & tech services
	Management of companies
	Educational services
	Health & social services
	Arts- Entertainment & recreation
	Government & non-NAICs
	Other services

Table 2 shows one of the transactions tables (for the year of 2013) compiled for the present research. In the IO models' transaction matrices, the industries are presented in both rows and columns. When reading down a column, the numbers indicate the amounts of inputs purchased from industries in that row for the production of the output of the industry given in the column header. Some transactions are also made within the same industry. For example, for the output production within manufacturing industry, nearly 306 million US Dollars of input was required from Agriculture, 1371 million US Dollars from Mining, and 3337 million US Dollars from manufacturing industry itself. The output from each industry is either bought by other industries to be used as input for their production or purchased for the final use. Purchases made by one industry from another industry to be used in production are called *intermediates* in this study. Besides the inputs from industries, output production also requires inputs from imports, plus value added by capital and labor in each sector.

When reading along rows, the numbers give the amounts of sales each industry provides to other industries. This table includes only intermediate sales to other industries. Besides those, the original IO models also include sales for final use (columns to the right from the intermediate demand), representing the demand by Households or Government, as well as Export sales. These are not required for the calculation of technical coefficients, however, are important in calculating the total sales performed by each sector. .

Table 2. The transactions table, 2013 (Millions of US Dollars)

	Purchases (intermediate demand)								
		Agriculture	Mining	Utilities	Construction	Manufacturing	Wholesale trade and transportation	Retail, food and lodging	Other services
Sales	Agriculture	793.72	0.73	2.15	8.89	306.13	0.51	9.03	6.15
	Mining	68.04	983.97	277.60	88.25	1371.10	36.09	8.59	70.95
	Utilities	64.58	31.25	806.76	47.75	221.42	174.54	124.06	635.20
	Construction	83.90	101.59	40.93	3.92	101.12	45.04	38.41	575.63
	Manufacturing	1152.01	245.39	104.69	1039.96	3337.07	418.85	246.03	695.34
	Wholesale trade and transportation	481.57	114.39	105.45	362.35	988.74	740.63	265.83	415.42
	Retail, food and lodging	14.62	10.21	35.88	891.03	115.14	80.46	88.74	274.25
	Other services	480.64	178.78	282.95	332.97	788.21	1172.50	913.04	4218.42
	Value added	2885.84	8174.56	2053.25	3180.73	3174.92	7030.12	3939.03	21252.72
	Imports	2887.904	682.2786	996.2365	1682.262	5545.207	1594.901	1039.857	4911.933
	Total Input	8912.82	10523.15	4705.90	7638.12	15949.05	11293.63	6672.62	33056.02

Technical coefficients tables are derived from transactions tables. The coefficients are calculated by dividing each number in a column by the column's total and represented as fractions of the total. Table 3 is one such technical coefficients table calculated for this study and given as a representative example.

Table 3. Technical coefficients for the Input-Output model (2013) used as input parameter in the system dynamics model

	Agriculture	Mining	Utilities	Construction	Manufacturing	Wholesale trade and transportation	Retail, food and lodging	Other services
Agriculture	0.089	0.000	0.000	0.001	0.019	0.000	0.001	0.000
Mining	0.008	0.094	0.059	0.012	0.086	0.003	0.001	0.002
Utilities	0.007	0.003	0.171	0.006	0.014	0.015	0.019	0.019
Construction	0.009	0.010	0.009	0.001	0.006	0.004	0.006	0.017
Manufacturing	0.129	0.023	0.022	0.136	0.209	0.037	0.037	0.021
Wholesale trade and transportation	0.054	0.011	0.022	0.047	0.062	0.066	0.040	0.013
Retail, food and lodging	0.002	0.001	0.008	0.117	0.007	0.007	0.013	0.008
Other services	0.054	0.017	0.060	0.044	0.049	0.104	0.137	0.128

The IO model coefficients provided by NDSU were used for validation of coefficients calculated based on IMPLAN's data. By using the crosswalk between the NDSU team's classification and the SIC provided by them together with the crosswalk between the SIC and NAICS officially available online, it is possible to compare some of the coefficients. According to the NDSU team, the technical coefficients stayed relatively stable over the years, undergoing only slight changes. In order to test that notion and validate the IO technical coefficients calculated for the present research, the coefficients were calculated for each available year of IMPLAN's data. A comparison of the calculation results over the years has shown that the technical coefficients have indeed been relatively stable for the 4 last data points (see Appendix A), confirming that the IO coefficients were calculated for this research sufficiently close.

Model description

Sub-models description

The purpose of the model is to analyze the dynamics governing labor demand in North Dakota and to test some possible scenarios of future oil price changes and their effects on labor demand within the eight sectors of the state's economy, with an emphasis on the mining sector.

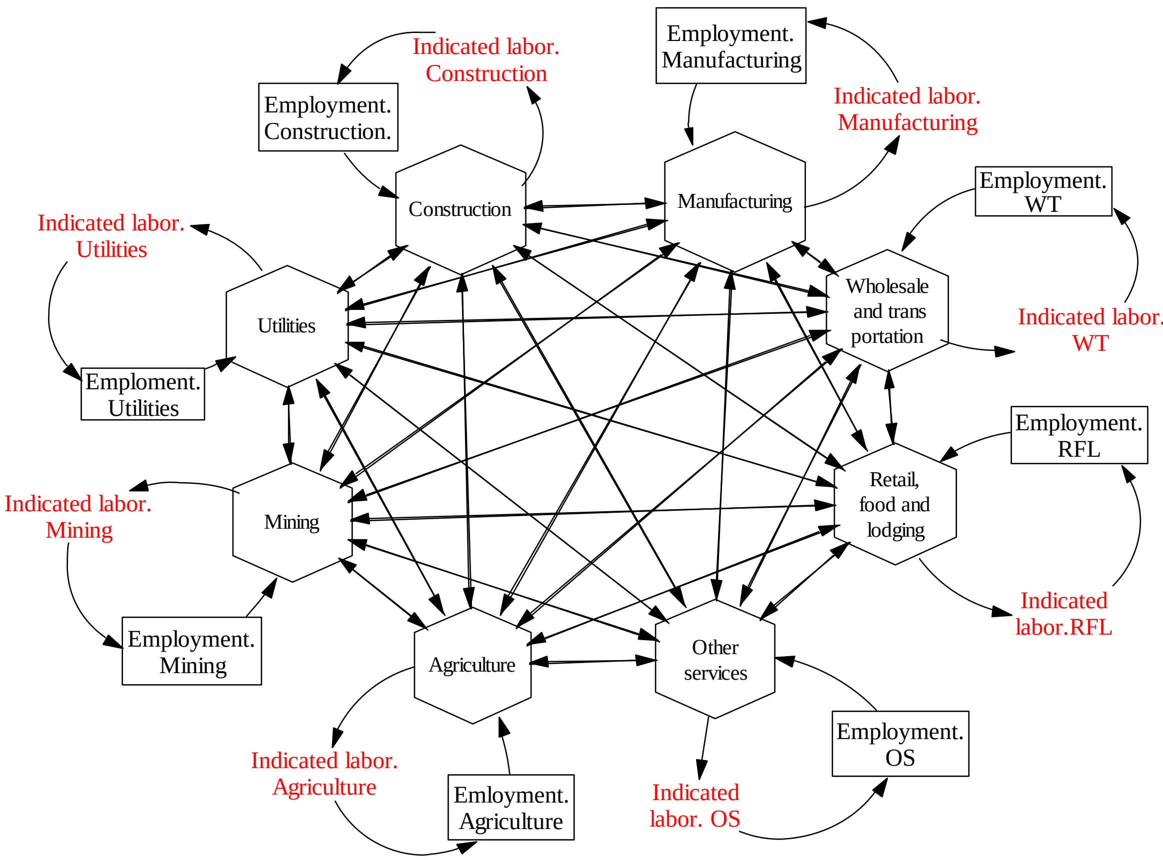
The time horizon of the model is 23 years, spanning the period from 1997 to 2020, and the general unit of time is a year. The system behavior analysis begins with the historical pre-boom period (1997-2006). The boom period is assumed to be from 2006 to 2015. The simulations for the 2015-2020 period are based on scenarios with changing oil prices.

The model structure is divided into 8 main modules corresponding to the 8 sectors, with several sub-models each.

Figure 4 is an illustration of the economic sectors of North Dakota and the relationships among the industries. It is given for conceptual understanding of the present research's model. As mentioned earlier, the 8 industry modules are the result of a statewide aggregation. A double-headed arrow shows the interconnectedness of the two industry sectors it joins, meaning that the sectors both take an input from and provide an output for the other sector's production. The *Inidicated labor* representing the demand for labor within each sector is the main output and purpose of the model.

The structures of production, capital, and labor sub-models of all sectors except Mining are similar. The structures of the model in the present research are based on generic SD structures and have been developed in accordance with the best System Dynamics practices for analyzing economic theories. The model takes an endogenous perspective on most of the structures, while such variables as oil prices, IO and import coefficients, normal unemployment rate, capital and labor intensity coefficients in production, and real interest rate for capital are treated as exogenous.

Figure 4. Conceptualization



The model boundaries:

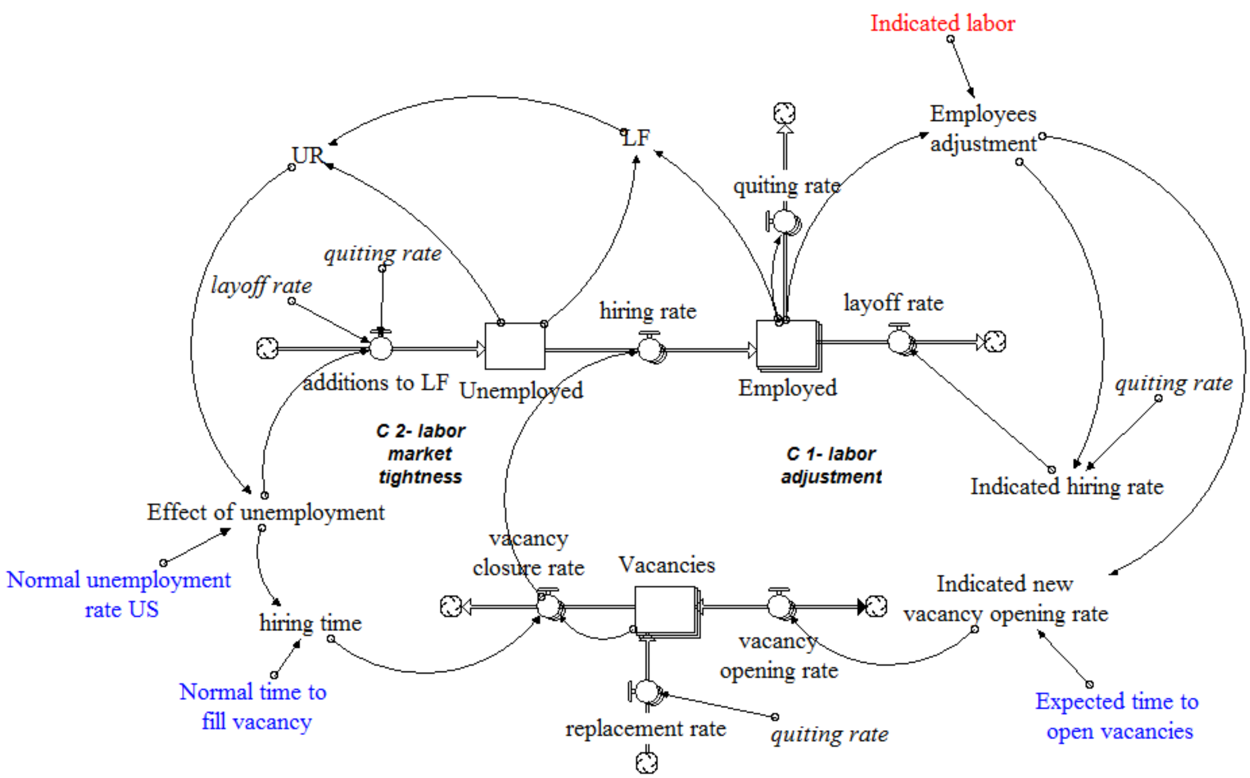
The following fall outside the boundaries of the model:

- Vacancy filling and employment selection procedure
- Increasing or reducing returns to scale in production
- Financial constraints on making capital investments or hiring labor
- ND government tax revenues
- Other sectors to be covered in complementary research

The workforce-job-matching sub-model

Figure 5 contains the structure of workforce matching. In this structure, labor demand, expressed as *Indicated labor,* is assumed to be known (the structure for labor demand is presented further in the paper).

Figure 5. The workforce-job-matching sub-model



The structure represents two counteracting loops. One is responsible for closing the gap between labor demand and actual employment, expressed as *Employed*. This loop's structure is straightforward. *Indicated labor* controls *hiring* or *layoff rates*. If it is higher than actual employment, new vacancies will be open. There are also replacement vacancies which are opened in order to replace workers quitting their jobs. Another counteracting loop represents the market tightness mechanism. Together, the two loops cover the workforce-job matching process. This structure is a simplified representation and alone is insufficient to replicate the existing job openings (vacancies) data. In order to do that, a more detailed structure of the labor supply and selection procedure for filling a vacancy is needed. Instead, the structure tries to overcome this shortcoming through certain mechanisms. For example, *Effect of unemployment* represents the employment tightness on the labor market. Whenever the unemployment rate in ND is lower than the US normal unemployment rate of 5%, the labor market is tight, which means that the 'scarce' pool of unemployed people slows down the person-job-opening matching process. So the *Effect of unemployment* increases the hiring time to close the vacancy that otherwise would be equal to *Normal time to fill vacancy*. This parameter varies among industries.

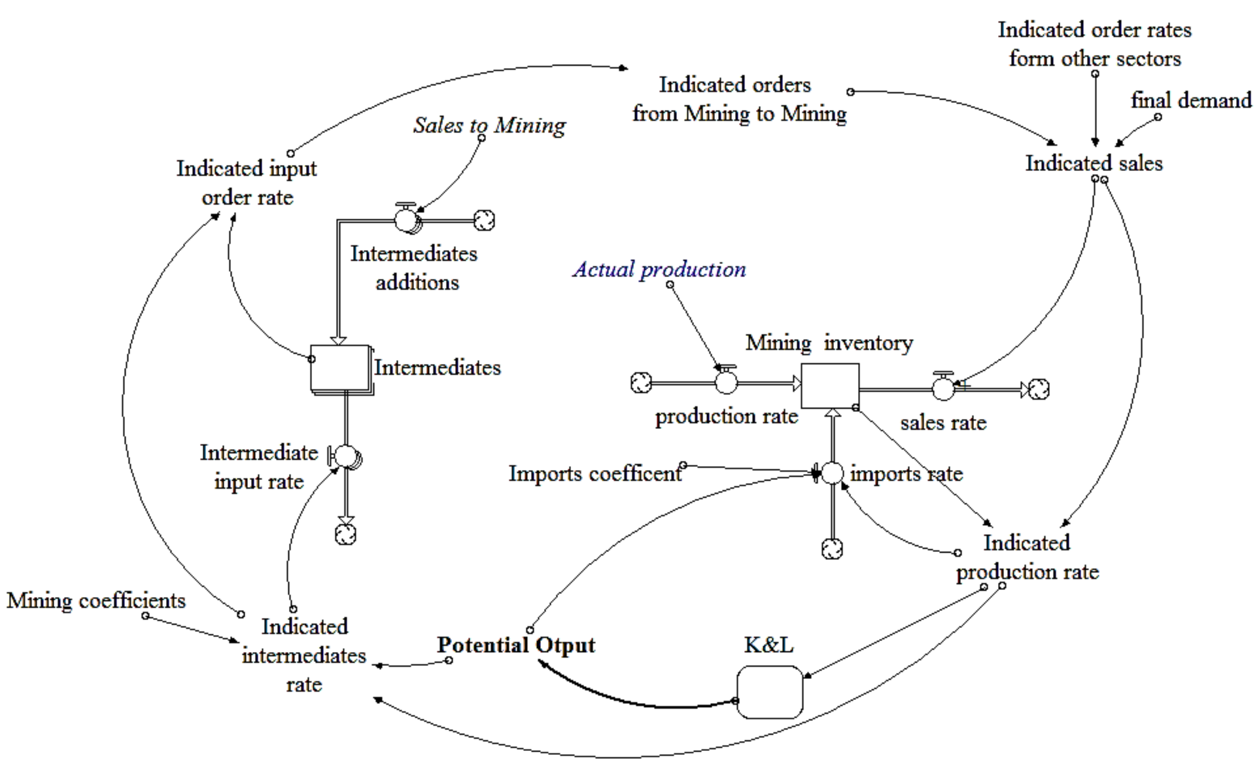
A low unemployment rate also has an effect on the additions to labor force (LF). The term 'labor force' in the present research covers both the workers residing in ND and out-of-state commuters.

The mechanism stands for a notion that with tightness of the market the wages also rise, which makes ND more attractive to job-seekers – local workers choose to stay in ND, outsiders, to come to ND. A high unemployment rate has an opposite effect on *Additions to LF*.

The production sub-model

Figure 6 shows a simplified structure of production and its inputs on the example of the Mining sector.

Figure 6. The production sub-model

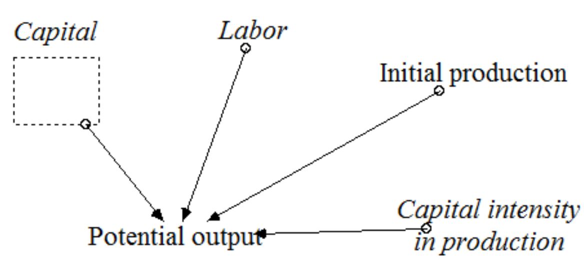


Production rate is measured in millions of US Dollars (USD) per year, leading to the *Inventory* accumulating in millions of USD. The production structure incorporates IO coefficients in order to identify the amounts of inputs – intermediates – from other industries, as well as imports. The IO and imports coefficients are exogenous inputs to the model. The structure of the production sub-model is adapted from the models developed by Wheat & Pawluczuk, (2014) and Sterman (2000).

The sales rate is determined by *Indicated sales*, which is the demand by other industries for inputs to their production processes, and *Final demand*, which is the final consumption and the export sales combined. Together with inventory adjustments, *Indicated sales* they define *Indicated production rate* (see Sterman, 2000, pg 768).

The arrayed *Intermediates* and other variables in the model contain 8 economic sectors of one of the two categories: the purchasing industries or the selling industries. The arrayed structure allows observing changes within each sector separately. *Indicated intermediates rate* and *Imports rate* are determined by multiplying the fractional coefficients of the inputs by the smaller of the values of *Indicated production rate* and *Potential output*. The reasoning behind the choice between the two mirrors the effects of real-life constraints on production: delays in adjusting to the Indicated production rate if it is higher than the production rate that can be generated by the current capacity. *Potential output* is the rate of production allowed by the current industry capacity, determined by the levels of capital and labor and generated within respective sub-models[4] (See Figure 7) (Tasrif, 2014).

Figure 7. Potential production calculation

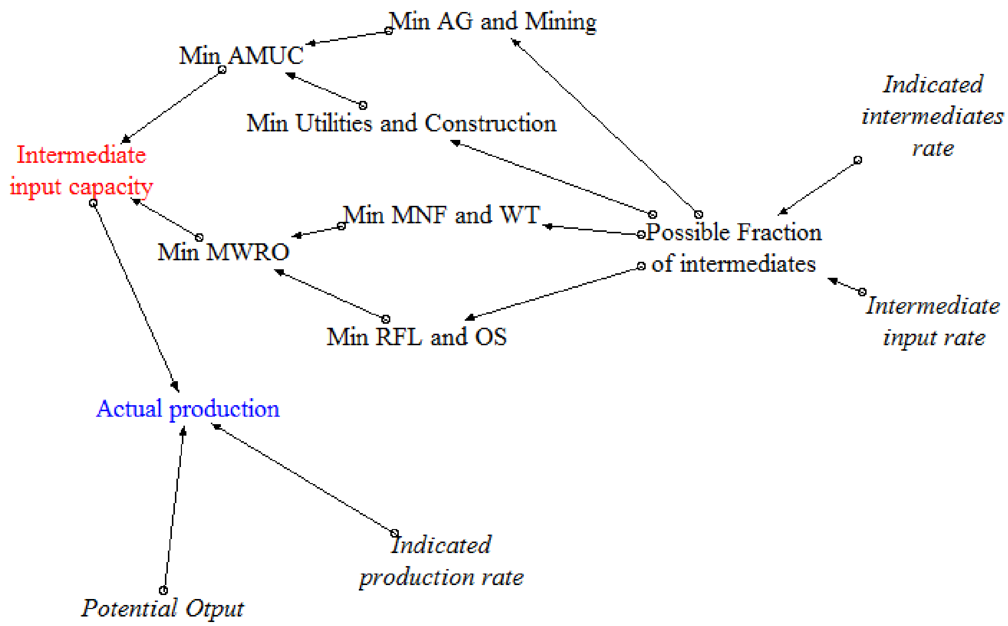


[4]Potential output is determined by the production function:

$$Potential\ output = Initial\ production \times \left(\frac{Capital}{Initial\ capital}\right)^{Capital\ intensity} \times \left(\frac{Labor}{Initial\ labor}\right)^{Labor\ intensity}$$

Intermediates also put constraints on production rate through *Intermediate input capacity*. Figure 8 depicts the structure that arrives at the variable.

Figure 8. The intermediate input capacity structure



Intermediate input capacity is determined by comparing *Indicated intermediates rate* to the actual *Intermediate input rate* for all sectors, in fractions of the indicated rate. The intermediate input capacity is calculated by taking the smallest values from among all the fractions. For example, the variable *Min AG and Mining* compares the two fractions of intermediate inputs from Agriculture and Mining sectors and takes the smaller value (MIN function). The structure continues to compare pairs of fractions, taking smaller values and arriving at the overall smallest value in the end. The value is used as a constraining factor in production. So, *Actual production* takes the smaller of *Potential output* and *Indicated production rate* and is multiplied by *Intermediate input capacity*.

Labor and capital

The decision-making structure of the Capital and Labor response to a change in the Indicated production rate is based on the Cobb-Douglas production function as used in the micro- and macroeconomic theory (Tasrif, 2014).

The Cobb-Douglas production function in the general notation is as follows:

$$Y = (K)^{\alpha}(QL)^{\beta}$$

and

$$\alpha = MPK \times \frac{K}{Y}$$

$$\beta = MPL \times \frac{L}{Y}$$

where *Y* is production, *K* – capital, *L* – labor, *Q* – technological change, *α* – capital intensity in production, *β* – labor intensity in production, *MPK* – marginal product of capital, *MPL* – marginal product of labor.

Note that the model assumes $\alpha + \beta = 1$, meaning that decreasing ($\alpha + \beta < 1$) and increasing ($\alpha + \beta > 1$) returns to scale are outside of the scope of this model.

Assuming operating under profit maximization (or cost minimization) conditions, i.e. when marginal product of capital equals to marginal cost of capital, and marginal product of labor equals to marginal cost labor, the following formulas can be derived from the production function formula:

Indicated Capital: $K^d = \frac{Y^d \times \alpha}{c}$

where Y^d – Indicated production, *c* – annual cost of capital

Indicated Labor: $L^d = \frac{Y^d \times \beta}{w}$

where *w* – real wages – i.e. annual cost of labor

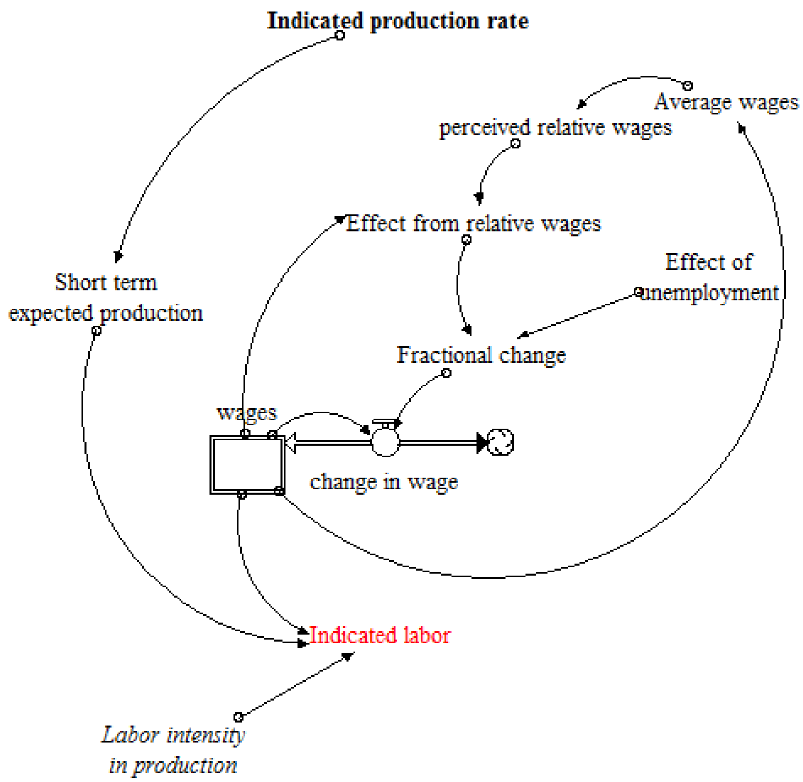
Labor productivity: $\frac{Y}{L} = (\frac{K}{L})^{\alpha} \times Q^{\beta}$

The incorporation of the formulas into the SD structure is presented below.

The labor demand sub-model

Figure 9 gives an overview of the labor demand sub-model structure.

Figure 9. Labor demand sub-model



The assumption is that expected demand, expressed as *Indicated production rate*, and wages drive the changes in the labor demand sub-model and determine *Indicated labor*, i.e. demand for labor. The intensity in production is assumed to be a constant. *Short-term expected production* is a first-order exponential smooth of *Indicated production rate*.

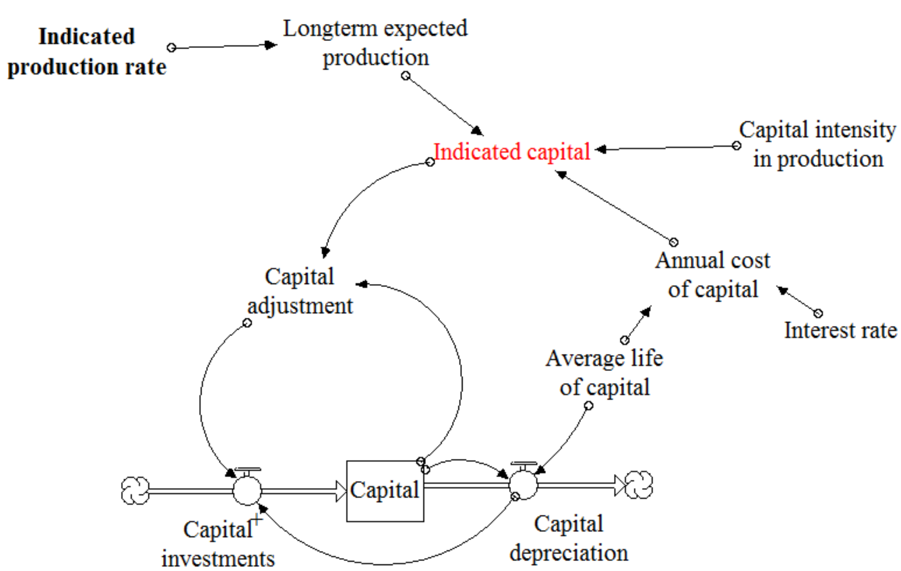
Wages are determined by *Effect of unemployment*, generated within the workforce-job matching sub-model, and average wages among the industries. The structure for the wages, as mentioned in the Introduction chapter of the present paper, is based on the fact that in the tight labor market employers try to increase wages in order to attract workers.

Another variable that impacts wage growth is *Unemployment rate*. The higher the unemployment rate, the less is wage growth rate. The structure for wages is a first-order linear positive-feedback-loop system resulting in their exponential growth.

The capital sub-model

Figure 10 represents a simplified structure of the capital sub-model. The structure is the classical generic structure for capital. The sub-model assumes that the long-term expected production and the cost of capital determine the capital needed for production.

Figure 10. Capital sub-model



Capital is measured in millions of USD. *Long-term expected production* is a first-order exponential smooth of *Indicated production rate* with a 3-year averaging time. *Annual cost of capital* is the sum of *Interest rate* and the inverse of *Average life of capital*. An increase in *Indicated capital* increases the gap between the desired and the actual capital levels, leading to higher *Capital investments*. *Capital investments* is a part of a first-order non-linear negative feedback system, also covering replacement of capital losses (depreciation) of the capital stock. The depreciation structure is a generic first-order linear negative feedback structure leading to exponential decay.

More detailed documentation of the model is provided in Appendix C.

Feedback analysis

Figure 11 shows the main feedback loops of the model. The behavior of the model is shaped by the their interactions. For simplicity, only one sector – the Agriculture sector - out of the eight aggregated industry sectors is presented. Within each of the eight sectors, six major feedback loops were identified. In the figure, an R indicates a reinforcing loop, while a C indicates a counteracting loop.

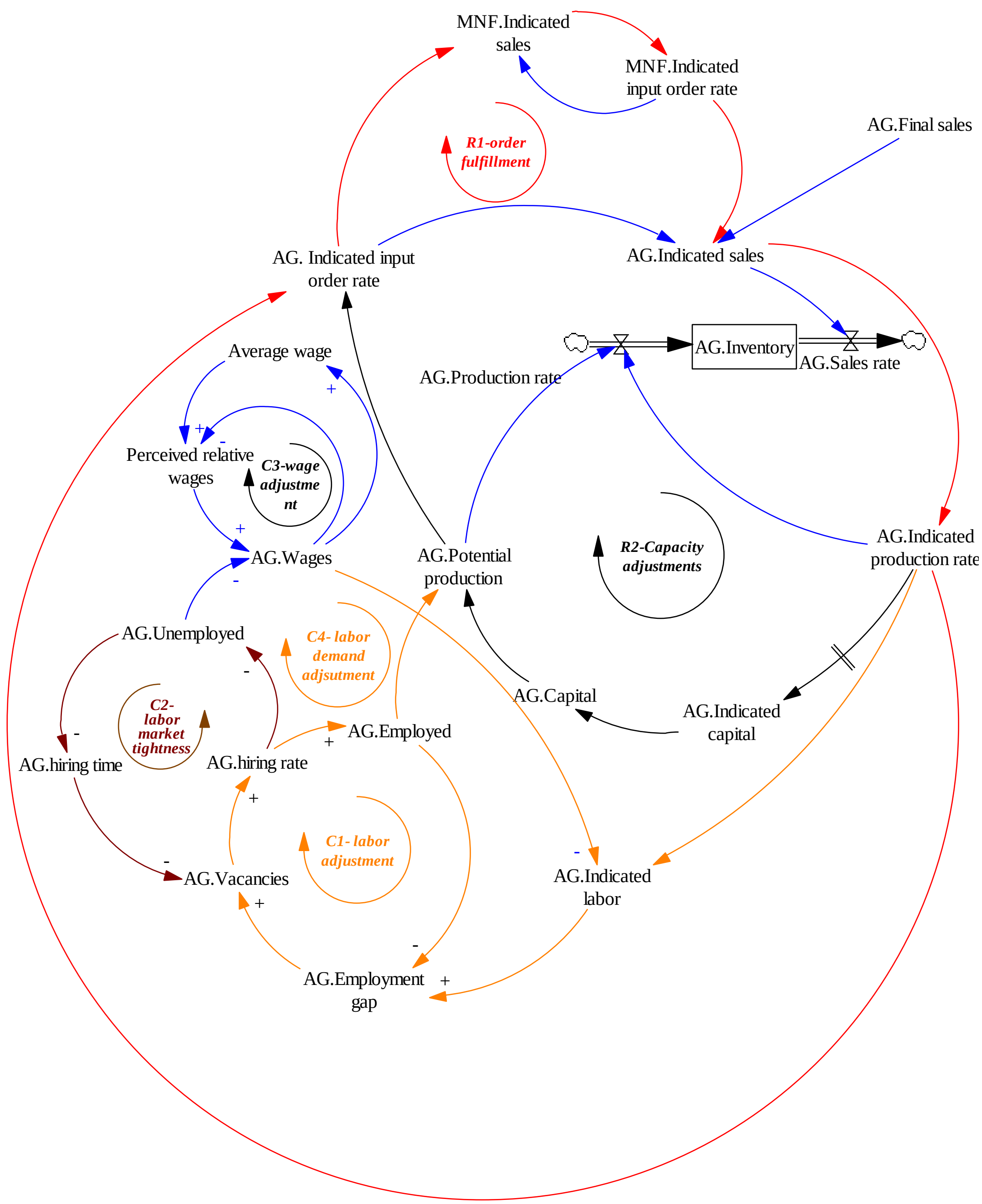
The R1 loop is a representation of an order-filling process. The higher the indicated production in one industry is, the higher its orders for inputs from other industries are. The orders increase the industries indicated sales and thus increase their indicated production. Since among the inputs needed for production there could be inputs from within the same industry, an increased *Indicated production rate* could imply increased orders from within the industry, thus increasing the industry's intra-sales. Increased sales lead to increased *Indicated production rate*.

Apart from the inputs from other industries, the production rate depends on the capacity – capital and labor – within the industry. R2 is a reinforcing loop that links delayed capital adjustments to the production rate. Because of the delays, the indicated production might be competing with the potential production which depends on the capacity constraints. An increased capacity to produce as a response to an increased production rate leads to more orders for inputs form other industries.

The increased *Indicated production rate* will be followed first by an increase in labor demand, expressed as *Indicated labor* due to a shorter time it takes to adjust to the expected demand. Through the C1 labor adjustment loop, labor demand strives to be satisfied. However, there could be constraints to meeting the labor demand, such as the C2 loop representing labor market tightness. When the labor market is tight, the worker-job matching process takes a longer time, slowing down the *hiring rate* and creating a gap between the desired and the actual numbers of workers. The market tightness also influences wages. In a tight labor market, the average wage is high. C3 is a counteracting loop representing wage adjustment within the industry. In order to attract workers, the industry increases the wages, driving up the average wage. However, higher wages decrease labor demand, since they imply higher labor costs.

Naturally, the feedbacks work as well in the reverse scenario of decreasing the indicated production. The system will behave in a way that gives signals to the capital and labor sub-models to decrease the production first by ordering less intermediate inputs, then by laying off labor, and then by decreasing capital capacity.

Figure 11. Feedback analysis



Model validation

The of concept validation

The concept of model validation in System Dynamics is controversial: there is no formally accepted list of tests an SD model has to pass to be considered validated (Barlas, 1996; Sterman, 2000). Validation is designed as an iterative and continuous process to reveal and correct errors in the model and to eventually gain confidence in the model's assumptions and structure. So, the process of validation is the process of building up confidence in the model.

However, no matter how many iterations a model goes through, it can never be considered completely validated and verified because, as Sterman (2000) famously stated, 'all models are wrong' since they are all simplified representations of reality.

The process of structural validation is subjective, semi-formal and conversational. Barlas (1994) pointed out that in SD, validity, foremost, refers to the 'internal structure of the model' rather than its output behavior, as it is possible to obtain 'the right behavior for the wrong reason'. Coyle & Exelby (1999) considers a model to be valid when it proves to be 'sound, defensible and well-grounded'. That means that the structure of the model should be developed based only on reliable methods, sources and other available knowledge about the system. No validation tests can be employed without referring to the purpose of the model (Sterman, 2000): a model's being valid does not imply that it is a true representation of reality, but rather that it is a useful one. In the present research, validity will be considered to be achieved when a model is useful with respect to its purpose.

Despite the limitations of validation stemming from its qualitative and iterative nature, Barlas suggested a logical sequence as a guideline for carrying out model validity tests in three stages: direct structural tests, structure-oriented tests, and behavior pattern prediction.

The model in the present research follows this guideline. The procedures for conducting the tests are explained further together with descriptions of the respective tests.

Structure validity

Direct structure tests

Direct structure tests do not involve simulations and are conducted by comparing each equation and logical function in the model against available theoretical or empirical knowledge about the aspect of the system being modeled (Barlas, 1994). Three direct structure tests were applied for the model's validation: a structure confirmation test, a parameter confirmation test, and dimensional consistency test.

Since the tests are very qualitative and not easily formalized by nature, the verification of the model's structure for this research was performed by presenting it to the stakeholders in Bismarck (July 10, 2015), consisting of government experts, and 'walking through the model' in order for them to reveal inconsistencies or confirm the model's fit. Thus, the model passed the ***structure confirmation test***. Many questions about the model's parameters were asked by North Dakota Job Service's market information manager Michael Ziesch, which made it possible to conduct the ***parameter confirmation test***.

The ***dimensional consistency test*** assesses whether the equations are dimensionally consistent within the model without using any 'dummy' parameters that do not exist in the real system (Barlas, 1996; Sterman, 2000). The dimensional consistency test was conducted with the help of the software 'Unit check' by the iThink software, in which an SD model was developed for the present research. The software confirmed that 'All units within the model appear to be consistent'.

Structure-oriented behavior tests

Structure-oriented behavior validation requires simulations, evaluating the validity of the model's structure indirectly, and is conducted by applying certain behavior tests to the behavior patterns generated by the model (Barlas, 1996; Forrester and Senge, 1980). Structure-oriented behavior tests are strong validation tests that can reveal structural flaws in a formal and quantified manner.

There are many types of structure-oriented behavior tests, however, not all are possible to conduct within the context of the present research. The following structure-oriented behavior tests were selected in accordance with the purpose of the model in this research: the ***extreme-condition test*** and the ***behavior-sensitivity test***.

Steady-state initializion

In model-structure simulation tests, the model is initiated in an equilibrium, i.e. steady-state, making it easier to observe the 'pure' response of the system to the tests (Richmond, 2013). The model is initialized in an equilibrium by fixing the values of the flows so that the inflows to the stocks equal to the sum of the outflows from the stocks, and by initializing stocks to desired levels (equal to the 'goal' variables). For convenience, sub-model structures were tested separately from each other.

Behavior-sensitivity test

A behavior-sensitivity test is conducted by 'shocking' the model away from its equilibrium and comparing the resulting behavior to the anticipated one on whether the real system would express similar sensitivity (Barlas, 1996). The purpose, however, is to reveal parameters that the model is highly sensitive to, which, if needed, could be used as leverage points for managing, controlling, or improving the system.

Several parameters, introduced below, were chosen to be presented in the current paper.

<u>*Testing the workforce matching sector*</u>

The stocks in this sector are initialized in an equilibrium state as follows:

- *INIT Employed = Initial_LF*(1-equilibrium__unemployment_rate)*
- *INIT Unemployed = Initial_LF* equilibrium__unemployment_rate*
- *INIT Vacancies = replacement_rate+vacancy_opening_rate)*Normal_time_to__fill_vacancy*

Here *Initial_LF = 300000.* The initial labor force was assumed to be a constant of 300,000 which is close to the real number from the historical data on the 1990s in ND.

The flows are initialized as follows:

quitting_rate = Employed/avg_tenure,

and, substituting the *quitting_rate* in the equation with the numeric value, *quitting_rate =300000*(1-0.5)/5=57000.* Since the inflow of additions to the labor force must be equal to the outflow of the quitting rate, the *additions to LF = 57000*.

The validation test is conducted by changing the values of *Indicated labor*. The STEP function is introduced starting from the year 2005 with the extreme values for *Indicated labor* at 0 and 1300000.

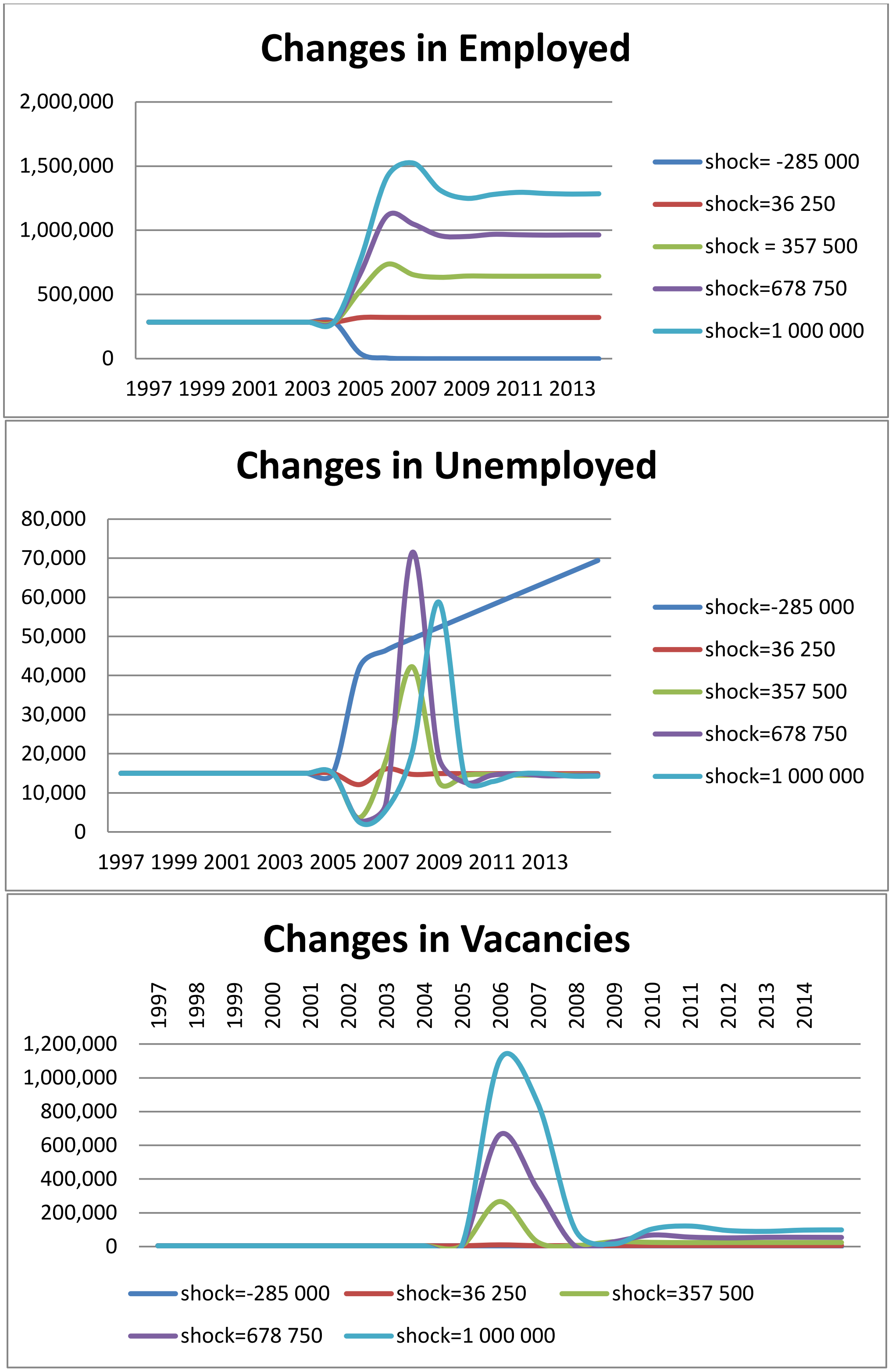
Other sectors impact the rest of the workforce matching sector through *Indicated labor*. 'Shocking' *Indicated labor* with the extreme values tests the sensitivity of the rest of the sector structure to the variable.

Through the 'Sensitivity Analysis Options' of the *iThink* software, *Indicated labor* is 'shocked' by setting the extremes of the variable's range to -285 000 and 1 000 000. The runs test the system by running values from the entire range of the given interval.

Figure 12 (the top graph) shows that the stock of 'Employed' behaves as expected, i.e. adjusts to the new 'goals' of employment. Due to the two counteracting loops in the workforce matching sector, the system oscillates around the goals right after 'shocking' and evens out by 2010.

The stock of 'Unemployed' (the middle graph in Figure 12), reacts as expected, showing a dramatic increase when the indicated employment is shocked with the STEP of -285 000, which makes the Employment stock drop to 0. In all other 'shock' cases where the indicated employment is increased, the stock of 'Unemployed' initially drops. However, the drops are followed by dramatic increases representing oscillations before the system reaches its equilibria. The reason for the oscillations is the two counteracting loops mentioned above. When the stock of 'Unemployed' declines, the effect of unemployment on additions to labor force increases, thus increasing the inflow to the unemployed. After the stock is saturated, the effect of unemployment drops again, decreasing the flow of additions to labor force, and the system again finds its equilibrium.

Figure 12. Behavior-sensitivity test: 'shocking' *Indicated labor*: the effects on the 'Employed', 'Unemployed' and 'Vacancies' stocks



The dramatic increase 'shocks' drive the 'Vacancies' stock (the bottom graph in Figure 12) up in 2005; however, the stock does not immediately drop to find an equilibrium, but rather has less steep declines due to decreased effects of unemployment (so-called labor market tightness), which increases the hiring time and, hence, slows down the vacancy closure rate.

Overall, the system responded as expected, arriving at equilibriums despite the initial oscillations after the shocks.

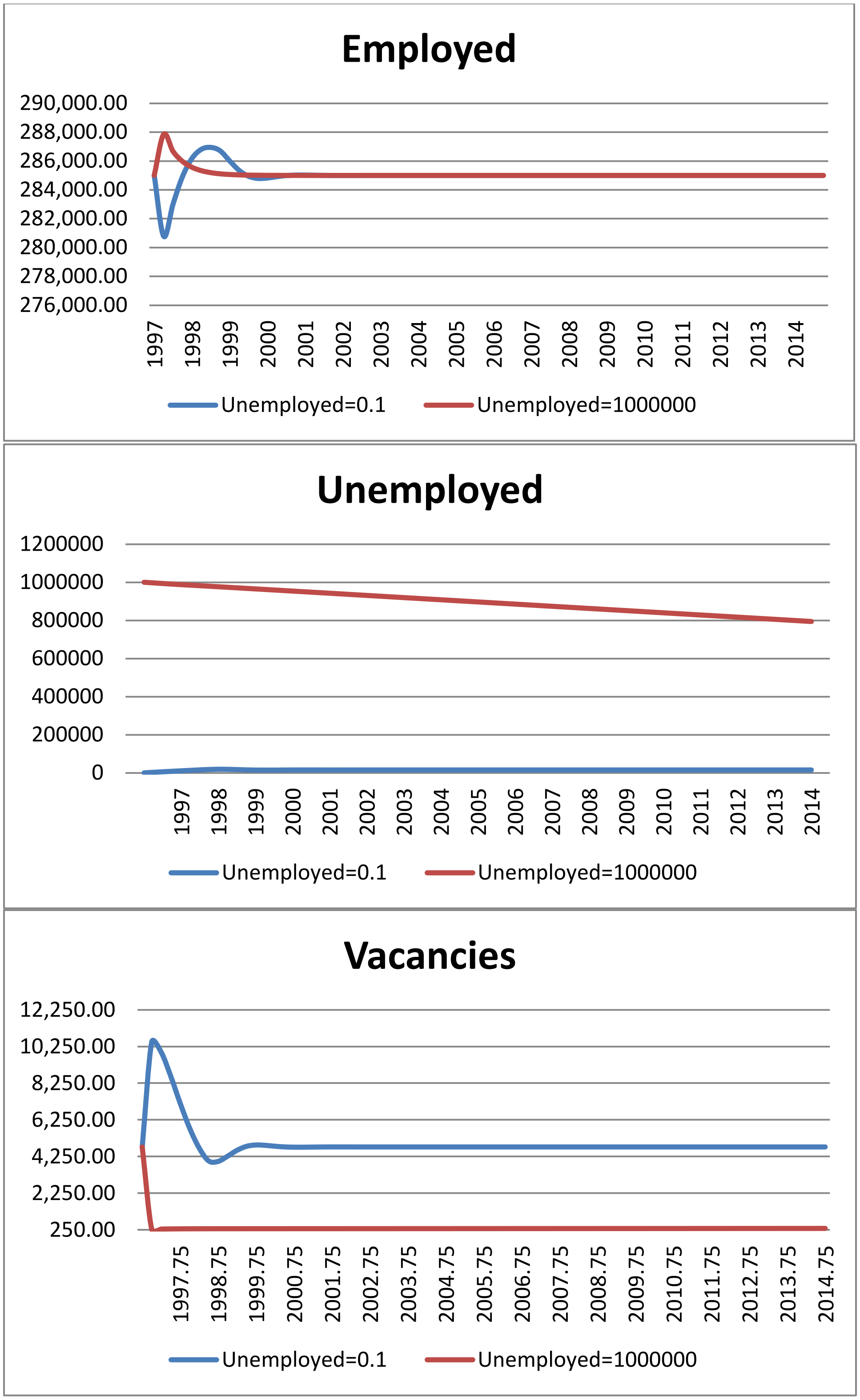
Extreme-condition test

As the name implies, the extreme-condition test tests the robustness of the model under extreme conditions of the parameters. No matter what extreme values are set, the structure should produce adequate responses to them. For example, in real systems, stocks can never drop below zero (Sterman, 2000), so they must not do so in modeled systems. In case of the present research, the stocks of Unemployed, Employed, Vacancies, Capital and Inventories must not drop below zero. Moreover, the production structure must adequately respond to the extreme-condition test. For instance, production cannot happen without labor, capital or materials for production.

The model was partially tested under extreme conditions during the behavior sensitivity test, when the *Indicated labor* was 'shocked' to assume extreme values and the responses of the three stocks were adequately represented. Another way to test the model in the extreme-conditions test is to initiate the stocks with extreme values.

To test the workforce structure under extreme conditions, the 'Unemployed' stock was initiated with two extreme numbers: 0.1 (the stock cannot be initialized to 0 since in some of the equations of the structure Unemployment appears in the denominator and a 'Division by zero' error is produced by the software) and 1 000 000. Figure 13 shows how the system reacts to the extreme conditions within the stocks of the workforce structure. The blue lines indicate how the stocks react when Unemployed is initialized to 0.1; the red lines, with 1 000 000. As expected, the stocks do not drop below zero and the system strives towards equilibrium. When *Unemployed* stock is initialized to 0.1, the stock of *Employed* (the top graph in Figure 13) drops since the system cannot compensate for the outflow from the stock. Once additions to the labor force start increasing the level of *Unemployed*, the stock of *Employed* follows suit to an overshoot, eventually reaching an equilibrium. The overshoots are caused by delays in the contracting loops adjusting *Employed* levels to the 'goal', i.e. *Indicated employment.*

Figure 13. Extreme-condition test: setting extreme values for Unemployed; the effects on ‘Employed’, ‘Unemployed’ and ‘Vacancies’ stocks



The behavior of the stock of Unemployed itself is also predictable (the middle graph in Figure 13). Additions to labor force raise the level of the stock and, in 2002, it reaches an equilibrium at 15 000 people. The level of *Vacancies* (the bottom graph in Figure 13) dramatically increases in 1997 as a result of the effect of unemployment on hiring time: the lower the unemployment rate in comparison with the normal unemployment rate, the longer the hiring time. The increase slows down the vacancies closure rate, and, in combination with greater inflows, increases the level of the stock. Quite opposite behavior of *Vacancies* is observed when the stock of Unemployed is initialized to the value of 1 000 000. Because the unemployment rate is much higher than the normal employment rate, the hiring time is very short, increasing the vacancy closure rate and thus decreasing the stock. When Unemployed is initialized to 1 000 000, none of the three stocks quite reach their equilibria within the observed period, slowly increasing or decreasing instead. They reach their equilibria in the year of 2089 of the simulation, when the level of Unemployed drops to 15 000. The system, therefore, behaves as expected and sooner or later reaches an equilibrium no matter what extreme initial values are assigned to the stocks.

To further test the validity of the model, other stocks were also initiated with extreme values. The system produced the expected behavior. The model has passed the extreme-condition test.

Behavior validity

Behavior pattern prediction test

Once the model has passed the assigned structure validity tests, the final validation step is to see whether the designed structure is able to reproduce the behavior of the real system. It is more important to reproduce the patterns (trends, phases, frequencies, etc.) than to implement point-by-point prediction (Barlas, 1996). As one of the reasons for difficulty achieving point-by-point predictions, Sterman (2000) names random noise, which is hard to simulate.

It should be mentioned that the desired employment used for the reference mode (the behavior of the real system), i.e. the sum of actual employment and vacancies, has limitations and is but a proxy for the actual desired employment for several reasons. Firstly, Vacancies reflects only online job openings, while the real numbers of vacancies throughout the state of North Dakota are unknown. Secondly, the data for the online job openings are available only starting from 2008, so the numbers for the earlier years were estimated with backtrending (discussed in detail in the methodology part of the present paper). Finally, the employment data are ambiguous since they do not reflect many categories of workers (also discussed in the methodology part of the present paper).

With the limitations described above, Figure 14 shows the simulated results compared to the results in the reference mode. Since the numbers from 1997 to 2008 were estimated using backtrending, the real numbers are not known, which makes it difficult to compare the patterns meaningfully. However, the real behavior pattern of the known period, 2008-2014, was closely reproduced by the model simulation. Both the drop of the year 2009 and the subsequent steep growth were adequately captured by the model. For the period after 2015, *iThink* projects the trends for the data and simulates further points for the reference mode. The structure produces a notable decline for the year 2015, followed by slow, gradual growth. Since the final data for the year of 2015 are not yet available, and the decline in demand for labor cannot yet be confirmed, validation of the behavior patterns starting from 2015 is not possible. However, based on the rather accurate replication of the behavior patterns for the known period, 2008-2014, it can be claimed at this point that the model has passed the behavior-pattern prediction test.

Figure 14. Behavior pattern prediction

However, even after passing all of the validation tests one could not prove that a model is correct and valid (Sterman, 2000). The present research considers the validity of the model from the point of view of usefulness to the stakeholders. During the presentation to the ND government representatives, the representatives expressed their interest in the model and found it useful and worth experimenting with.

Model runs

Base run

This chapter focuses on the behavior of the variables of interest to the present research. Since there are 8 sectors, each with production and capital-labor sub-models with hundreds of variables, this section focuses on the behavior of only selected variables. Additional variables' behavior examination requires access to the model itself.

Stocks initialization

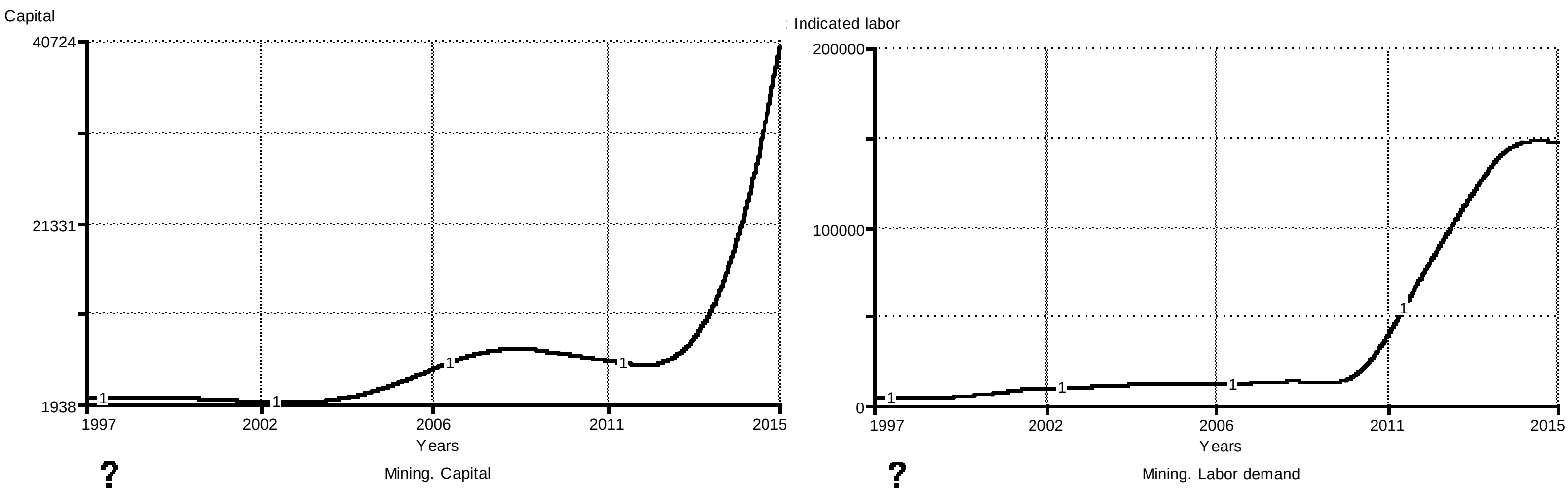
As mentioned above, one major problem encountered by this research was shortage of data. The shortage negatively impacted the quality of the simulations, especially when setting the initial values for the stocks *Inventory*, *Intermediates* and *Capital* in each sector. In order to initialize the stocks, assumptions had to be made. Inventory stocks were initialized by the *Initial sales*, which is total sales for the year 1997, multiplied by the *Indicated inventory coverage*. The estimations of the initial values for Capital were based on the above-mentioned production function initialized to the values produced by the formulas for *Indicated labor* and *Indicated capital* presented in the Model description chapter with the assumption that, in 1997, *Indicated labor* was equal to the actual labor and *Indicated capital* was equal to the actual capital. Since the data for employment and initial production were available, the labor intensity coefficients were calculated for each sector, which allowed to calculate the *Indicated capital* values for 1997. The values were then used to initialize *Capital* stocks. The calculation procedure is provided in Appendix B.

Capital and Labor sub-models

With growing demand, indicated production rate also rises, sending signals to Capital and Labor sub-model.

Figure 15 shows the behavior of the *Capital* stock (left graph) in the Mining sector. During the pre-boom period, capital was low by comparison with the boom period. The drop observed in 2012 is a delayed response of the system to the decrease in *Indicated production* in the year 2009. The relatively low labor demand during the pre-boom period (right graph) also indicates that production activity was not yet significantly growing. The dramatic growth in labor demand agrees with the knowledge gained from media and government reports discussed earlier in the paper.

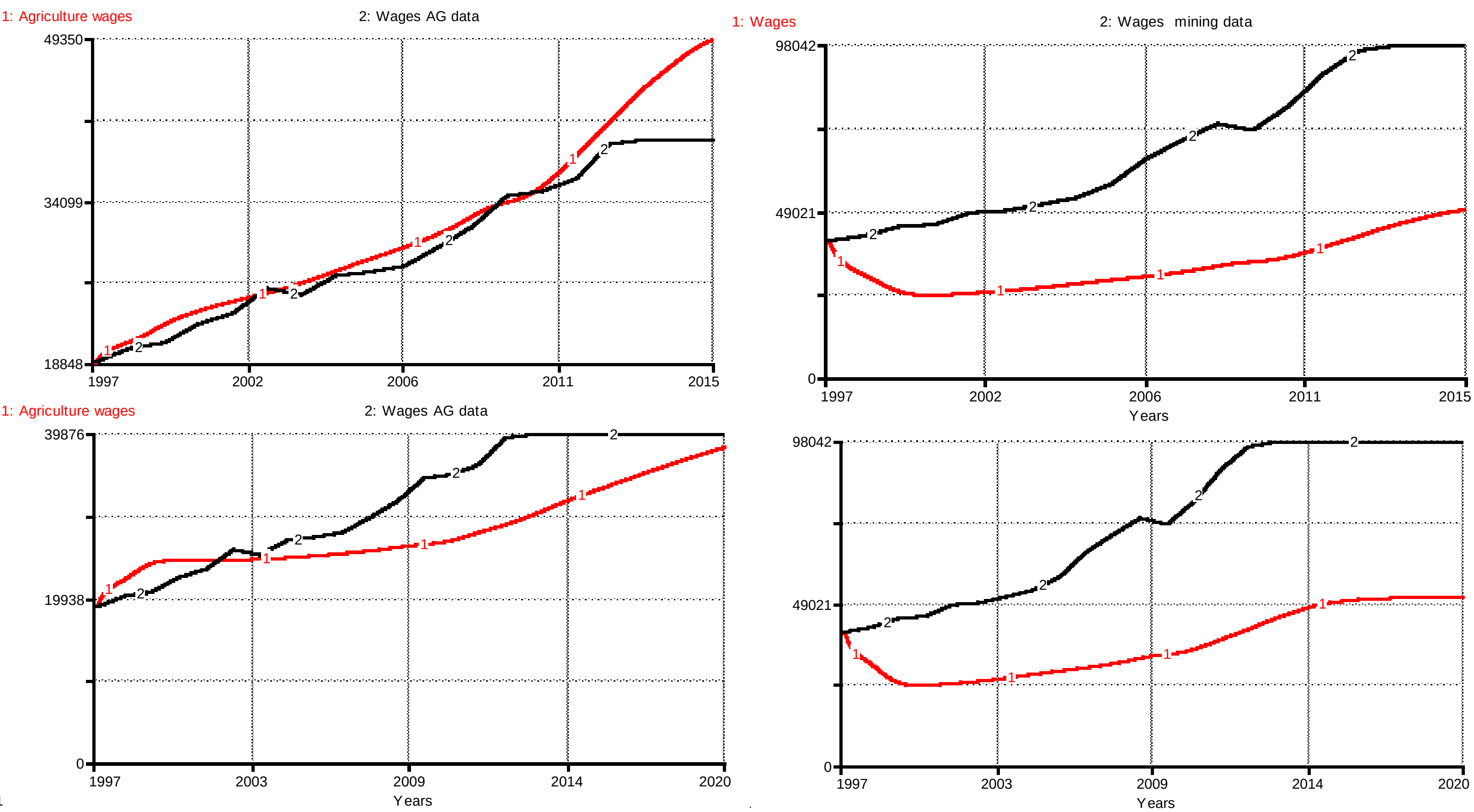
Figure 15. Simulations of Capital and Indicated labor in Mining



High-wage vs. low-wage industries

Within the labor sub-models, the structure for wages produces different results for high-wage and low-wage industries. When, the average wages are taken exogenous, i.e. as data input, for the low-wage sectors, namely Agriculture, Utilities, Retail food and lodging, and Other services, the structure produces the historical behavior. In case of the high-wage industries, namely Mining, Constriction, Wholesale and transportation, the results are mixed. The behavior produced by the structure to some extent replicates the historical behavior for Construction and Wholesale and transportation, but for the Mining sector the structure fails to reproduce the historical behavior: the historical data values are nearly twice as high as the simulated values. Thus, naturally, when the average wage is taken endogenously, these simulated values influence the average wage, which becomes lower than the historical data for average wages, affecting the rest of the sectors. Figure 16 shows the comparison of wages between the two sector types. As the average wages grow throughout the state of North Dakota, the lower-paid sectors, in order to stay competitive in attracting the workers, raise wages towards the average. High-wage industries are not trying to match the average wage, being the drivers of wage growth.

Figure 16. Comparison of the wages behavior with the average wages as exogenous (top graphs) vs. the average wages as endogenous (the bottom, graphs): Low–paid vs. highly-paid sectors (Agriculture vs. Mining)

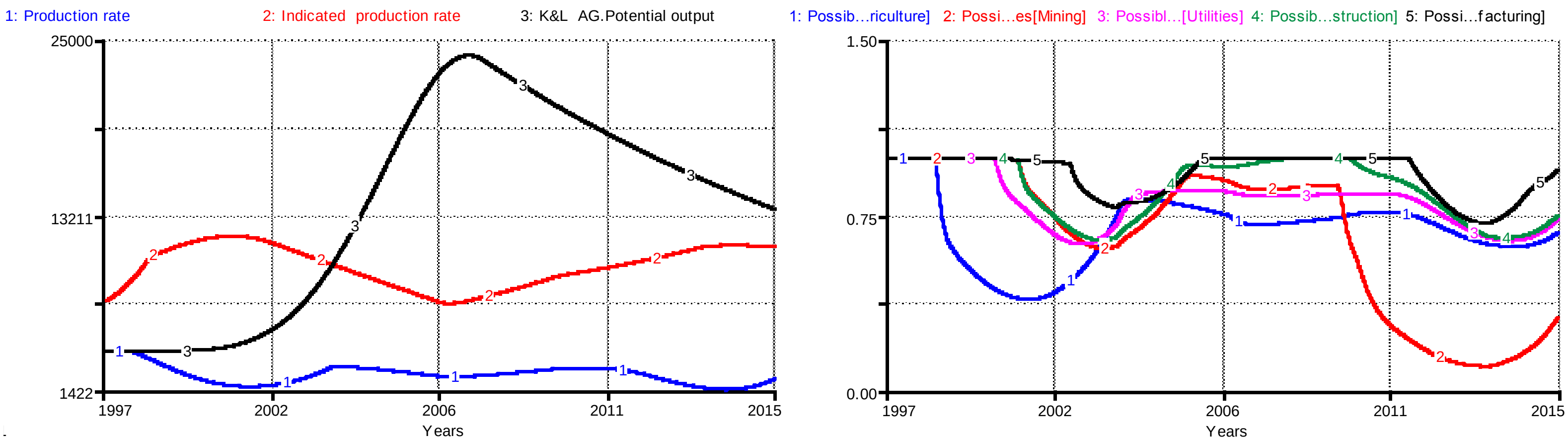


Scott Johnson suggested during a discussion that the most probable reasons for the high wages in energy industries are the high risk of injuries and the harsh working conditions. The present paper does not address these factors, and further research is needed.

The production sub-model

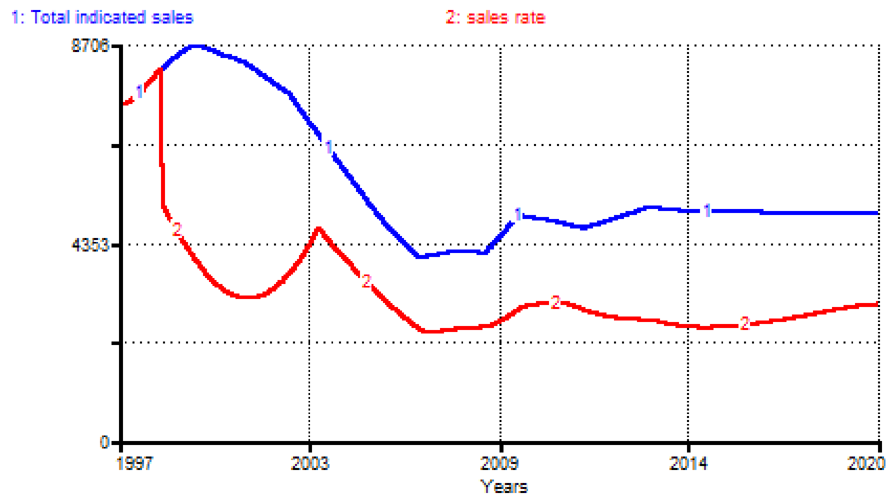
Figure 17 demonstrates how production constraints impact the actual production rate on the example of the Agriculture sector.

Figure 17. Production rate and production rate constraints for the Agriculture sector.



After *Indicated production* grows or decreases, it takes 3-years to adjust the fixed assets. Because of this delay, the capital stock overshoots the potential output capacity and then adjusts to the declining *Indicated production*. Although the capacity allows for higher production, another constraining factor hits the system. If the level of even one of the intermediates necessary for production falls short of the required amount, it brings down the production rate, no matter how much of other intermediates are available. The right graph demonstrates some of the fractions of the intermediate inputs that influence the actual production in Agriculture. This constraint is straightforward. It originates within the order rate of each sector. If a sector cannot handle order rates coming from other industries, its inability to comply restraints the production rates of the sectors specifying the order. The difference between the amount of orders, expressed as *Total indicated sales*, and the actual sales rate for Agriculture is illustrated in Figure 18.

Figure 18. The comparison between the indicated sales and actual sales for the Agriculture sector.



Workforce-job matching sub-model

The graph in figure 19 illustrates total labor demand, expressed as *Total indicated employment*, and to what extent the demand was met as *Total employed*. The gap between the two graph lines represents the unfilled job openings, i.e. vacancies, in ND.

Figure 19. Labor demand and employment

Scenario runs

In order to address the main research question – 'How will possible future changes in oil prices affect workforce demand in the state of North Dakota?' – two main scenarios with several conditions (sub-scenarios) were considered:

1. The effect of oil price changes on labor demand with a fixed volume of oil production.
2. The effect of concurrent changes in oil prices and oil production volume on workforce demand.

The oil price that is used in this study for the scenarios is Western Texas Intermediate (WTI) crude oil. WTI is a benchmark for the crude (i.e. unrefined) oil that is produced in the US, including the oil produced in ND. Compared to the 'Brent Blent' price for oil that is mostly produced in the Northern Sea, and to the 'Dubai' oil price for oil that is produced in the Middle East, WTI is usually cheaper (Eberhart, 2015).

Based on the data from IMPLAN, in 1997, the year when the data for the mining sector were more disaggregated - consisting of coal mining, natural gas and oil, and other mining - the share of exports made up by oil and natural gas was calculated at 85%. The data for the mining sector for the other four years – 2001, 2006, 2009 and 2013 – provided by IMPLAN were more aggregated and did not allow calculating shares of oil and natural gas in the total mining sector's exports. Therefore, since 1997 is the year of the pre-boom period, the general assumption for all scenarios is that the share of oil exports within the mining sector in North Dakota is at least 85%. Also, since the data does not allow separating oil exports from the exports of natural gas, it is assumed that the 85% is made up by the exports of crude oil. This assumption is justified by the fact that most natural gas production comes as a by-product of oil extraction and that the volumes of natural gas production are considerably lower than those of oil production. The scenarios make it possible to consider different shares of oil exports within *Mining* that are above 85%, in order to see how sensitive the system's reaction is to the percentage of oil exports in *Total mining*.

The structure of the scenarios is introduced in the Figure 20. The scenarios influence the system through *Exports* in mining sector, measured in millions of USD per year. This variable, as part of final demand, influences the final sales and hence the indicated production in the mining sector. All scenario simulations are run for the period of 2015-2020.

Since there is no data on how much crude oil produced in ND is exported outside of the state, the volumes will be a subject for speculations. To estimate the volumes based on the available data, assumptions are made as follows. In the scenarios' structure, the calculation of *Share of the oil exported outside of ND* is based on *Crude oil production data*, measured in barrels produced per year, and on *Volumes of oil exported*, which, in its turn, is based on the assumed *Percentage of the oil exports in total mining*. The scenarios will allow for eventual adjustment of the parameters for a more accurate result once the research stakeholders in the ND government supply the relevant information.

Figure 20. Scenarios' structure

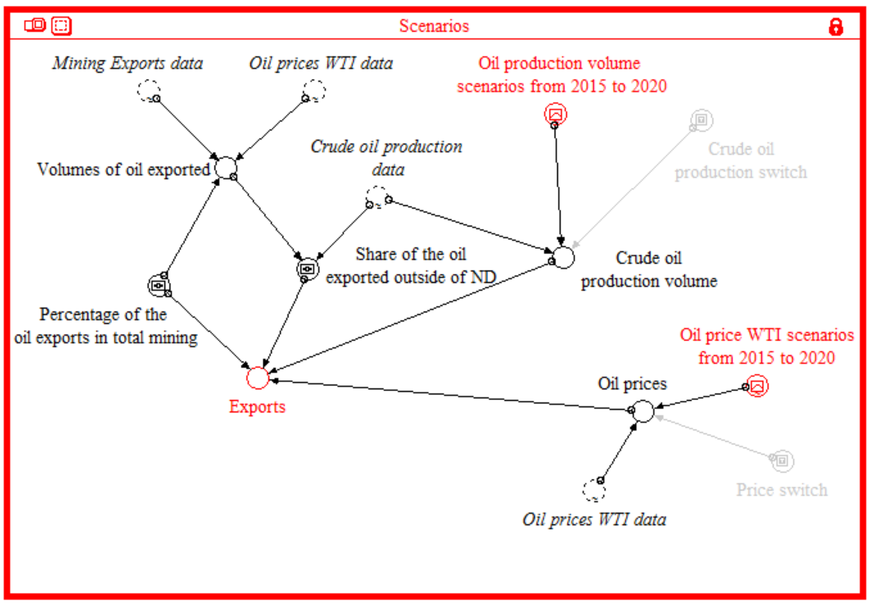
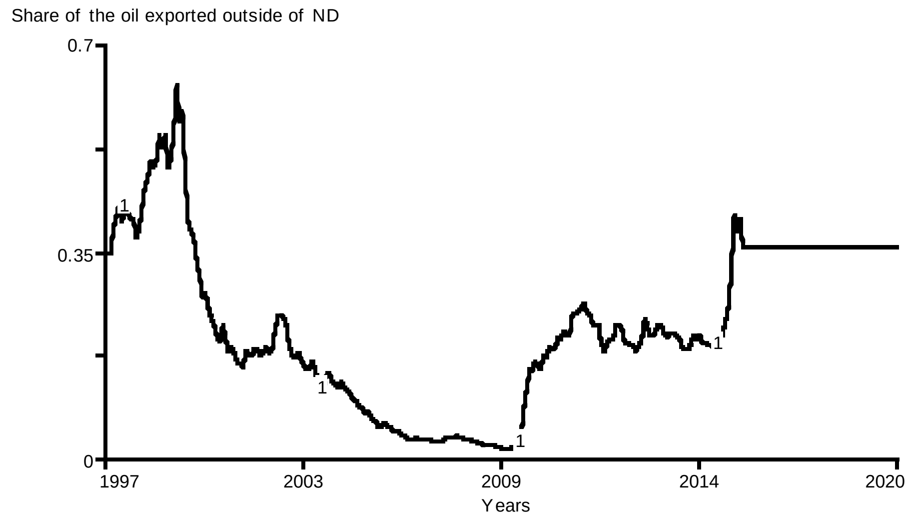


Figure 21 shows the calculated *Share of the oil exported outside of ND.* The calculations for the period of 2015-2020 are fixed at 35%. So the general assumption for the scenarios is that the share will remain at the level of 35%.

Figure 21. The share of the oil exported outside of ND, 1997-2020.



Scenario 1

The effect of oil price changes on labor demand with fixed volume of oil production.

Here are the general assumptions made in the scenario:

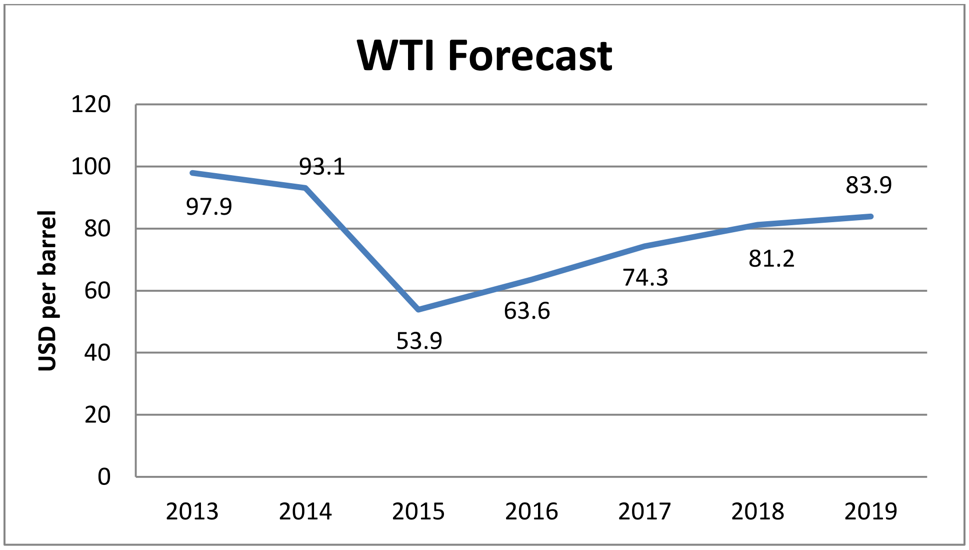
- The percentage of oil exports in the total mining exports of ND is 85%.
- The share of the oil exported outside of the ND is 35%.
- The volume of crude oil production is fixed at 313 801 706 barrels per year, the level of year 2013 – the last year with available data.

The multiple runs for scenario 1 are based on (1) changing oil prices according to the oil price projections by the Economist Intelligence Unit (EIU), (2) an optimistic scenario, and (3) a pessimistic scenario.

1.1. ***Projections Scenario***. Oil price changes are based on the WTI crude oil price forecast by EIU.

The long-term projections by the World Bank and the International Monetary Fund for Brent crude oil price predict that the oil price will have risen to the level of the 2013 by the year 2020 (Kolesnikov, 2015). EIU has released a forecast specifically for the WTI crude oil price which contains more optimistic projections (See Figure 22), also predicting that the price will relatively recover by 2019. The projection values are entered for the scenario run.

Figure 22. WTI crude oil price forecast, USD per barrel, 2013-2019



Source: Knoema, Crude Oil Price Forecast, 2015

1.2. ***Optimistic Scenario.*** WTI crude oil price increases to 100 USD per barrel by 2016 and remains at that level until 2020.

1.3. ***Pessimistic Scenario.*** WTI crude oil price decreases to 40 USD per barrel by 2016 and remains at that level until 2020.

Figure 23 shows the graphical functions that set the scenarios in the order in which they are presented above.

Figure 23. Graphical functions for scenario runs of the WTI oil price change, 2015-2020

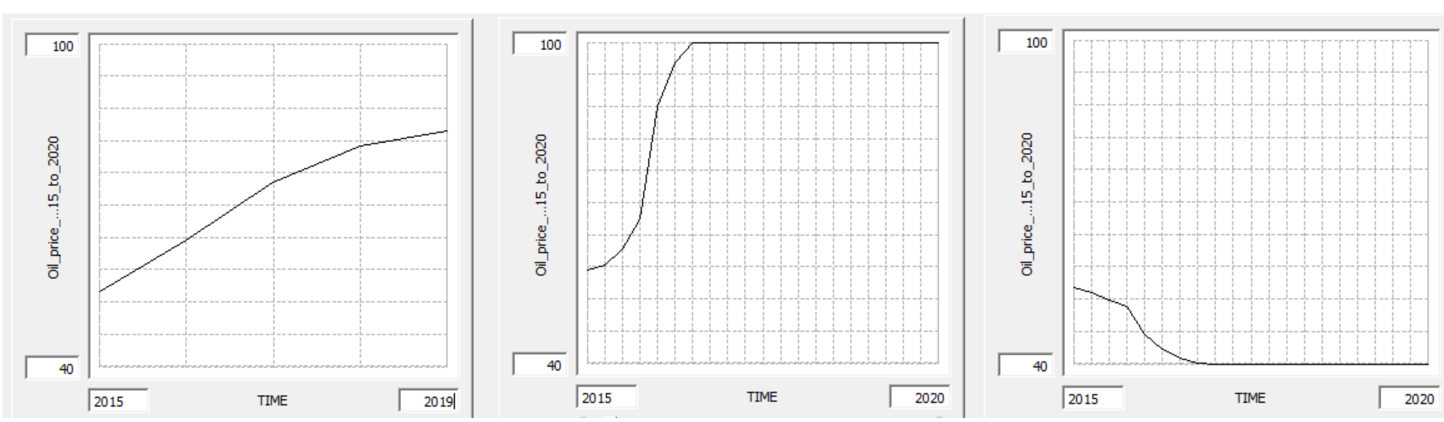
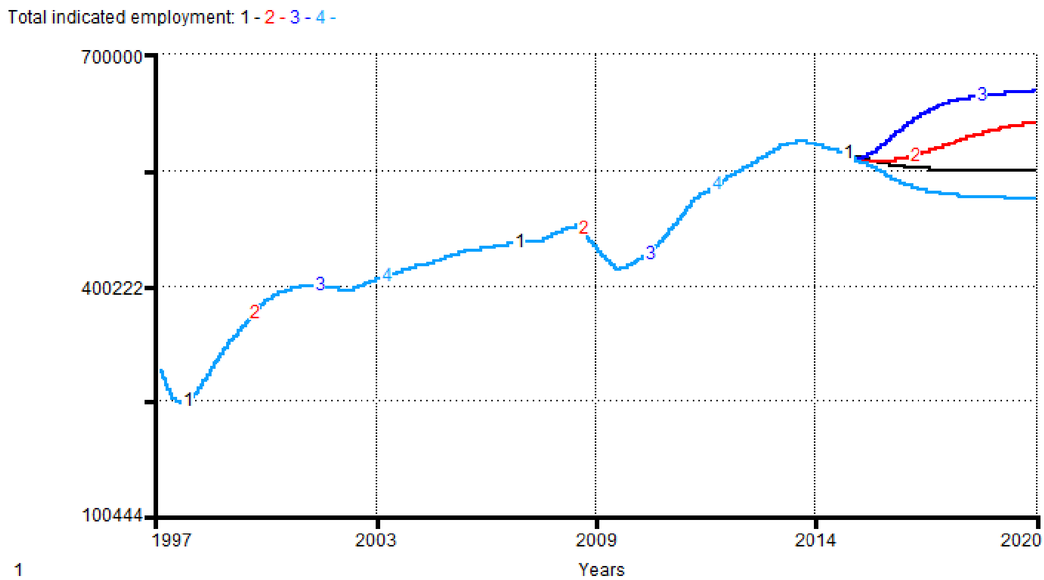


Figure 24 presents simulation results of the mentioned scenario runs for *Total indicated employment*. The first run is a base run which assumes that after 2015 the oil price remains at the level of 54.45 USD per barrel for the period of 2015-2020.

Figure 24. Comparative graph of the base run and the scenario runs for *Total indicated employment*, 2015-2020



The simulation results indicate that labor demand is sensitive to the price of oil. Assuming the volume of oil production remains the same, an increase in the oil price leads to higher export receipts and higher final demand in the mining sector, leading in turn to an increase in the indicated production and indicated labor. Similarly, a decrease in oil price leads to a decrease in labor demand.

This answers the main question of the research.

Scenario 2

The effect of oil price changes and oil production volume changes on workforce demand.

The general assumptions in scenario 2 are as follows:

- The percentage of oil exports in the total mining exports of ND is 85%.
- The share of oil exported outside of ND is 35%.

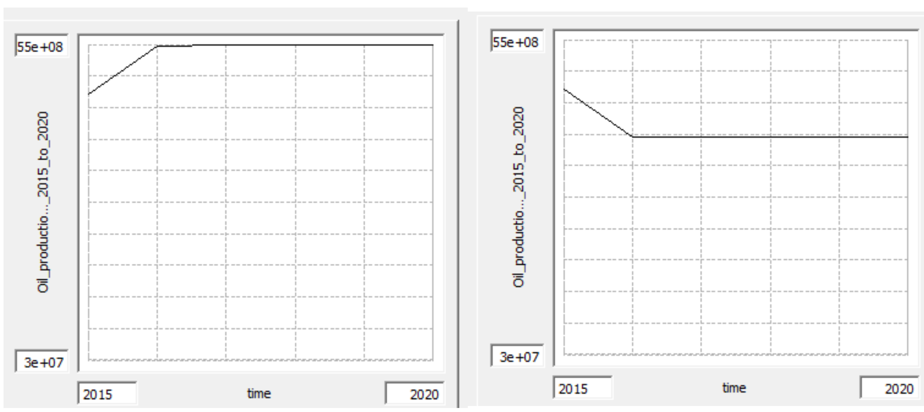
2.1 ***The fixed price, increasing production volume scenario***. Oil prices are fixed at the level unchanged since 2015 and production volumes grow to 350 million barrels per year.

2.2 ***The fixed price, decreasing production volume scenario***. Oil prices are fixed at the level unchanged since 2015 and production volumes drop to the values of 255 million barrels per year.

2.3 ***The optimistic scenario***. Oil prices change according to the EIU projections and production volumes grow to 350 million barrels per year.

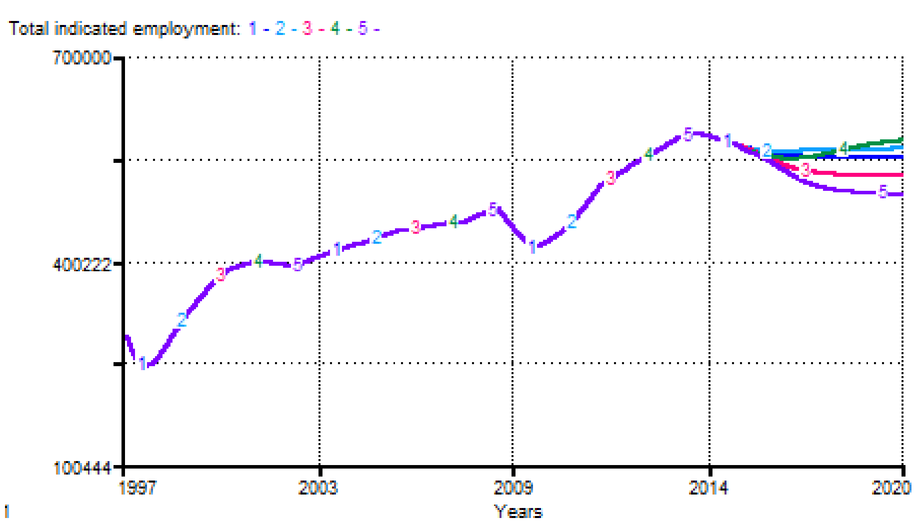
2.4 ***The pessimistic scenario***. Oil prices drop to 40 USD per barrel and production volumes decrease to the pre-boom values of 30 million barrels per year.

Figure 25. Graphical functions for scenario runs of oil production volume changes, 2015-2020.



The graph in Figure 26, overlaying the scenarios together, shows that labor demand is differentially sensitive to changes in the production volume of oil when oil prices are fixed.

Figure 26. Base run and Scenario runs 2.1-2.4



highest sensitivity is observed when the oil production volume is low. The scenario shows that labor demand becomes less sensitive as the oil production volume grows. When the annual production volume is increased by 50 million barrels, to 350 million barrels, the total indicated labor shows an increase by 8-10 thousand people. However, when the volume is decreased by 50 million barrels, to 255 million barrels, labor demand drops by as much as 25 thousand people.

It means that if oil prices and production volumes decrease simultaneously, labor demand will dramatically decrease throughout the state of North Dakota.

Concluding remarks

Addressing the research questions

The first research sub-question of the main question – What is the dynamics of the workforce demand in North Dakota during the pre-boom period of 1997-2006 and during the boom period of 2006-2015? – was addressed within the Introduction when the proper reference mode was determined by generating plausible data with the help of certain mathematical techniques. Since workforce demand data from before 2006 is unreliable, the chosen reference mode helped to understand that the workforce demand increased from 2008, but exhibited a sharp fall in 2009 and a dramatic increase after that.

The second research sub-question targeted the driving force of workforce demand in North Dakota. The dynamic hypothesis was that the boom in the oil industry has created a ripple effect propagating throughout other industries, increasing labor demand not only in the oil industry but also in other sectors. A system dynamics model was built to test the hypothesis. In order to see how the oil industry impacts other industries, the linkages among the industries need to be known. To do so, IO model technical coefficients were calculated separately and incorporated into the system dynamics model.

Workforce demand within each industry is driven by increased demand for the industry's production. In order to meet the demand, any given industry starts increasing its orders for other industries' outputs used as inputs for its own production.

The third sub-question of the main research question – 'What are the effects of oil price changes on workforce demand in North Dakota?' – was addressed in the *Scenario run*s section of the *Model runs* chapter. The model simulation results suggest that oil prices affect labor demand initially only in the mining sector. A drop in oil prices causes a decrease in labor demand leading to layoffs in the mining sector and to saturation of the unemployment stock. The latter causes a decrease in average wages that allows other sectors to hire more workers. Therefore, the initial reaction of non-oil industry sectors is a slightly increased labor demand. However, once the mining sector decreases its orders to other sectors, the declined demand will decrease the labor demand in those sectors in the long-run. Overall, a decline in oil prices will eventually lead to a decline in labor demand throughout ND.

By addressing the research sub-questions, this study achieved the objective outlined in the Introduction.

Limitations and further research

There were some limitations that put major constraints on the research:

1. ***Data insufficiency.*** As mentioned above, the data for the reference mode were not available, so some estimation methods were used in order to determine the reference mode, hence comparisons of the simulated behavior to the reference mode lack necessary rigor. Another data constraint was the unavailability of data for fixed assets, i.e. Capital, to input to the model. In order to work around this limitation, additional assumptions and estimations were made. This produced a range of input values for the model; however, there is no known way for this research to validate how accurate the estimations were.
2. ***Model boundaries.*** The model examines the potential impact of oil price changes on workforce demand in ND. The set boundaries treated some variables as exogenous. Among the most important exogenous variables are the IO technical coefficients, despite the significance of a system dynamics principle of taking an endogenous perspective on variables of major importance. Further research is needed on ways to endogenize the calculation of the IO technical coefficients.

Further research is also indicated on the following issues:

- The effect of oil price drops on government tax revenues and, as a result, on government consumption, which is part of the final demand for the industries' output that might affect labor demand as well.
- Existing and recommended government policies and actions towards meeting labor demand in North Dakota.

References

American Enterprise Institute. (2015, June 12). Shale oil turned North Dakota from one of the poorest US States into the second most prosperous states in a decade. Retrieved from https://www.aei.org/publication/shale-oil-turned-north-dakota-from-one-of-the-poorest-us-states-into-the-second-most-prosperous-states-in-a-decade/

Barlas, Y. (1994). Model validation in System Dynamics. *Proceedings of the 1994 International System Dynamics Conference*.

Barlas, Y. (1996). Formal aspects of model validity and validation in system dynamics. *System Dynamics Review*, *12*(3), 183–210. doi:10.1002/(SICI)1099-1727(199623)12:3<183::AID-SDR103>3.0.CO;2-4

Baxter, A. (2015). North Dakota oil town: Is it bust or slowdown. *WHQR* Retrieved from http://whqr.org/post/north-dakota-oil-town-it-bust-or-slowdown

Bennich, T., Collste, D., & Bongers, T. (2014). Unintended consequences of the North Dakota oil boom : Stress on the Local Counties. In *Proceedings of the 2014 International System Dynamics Conference* (pp. 1–16).

Blake, E. (2011, October 20). Double your salary in the middle of nowhere, North Dakota. *CNN Money*. Retrieved from http://money.cnn.com/2011/09/28/pf/north_dakota_jobs/

Braden, C. H. (1981). System Dynamics and Input-Output analysis. In *Proceedings of the 1981 International Conference of the System Dynamics Society* (pp. 1–12). Rensselaerville, New York.

Briody, B. (2013, November 5). 10 Highest-paying jobs in North Dakota's oil boom. *The Fiscal Times.* Retrieved from http://www.thefiscaltimes.com/Articles/2013/11/05/North-Dakota-Oil-Jobs-10-Highest-Paying-Positions

Bureau of Economic analysis. 2015). [Data files] Retrieved from www.bea.gov

Bureau of Labor Statistics. (2015). [Data files] Retrieved from http://bls.gov

Conlin M. (2014, February 14). Hot economy, cold comfort: North Dakota's homeless problem. *Reuters.* Retrieved from http://www.reuters.com/article/2014/02/11/us-homelessfinal-north-dakota-idUSBREA1A1OT20140211

Coon, R. C., Lelstrltz, F. L., Hertsgaard, T. A., & Leholm, A. G. (1985). *The North Dakota Input-Output model : A Tool for analyzing economic linkages*. Fargo, North Dakota.

Coyle, R. G., & Exelby, D. R. (1999). The validation of commercial system dynamics models. In *Proceedings of the 17th International Conference of the System Dynamics Society and 5th Australian & New Zealand Systems Conference* (p. 15).

Davidson, P. (2015, March 21). Cheap oil prices chop jobs by thousands. USA Today. Retrieved from http://www.usatoday.com/story/money/business/2015/03/31/oil-job-cuts/70683670/

Diehl, E. (1985). Adjustment dynamics in a static input-output model. In *Proceedings of the 1985 International Conference of the System Dynamics Society* (pp. 161–178). Keystone, Colorado.

Eberhart, D. (2015). What's in a name: The difference between 'WTI' and 'Brent'. *Canary*. Retrieved from http://canaryusa.com/difference-between-wti-and-brent/2/

E.L. (2014, December 8). The Economist explains: Why the oil price is falling? *Economist* .Retrieved from http://www.economist.com/blogs/economist-explains/2014/12/economist-explains-4

Elias, A. a., Cavana, R. Y., & Jackson, L. S. (2001). Stakeholder analysis to enrich the systems thinking and modelling methodology. *Proceedings of the 19th International Conference of the Systems Dynamics Society*, 52–70. Retrieved from http://www.systemdynamics.org/conferences/2001/papers/Elias_1.pdf

'Find the Good Life in North Dakota'. (2015). Why North Dakota? Retrieved from http://www.findthegoodlifeinnorthdakota.com/why/

Ford, A. (1976). Boom1Summary.pdf.Unpublished manuscript.

Forrester, J.W. & Senge, P.M. (1980). Tests for building confidence in system dynamics models. TIMS Studies in the Management Sciences 14 (1980), 209 - 228. North Holland Publishing Company

Forrester, J.W. (1994). Policies, decisions and information sources for modeling, in modeling for learning organizations. .*European Journal of Operational Research*, *59*, 42–63.

Forrester, J. W., Mass, N. J., & Ryan, C. J. (1976). The system dynamics national model: Understanding socio-economic behavior and policy alternatives. *Technological Forecasting and Social Change*, *9*(1-2), 51–68. doi:10.1016/0040-1625(76)90044-5

Gilmore, J. S. (1976). Boom towns may hinder energy resource development. *Science (New York, N.Y.)*, *191*(4227), 535–540. doi:10.1126/science.191.4227.535

IMPLAN Group, LLC. IMPLAN System. Retrieved from www.IMPLAN.com

Jacobsen, G. D., & Parker, D. P. (2014). The economic aftermath of resource booms: Evidence from boomtowns in the American West. *The Economic Journal*, 1–51. doi:10.1111/ecoj.12173

Jacquet, A. J. B., Kay, D. L., Ramsey, D., & Kay, D. L. (2014). The unconventional boomtown : New spatial and temporal scales. *Journal of Rural and Community Development*, *9*(1), 1–23.

Kolesnikov, I. (2015). Crude oil price forecast: Long term 2015 to 2025. Knoema. Retrieved from http://knoema.com/yxptpab/crude-oil-price-forecast-long-term-2015-to-2025-data-and-charts

Luna-Reyes, L. F., & Andersen, D. L. (2003). Collecting and analyzing qualitative data for system dynamics: methods and models. *System Dynamics Review*, *19*, 271-296.

Markusen, A. R. (1978). *Socioeconomic impact models for boomtown planning and policy evaluation*. Unpublished manuscript

National Center for Policy Analysis. (2014, October 15). North Dakota's job boom. Retrieved from http://www.ncpa.org/sub/dpd/index.php?Article_ID=24961

North Dakota Workforce intelligence. (2007). [Data files] Retrieved from https://www.ndworkforceintelligence.com

Power, G., Gillespie, W., Wittkowski, D., & Rink, R. E. (1980). Computer modeling of boomtown housing: The Fort McMurray study. *Canadian Journal of Regional Science, 3,* 29–48.

Putz, A., Finken, A., & Goreham, G. A. (2011). *Sustainability in natural resource-dependent regions that experienced boom-bust-recovery cycles: Lessons learned from a review of the literature*. Fargo, North Dakota.

Richmond, B. (2013). *An introduction to systems thinking , iThink.* Isee Systems, Inc.

Runge, D. (1976). Labor market dynamics. In *Proceedings of the 1976 International Conference on System Dynamics* (pp. 97–126). Geilo, Norway.

Saunders, M., & Lewis, P.(2012). *Doing research in business and management. An essential guide to planning your project*. Harlow, England: Financial Times Prentice Hall.

Skribans, V. (2014). Preconditions of latvian labour market forecasting and policy analysis system dynamics model development. In *Proceedings of the 2014 Asia-Pacific System Dynamics Conference* (pp. 1–21). Tokyo: System Dynamics Society.

Soto Torres, M. D., & Fernandes Lechon, R. (1995). A Dynamic Model of labor market. In *Proceedings of the 1995 International System Dynamics Conference: System Dynamics '95* (Vol. 2). Tokyo: International System Dynamics Society.

Sterman, J. D. (2000). *Business dynamics: systems thinking and modeling for a complex world*. (S. Isenberg, Ed.). Boston, MA: McGraw-Hill Companies.

Tasrif, M. (2014). System dynamics model of technology and economic growth : A preliminary study. In *Proceedings of the 2014 International System Dynamics Conference* (pp. 1–22).

United States Census Bureau. (2015). [Data files] Retrieved from https://www.census.gov

Vachon, M. C. (2014). The impact of local labor market conditions on migration: Evidence from the Bakken oil boom, 0–32.

Weber, B. a., Geigle, J., & Barkdull, C. (2014). Rural North Dakota's oil boom and its impact on social services. *Social Work (United States)*, *59*(1), 62–72. doi:10.1093/sw/swt068

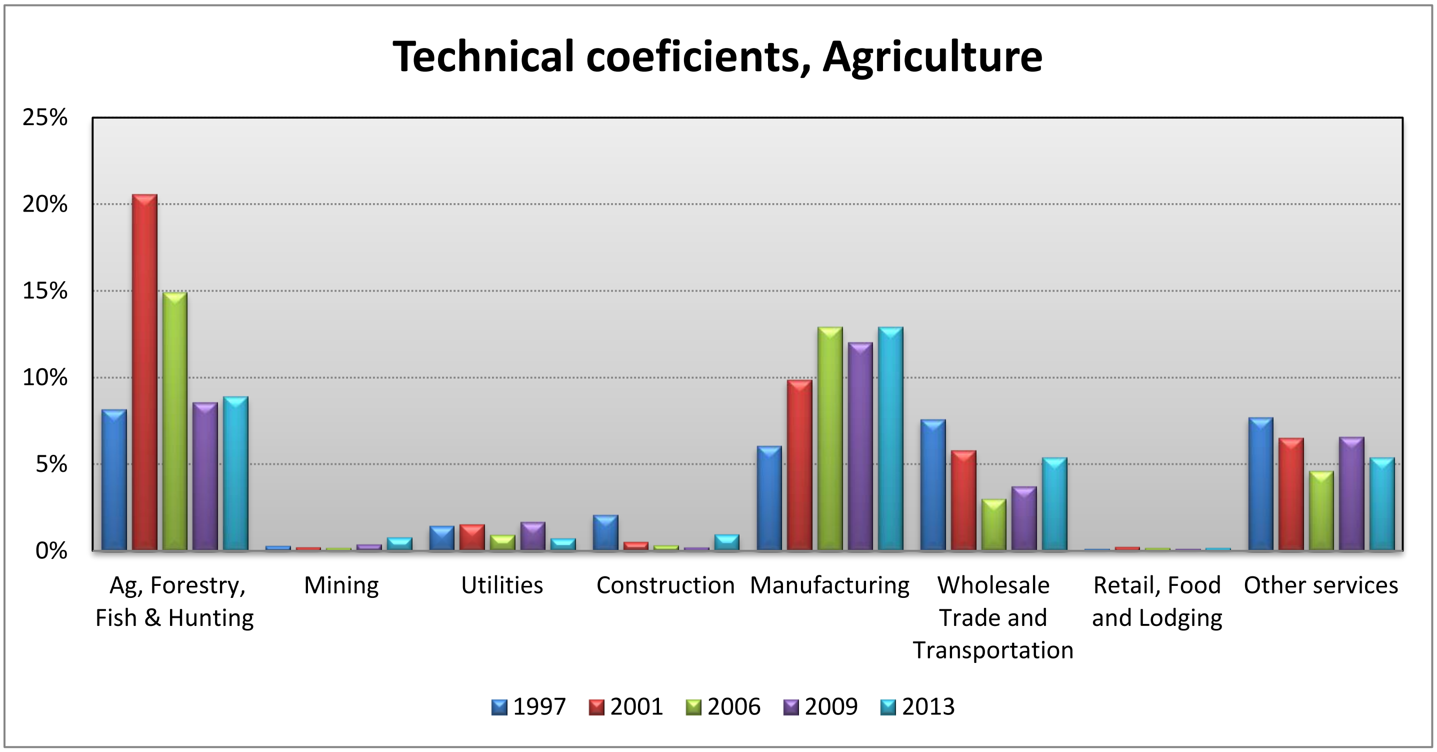
Wheat, I. D. (2007). *The Feedback method*. Doctoral dissertation.

Wheat, I. D., & Pawluczuk, A. (2014). Dynamic regional economic modeling : a systems approach. *Economics and Management*, (4), 230–241. doi:10.12846/j.em.2014.04.18

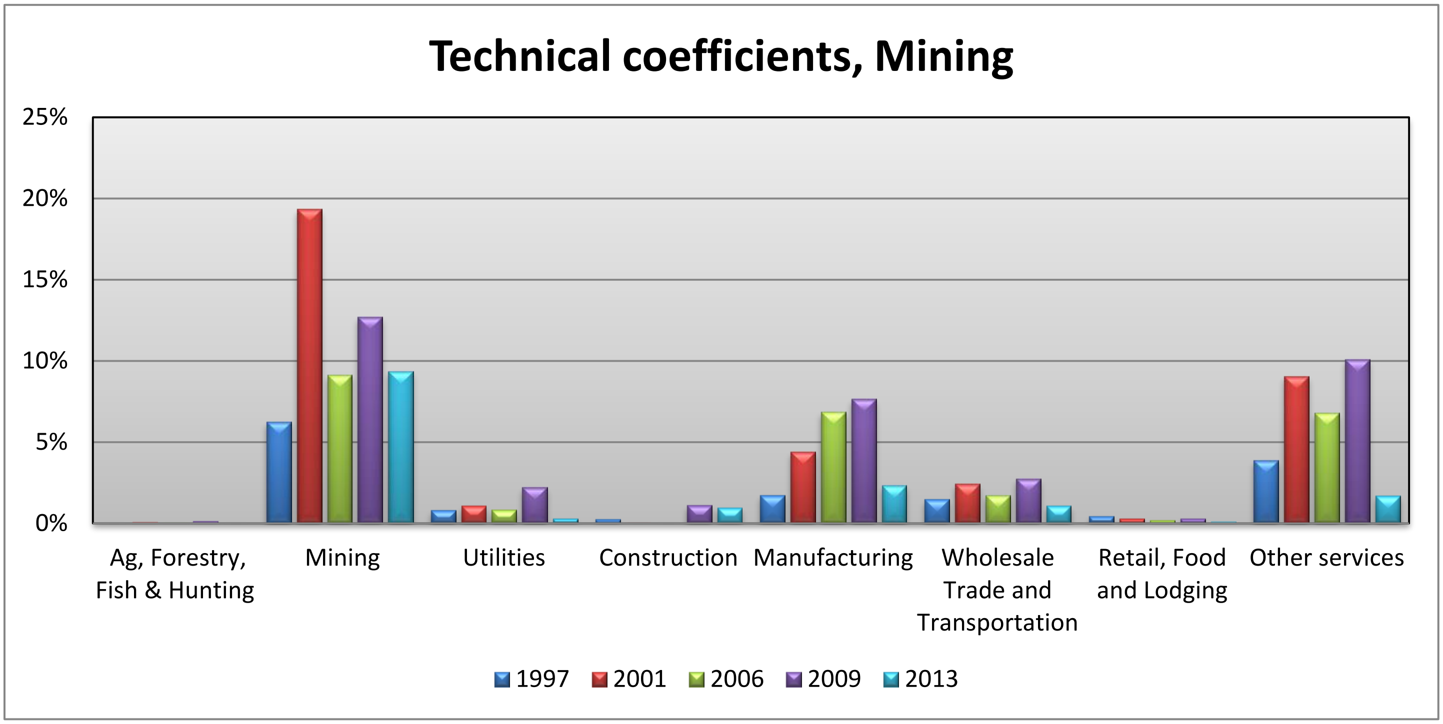
World Bank Group. (2015). [Data files] Retrieved from www.worldbank.org.

Appendices

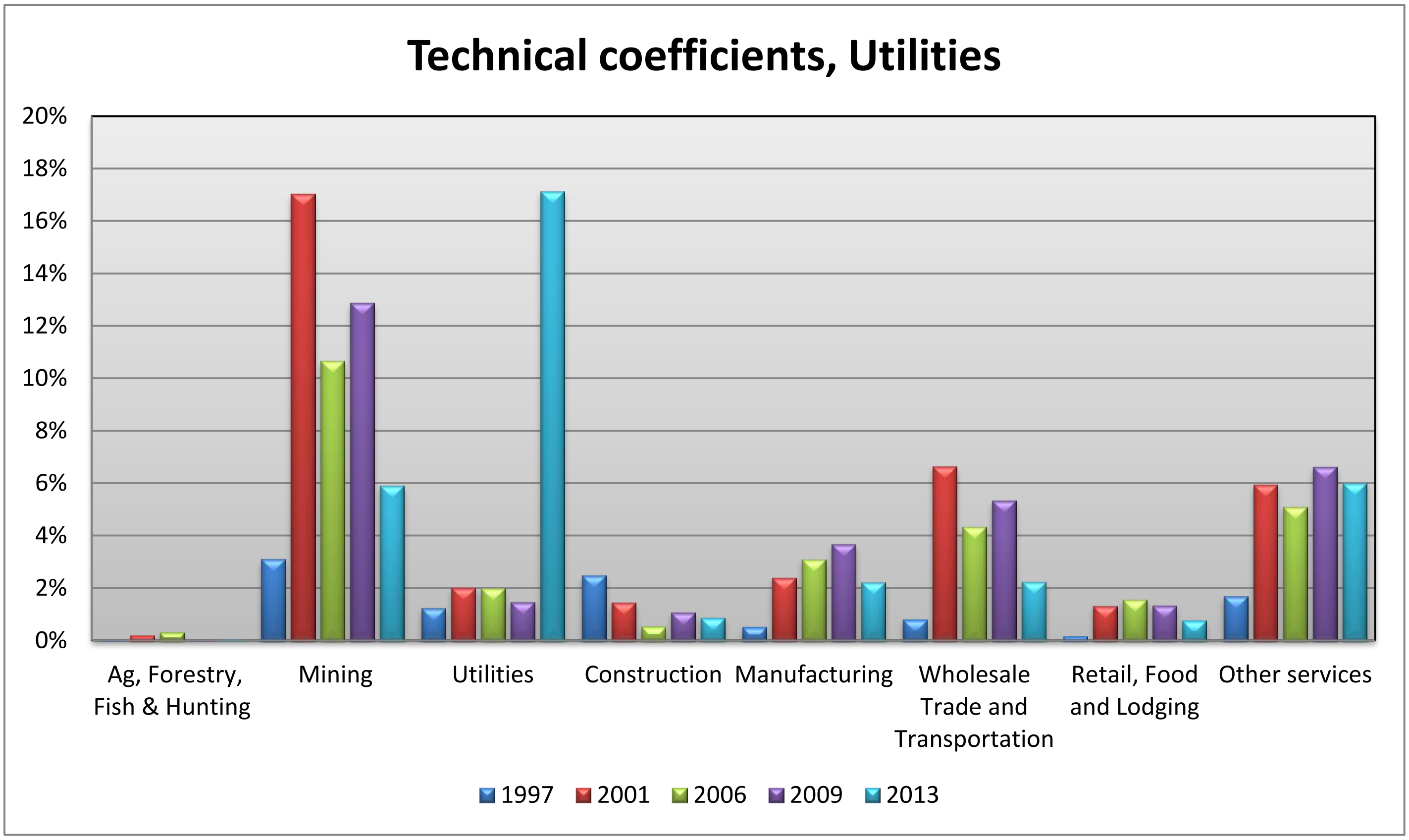
Appendix A

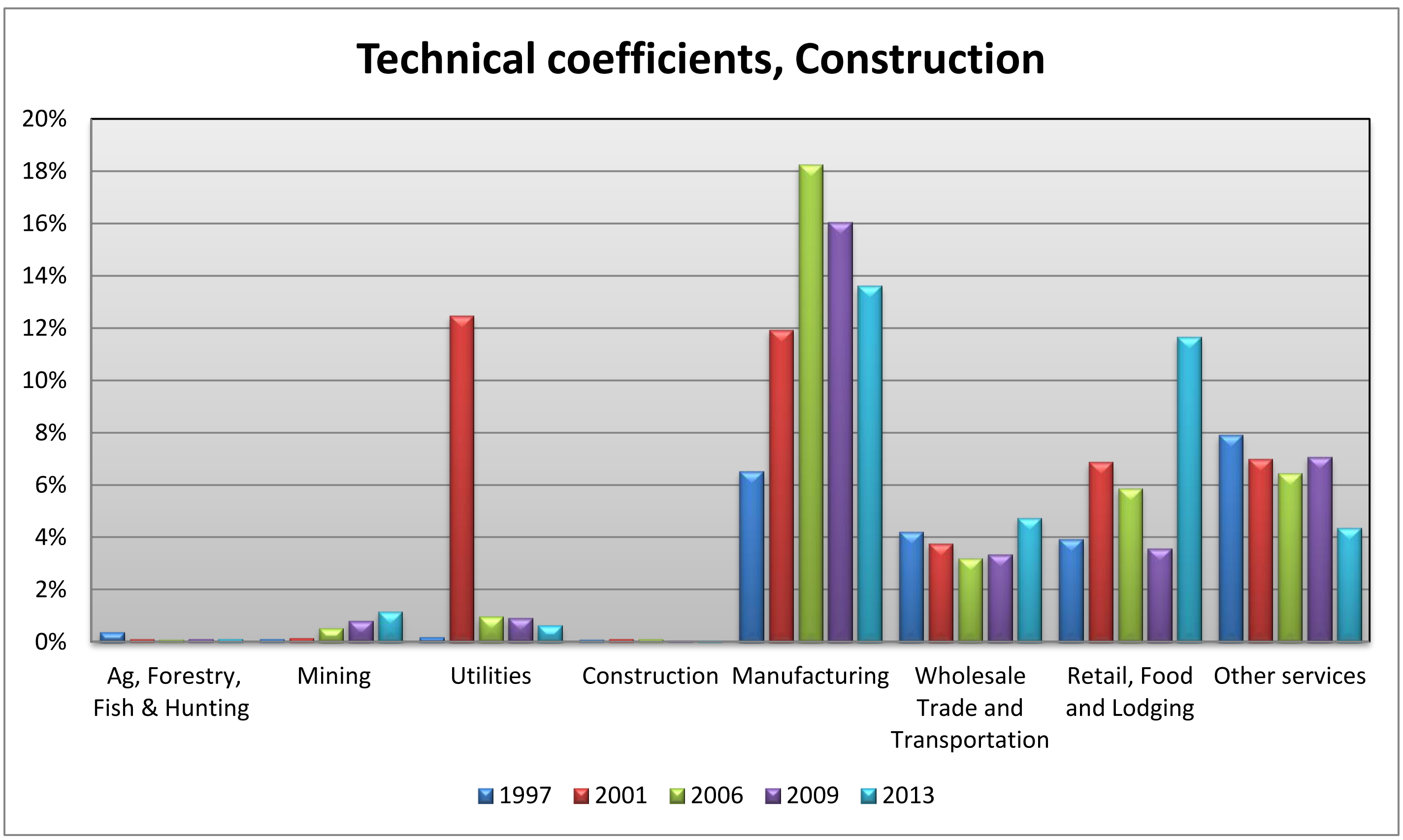


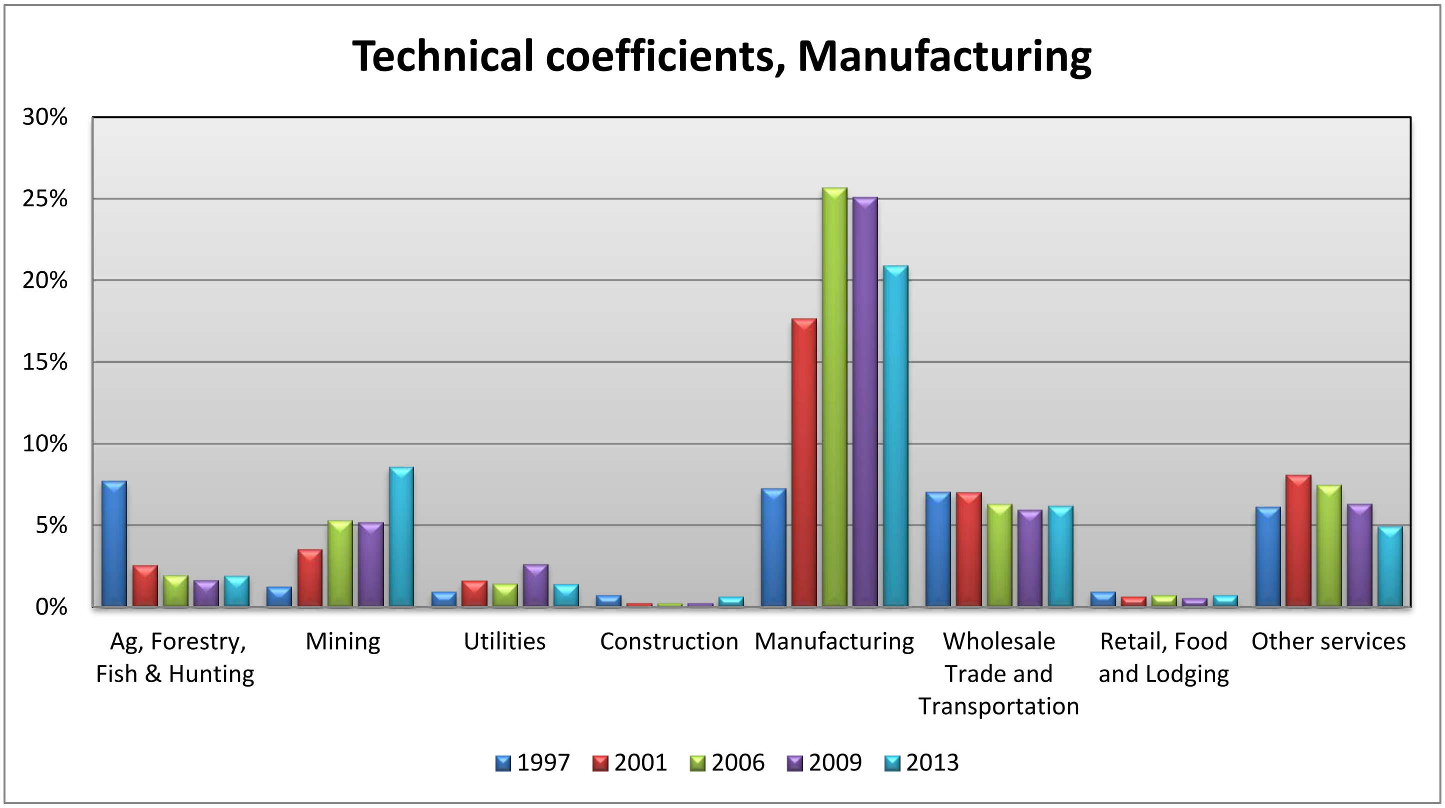
Technical coeficients, Agriculture
25%
20%
15%
10%
5%
0%
Ag, Forestry, Fish & Hunting
Mining
Utilities
Construction
Manufacturing
Wholesale Trade and Transportation
Retail, Food and Lodging
Other services
1997
2001
2006
2009
2013



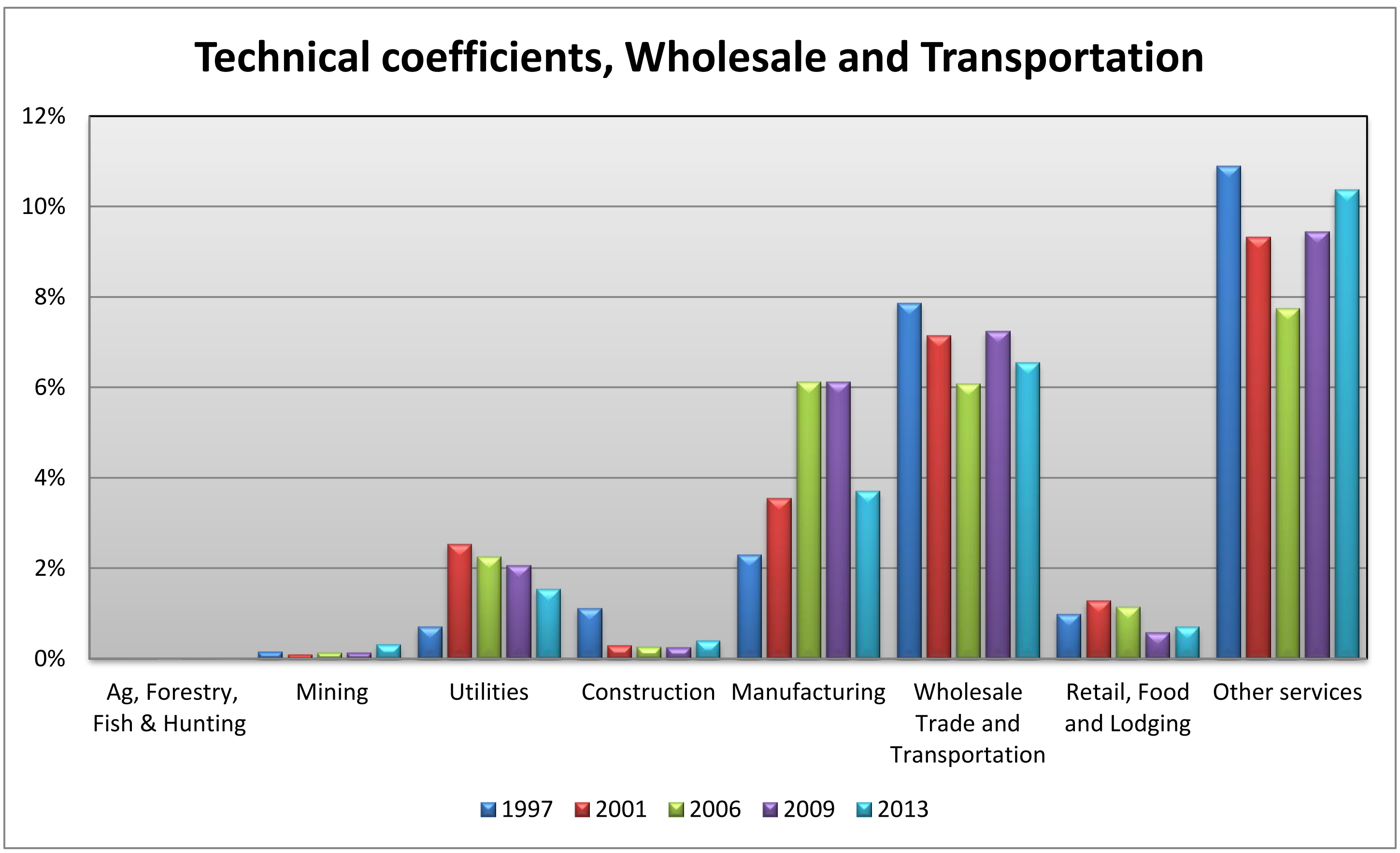
Technical coefficients, Mining
25%
20%
15%
10%
5%
0%
Ag, Forestry, Fish & Hunting
Mining
Utilities
Construction
Manufacturing
Wholesale Trade and Transportation
Retail, Food and Lodging
Other services
1997
2001
2006
2009
2013


Technical coefficients, Utilities
20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
Ag, Forestry, Fish & Hunting
Mining
Utilities
Construction
Manufacturing
Wholesale Trade and Transportation
Retail, Food and Lodging
Other services
1997
2001
2006
2009
2013

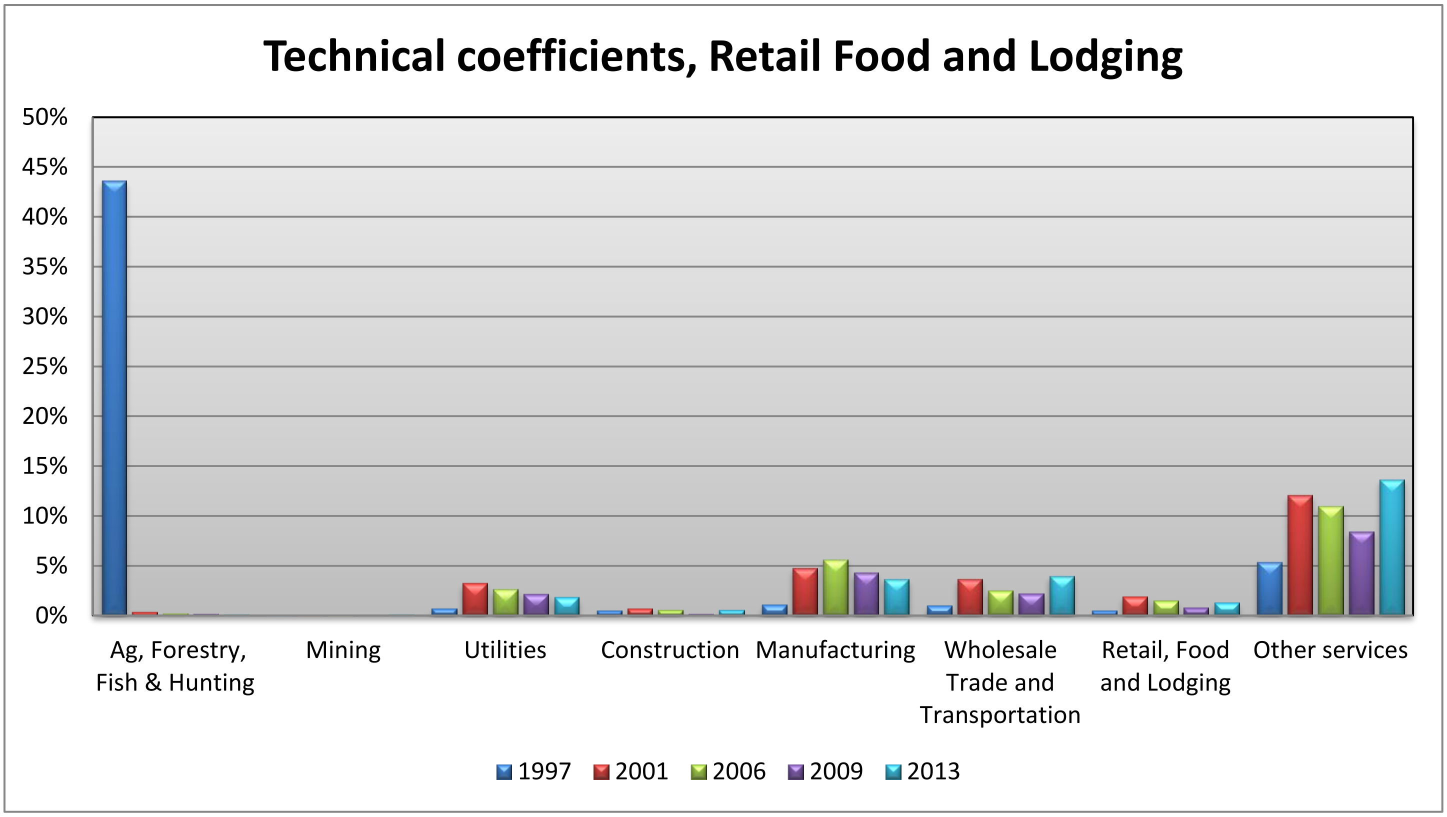

Technical coefficients, Construction
20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
Ag, Forestry, Fish & Hunting
Mining
Utilities
Construction
Manufacturing
Wholesale Trade and Transportation
Retail, Food and Lodging
Other services
1997
2001
2006
2009
2013

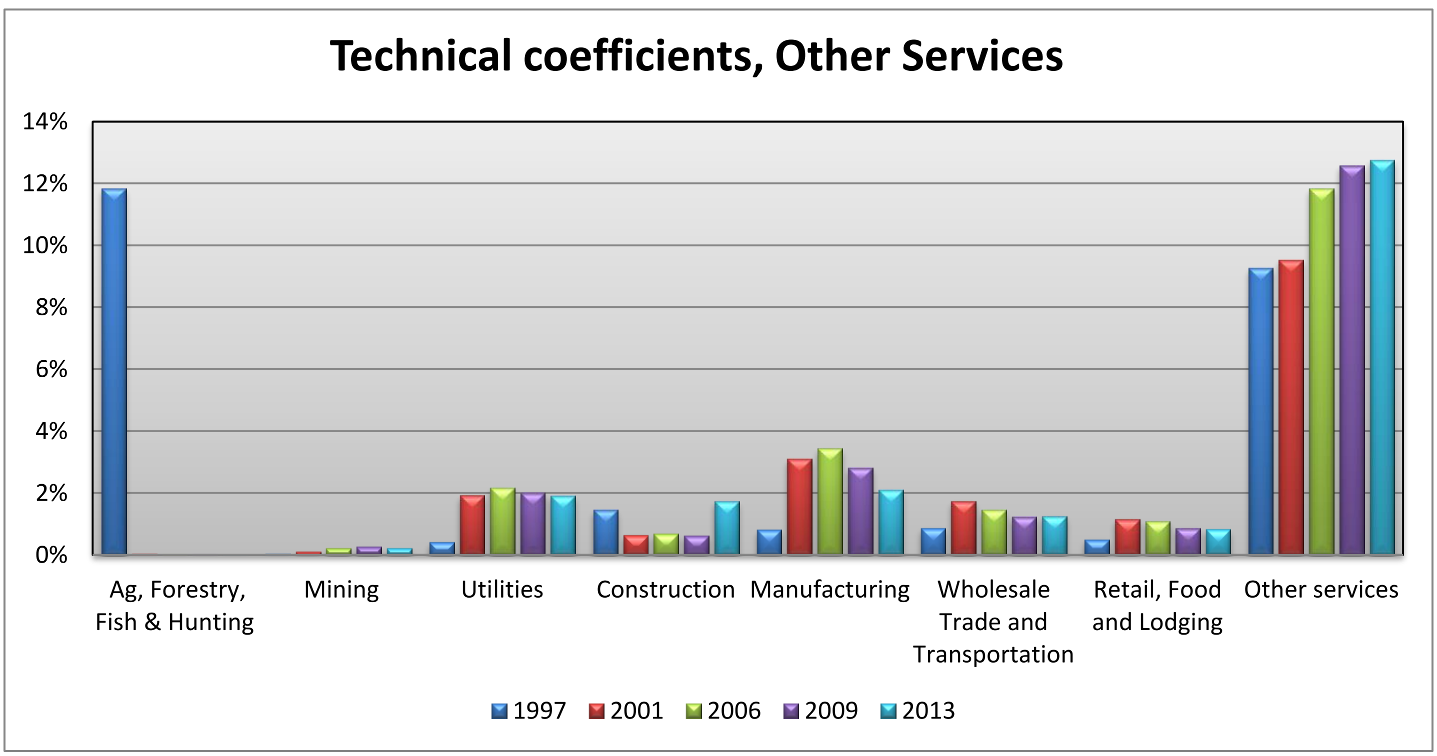


Technical coefficients, Manufacturing
30%
25%
20%
15%
10%
5%
0%
Ag, Forestry, Fish & Hunting
Mining
Utilities
Construction
Manufacturing
Wholesale Trade and Transportation
Retail, Food and Lodging
Other services
1997
2001
2006
2009
2013



Technical coefficients, Wholesale and Transportation
12%
10%
8%
6%
4%
2%
0%
Ag, Forestry, Fish & Hunting
Mining
Utilities
Construction
Manufacturing
Wholesale Trade and Transportation
Retail, Food and Lodging
Other services
1997
2001
2006
2009
2013


Technical coefficients, Retail Food and Lodging
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Ag, Forestry, Fish & Hunting
Mining
Utilities
Construction
Manufacturing
Wholesale Trade and Transportation
Retail, Food and Lodging
Other services
1997
2001
2006
2009
2013


Technical coefficients, Other Services
14%
12%
10%
8%
6%
4%
2%
0%
Ag, Forestry, Fish & Hunting
Mining
Utilities
Construction
Manufacturing
Wholesale Trade and Transportation
Retail, Food and Lodging
Other services
1997
2001
2006
2009
2013

Appendix B

Calculating Labor Intensity

$$\text{Indicated labor} = \frac{Q_0(1-\propto)}{rW}$$

Agriculture: $2363 = \frac{8014.017398(1-\propto)}{0.018419}$ $\propto = 0.98915$

Mining: $3686 = \frac{528.782692(1-\propto)}{0.039348}$ $\propto = 0.7257158$

Utilities: $14785 = \frac{1026.39725(1-\propto)}{0.021759}$ $\propto = 0.686566986$

Construction: $16182 = \frac{2353.940972(1-\propto)}{0.026682}$ $\propto = 0.8165764864$

Manufacturing: $22547 = \frac{5012.069616(1-\propto)}{0.026925}$ $\propto = 0.878876618$

Wholesale and transportation: $28745 = \frac{3517.754411(1-\propto)}{0.027460}$ $\propto = 0.7756131873$

Retail, food and lodging: $67006 = \frac{7272.755874(1-\propto)}{0.012430}$ $\propto = 0.808070415$

Other services: $141197 = \frac{13161.77486(1-\propto)}{0.022784}$ $\propto = 0.7555776115$

$$\text{Indicated capital} = \frac{Q_0 \propto}{\text{Cost of capital}}$$

Indicated capital for Agriculture: $= \frac{4014.017398 * 0.98915}{0.137429}$ $= 28891.0296$

Indicated capital for Mining: $= \frac{528.782692 * 0.7257158}{0.156901}$ $= 2445.6593565365$

Indicated capital for Utilities: $= \frac{1026.39735 * 0.686566986}{0.099333}$ $= 7094.2238231795$

Indicated capital for Construction: $$= \frac{2353.940972 * 0.8165764864}{0.166000} = 11579.354506679$$

Indicated capital for Manufacturing: $$= \frac{5012.062616 * 0.878876618}{0.132667} = 33203.318392323$$

Indicated capital for Wholesale and transportation: $$= \frac{3517.754411 * 0.7756131873}{0.166000} = 16436.24524611$$

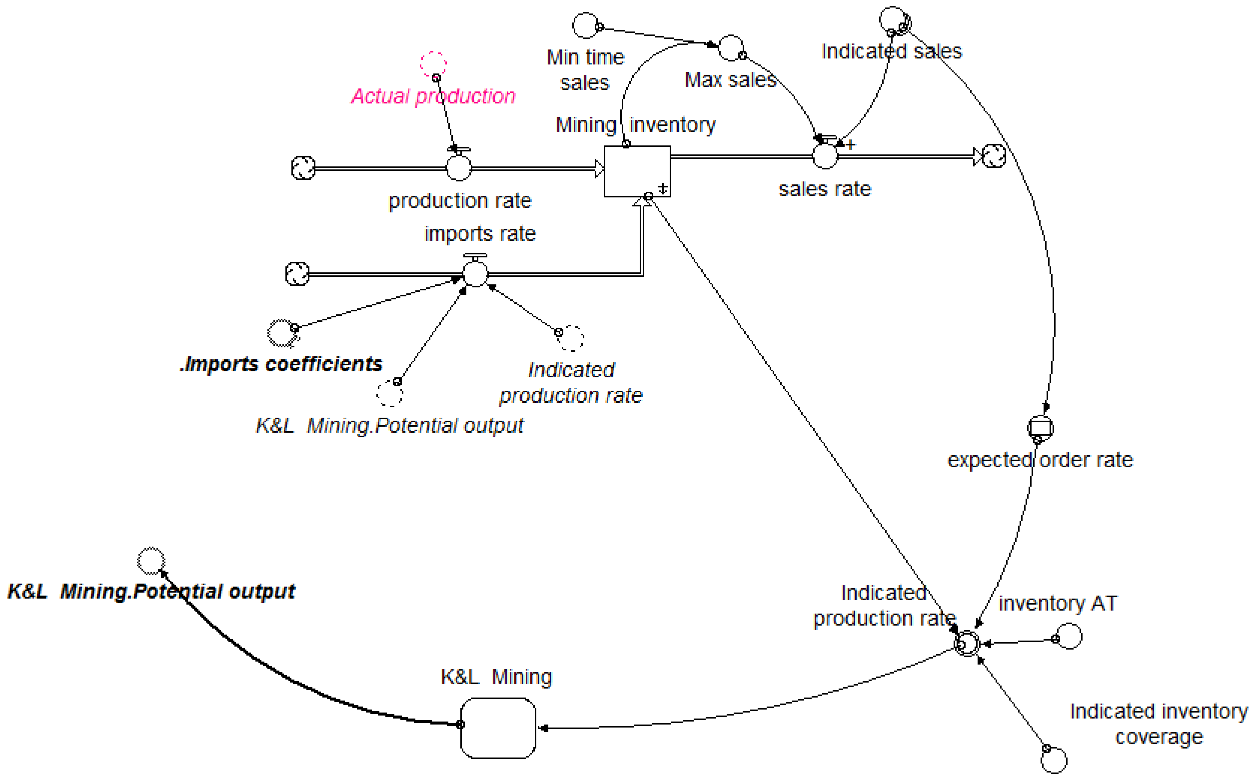
Indicated capital for Retail, food and lodging: $$= \frac{4272.745874 * 0.8080704155}{0.166000} = 20722.055987775$$

Indicated capital for Other services: $$= \frac{13161.77486 * 0.7555776115}{0.166000} = 59908.08681819$$

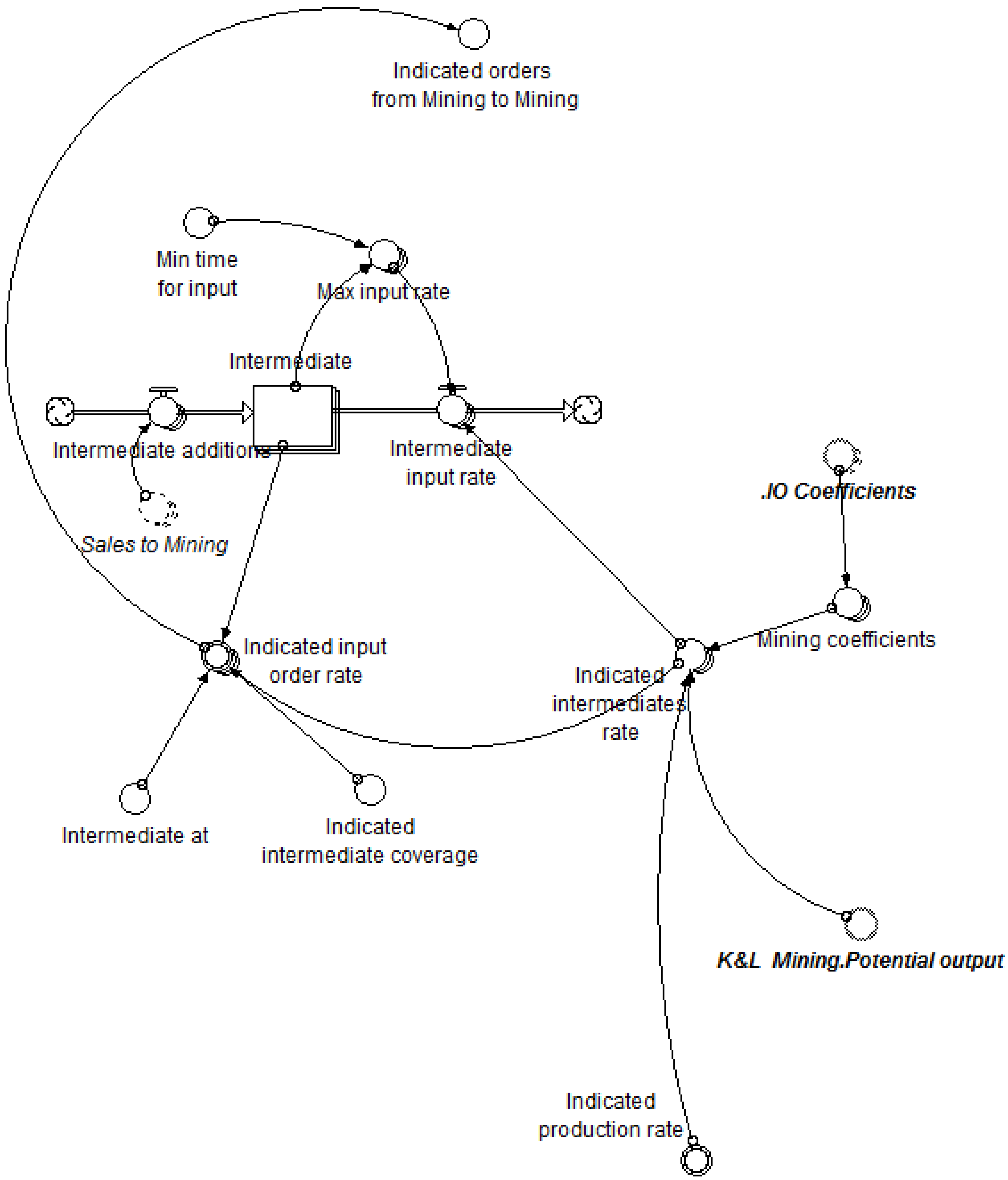
Appendix C

Model documentation

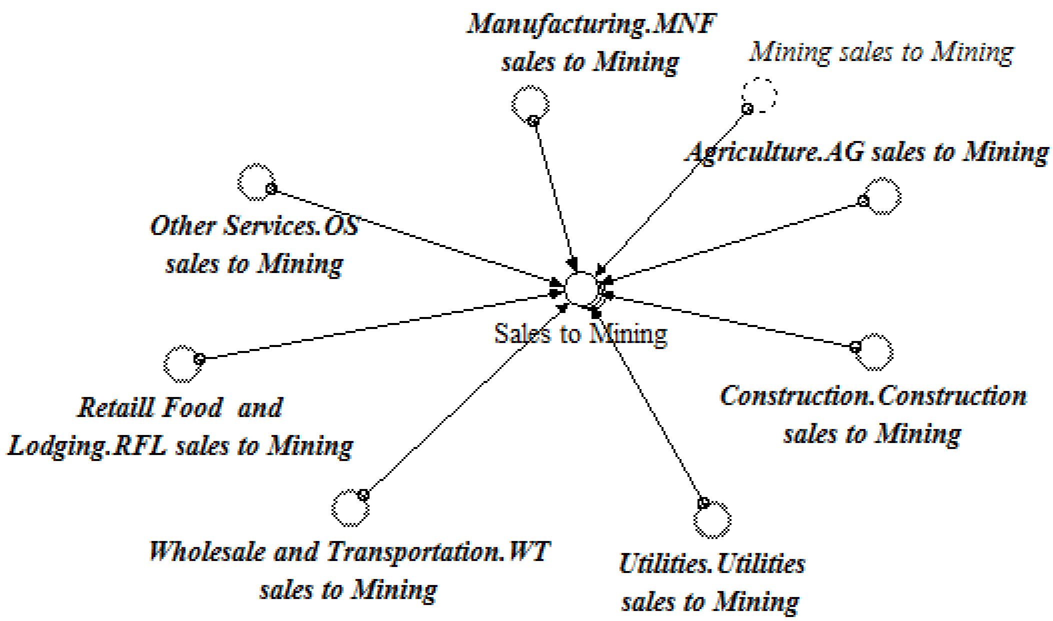
A production and sales process within each industry is determined by its desired levels and its constraints.



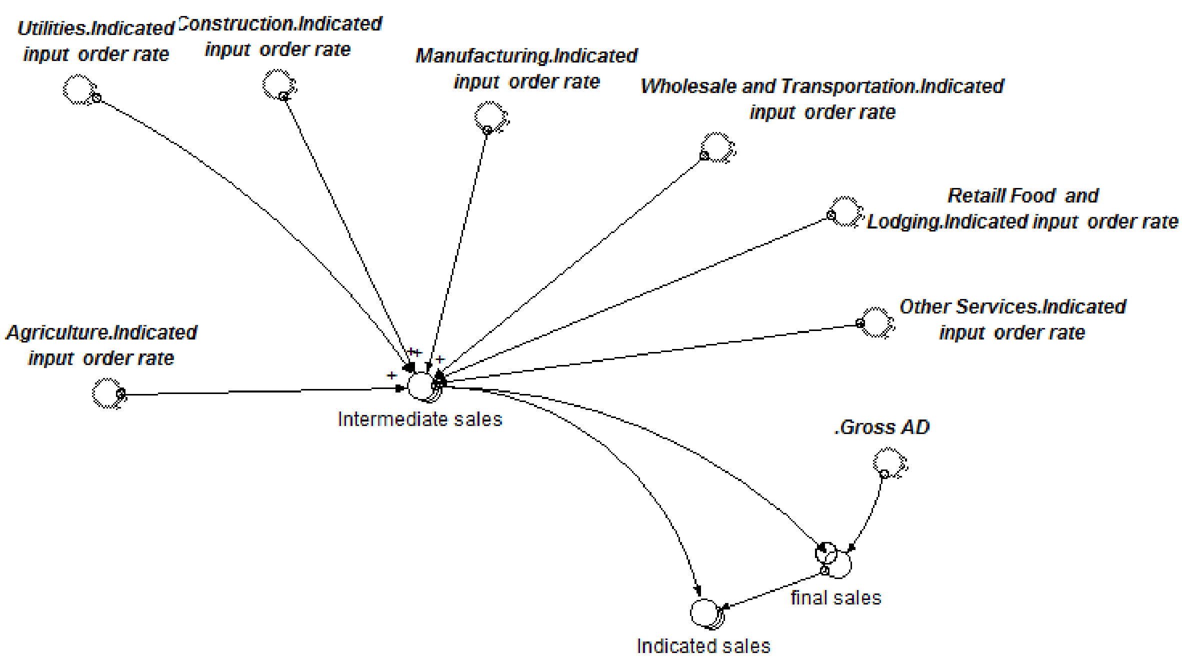
The sales rate is determined by taking the smaller of two variables: *Indicated sales* and *Max sales.* The latter works as a constraint acknowledging that no sales can take place if there is no inventory available. *Max sales* is calculated by dividing the inventory by the minimum amount of time (*Min time sales)* required to conduct sales. No formal-source information is available for this parameter; the parameter is assumed to be one week. *Indicated sales* signals what the expected orders are, which, together with the desired level of inventory, determine *Indicated production rate*. The inventory is generated by both production and import rates. Their shares are determined by the technical coefficients calculated within the IO model. The use of the coefficients is presented in the figure below.



The IO coefficients dictate how much of the inputs from one industry to another is required. To do so, the lesser of two variables, *Potential output* and *Indicated production rate,* is taken. In its turn, *Intermediate input rate*, like *Sales rate*, is determined by the smaller of two variables: *Max input rate* and *Indicated intermediate rate.* Together with the intermediate inventory adjustment structure, they define *Indicated input order rate*, which is the orders specified by the industry, including intra-industry orders. However, some of the orders might remain unfilled by other industries. The actual additions to *Intermediate inventory*, i.e. the sales from other industries to the industry, are determined in the figure below.

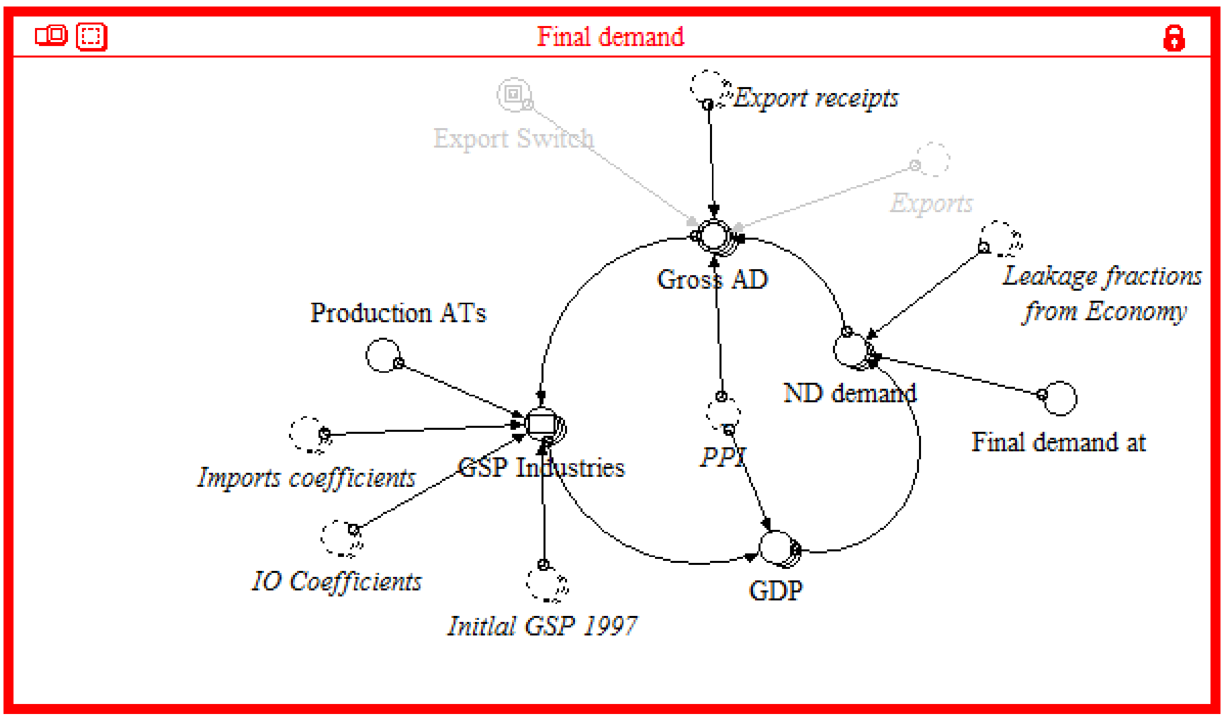


Orders to the industry from other industries comprise the indicated intermediate sales and together with final sales make up *Indicated sales*.

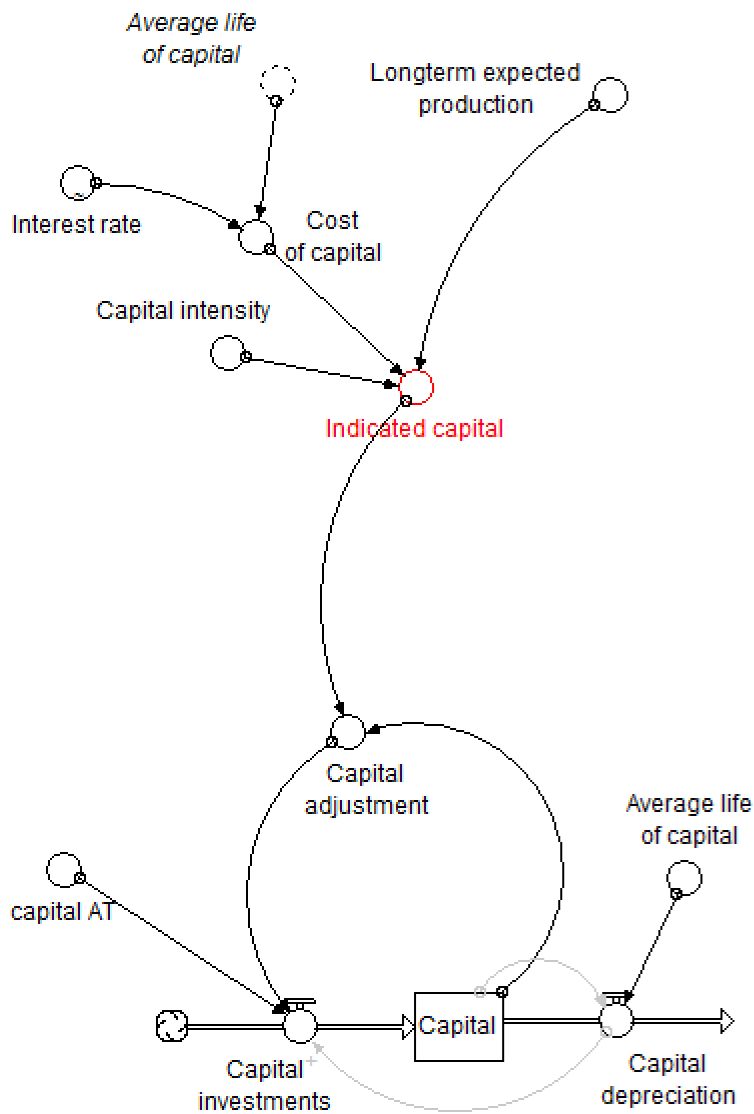


The final sales represent the final demand for consumption, from government and households, as well as exports. The structure below shows how *Final sales* is calculated. A "semi-exogenous"

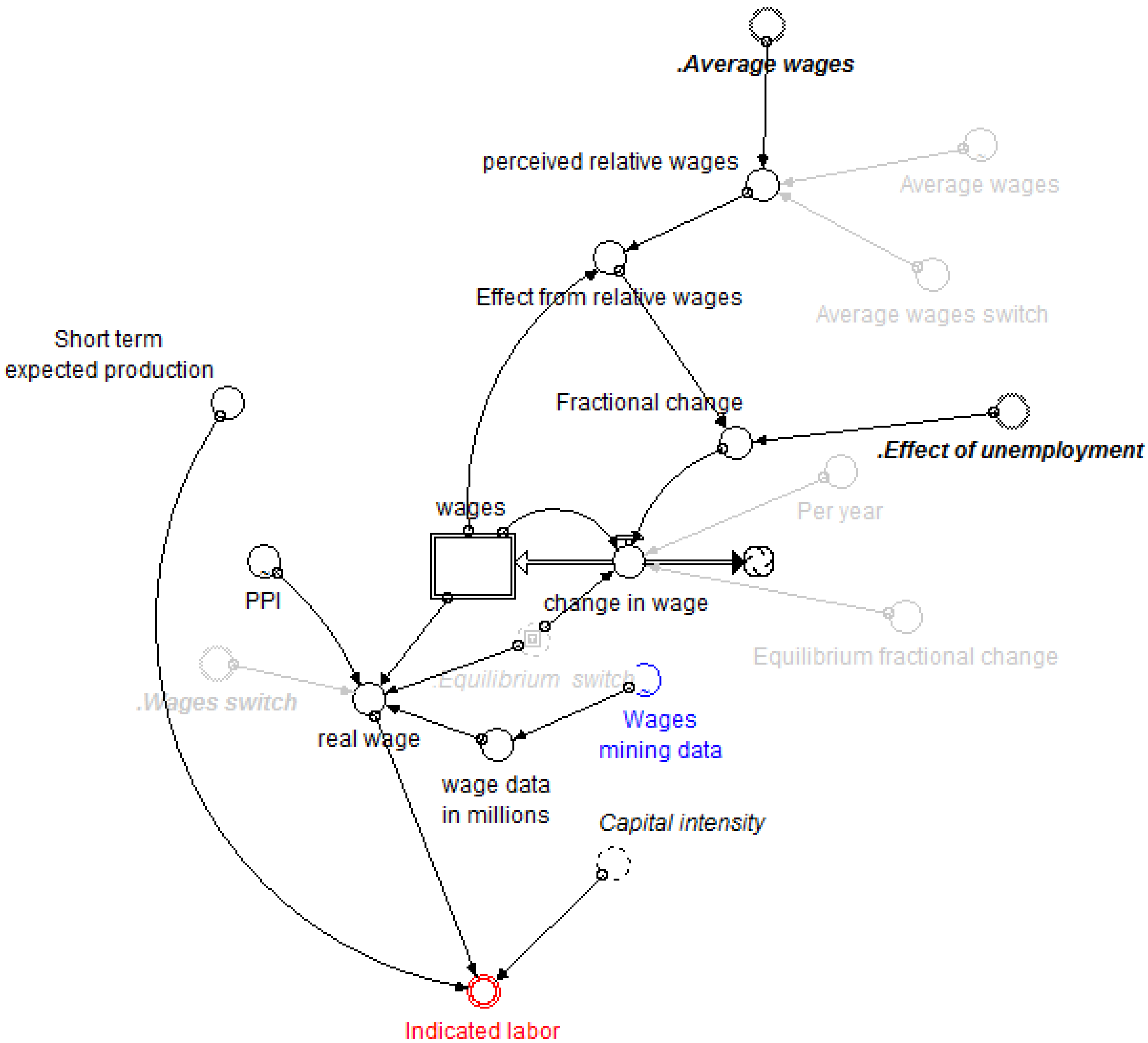
perspective is taken, since *Final sales* is driven by the exports receipts data, leakage fractions of the economy, and IO and imports coefficients. The Gross State Product (GSP) by industry is calculated as value added: from Gross Aggregated Demand (AD), imports and intermediates are subtracted. Gross Domestic Product (GDP) per industry can be calculated as value added. In order in see the real GDP, producers' price index (PPI), as an index price accounting for inflation, is included. *Leakage fraction from Economy* is the calculated fraction of the Gross Product that leaves ND. Knowing the fraction, the product that has remained in ND, i.e. ND demand, can be calculated. ND demand together with exports makes up the Gross AD.
The structure was suggested by David Wheat.



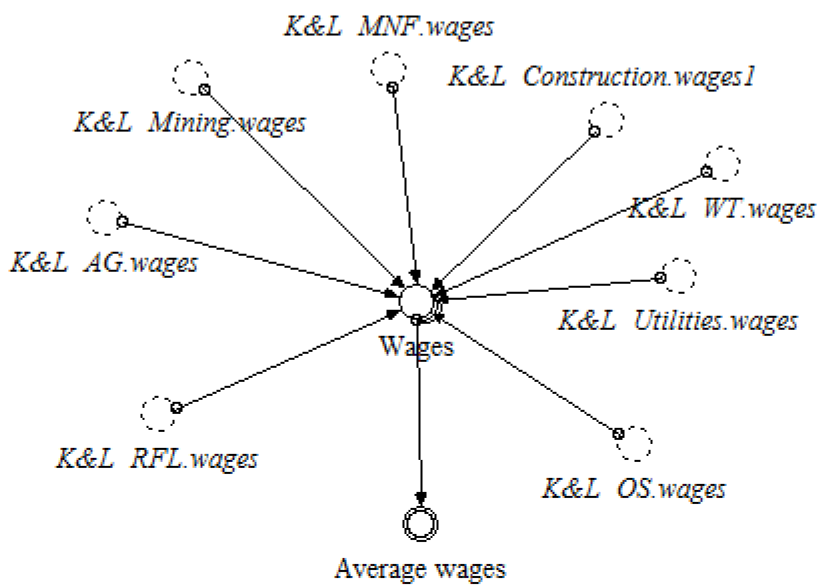
As stated above, production rate's constraints are those coming from capacity and intermediates. The capacity constraints come from capital and labor. *Indicated production rate* dictates the desired levels for both capital and labor. Capital responds to the demand with several-year delays. In economics, *Cost of capital* and *Capital intensity in production* are crucial factors in determining the optimal capital, i.e. *Indicated capital*. Both variables comprising the cost of capital, *Interest rate* and *Average life of capital*, are treated as exogenous and retrieved from the World Bank and Bureau of Economic analysis online databases, respectively. Inside the capital adjustment structure described in *Model description* chapter, *Capital* is adjusted to the desired level.



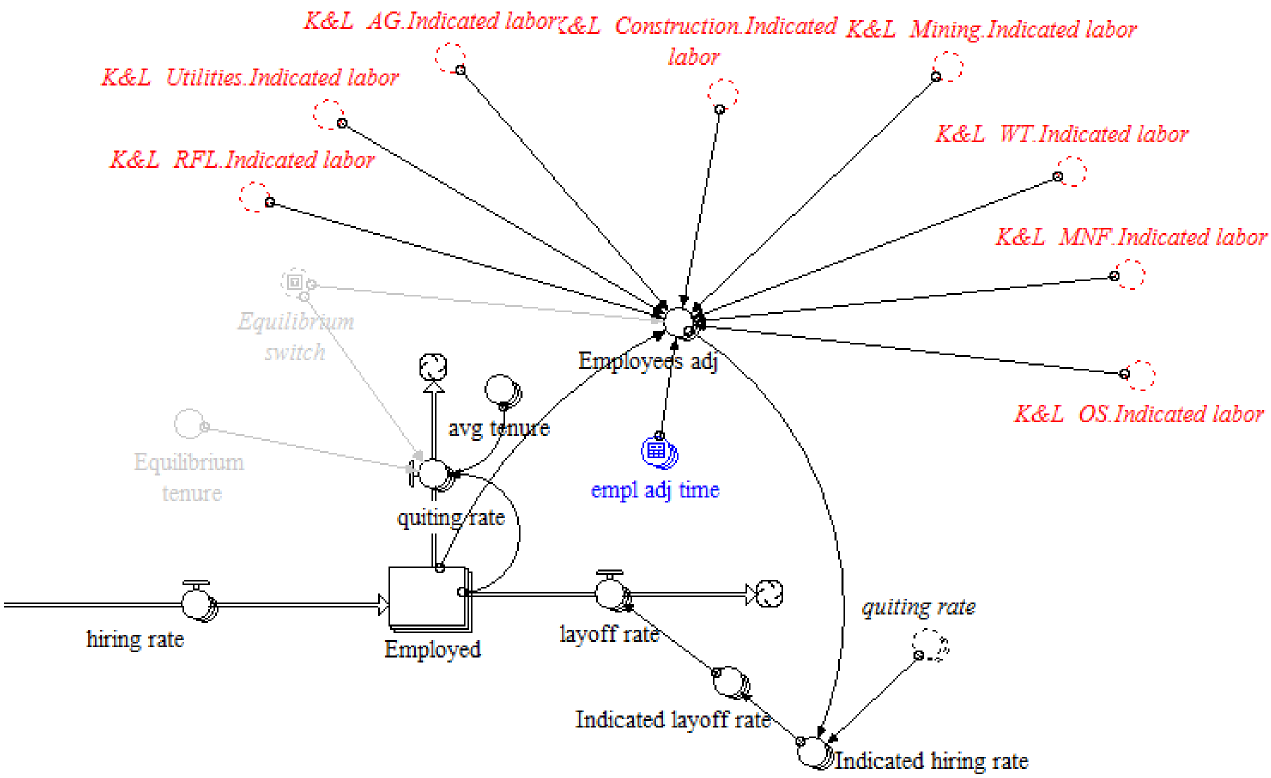
The optimal labor, i.e. *Indicated labor*, is determined by *Short-term expected production*, calculated as half-a-year-delayed *Indicated production rate;* the cost of labor, expressed as real wages; and labor intensity in production (that equals to $1 - Capital\ intensity\ in\ production$). Wages are treated as endogenous. The wages in the current industry are based on the *Average wages* among all the industries. Initially, the wages in the industry are compared to the average, which produces *Perceived relative wages*. If there is discrepancy, *Effect from relative wages* increases the wage by the fraction of the wages' differences. Another effect impacting the fractional change of the wages is *Effect from unemployment*. This effect has been explained earlier in the paper.



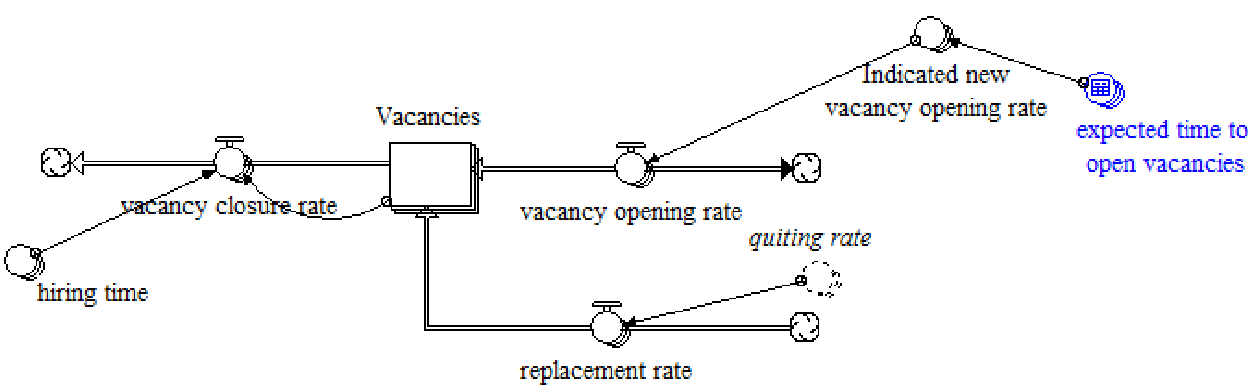
The figure below represents the structure by which *Average wages* among all the industries is calculated.



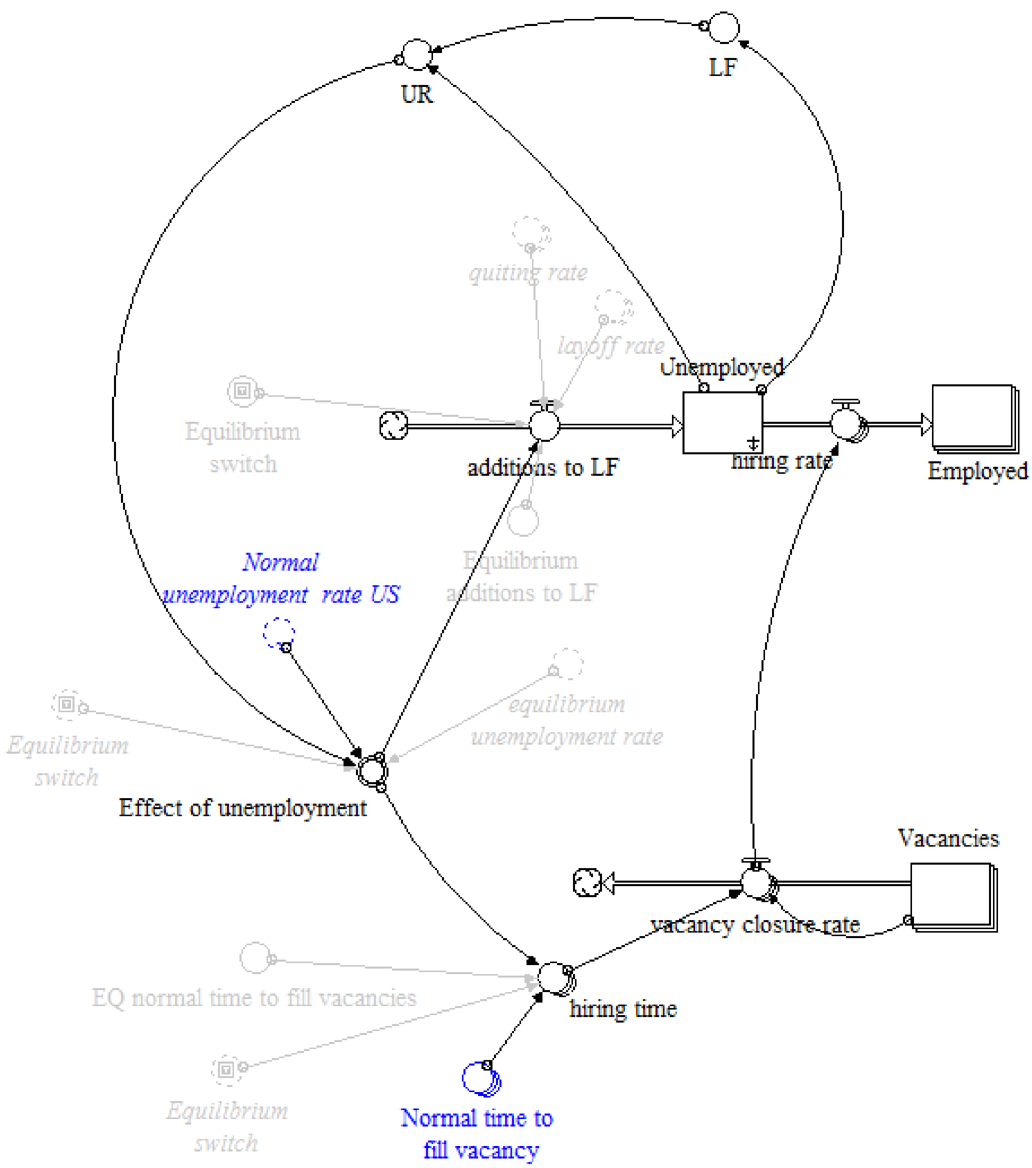
Signals for labor demand from each of the sectors are compared to the actual employment and an adjustment takes place, if necessary. The employment adjustment time for the employment is assumed to be 3 months (0.25 years). Depending on whether the actual employment is higher or lower than the indicated employment, the respective *Indicated hiring rate* can be either negative or positive. The indicated hiring rate also accounts for the quitting rate. When *Indicated hiring rate* is positive, *Indicated layoff rate* and *Actual layoff rate* are both at 0; when *Indicated hiring rate* is negative, they are equal to *Indicated hiring rate*. *Quitting rate* represents employees' normal leaving process by employment tenure. Information for average tenure is available from BLS for each industry and represents the US average (http://bls.gov, 2015) rather than North Dakota's.



Employment adjustment takes place through opening or closing vacancies. The time to go through all the necessary procedures and open a vacancy is assumed to be one week. Besides new vacancies, there are replacement vacancies, which are opened to replace employees who quit. Vacancies are filled, i.e. closed, at a *Vacancy closure rate* that is dependent on *Hiring time*.



The hiring time is determined by the tightness of the labor market. According to the common economic definition, the numbers of employed and unemployed people together comprise the labor force (LF). By dividing the unemployed by the labor force, unemployment rate (UR) is identified. Tightness of the labor market is considered when comparing the actual UR to the normal unemployment rate, which stands for the fractional unemployment rate. The fractional unemployment is the unemployment which exists in any, even the most efficient, economies due to the process of movement of people from one job to another. The rate used in this research is the US normal unemployment rate. By dividing the UR by the actual UR, *Effect of the unemployment* is calculated, which is a representation of the labor market tightness. It increases the normal hiring time if the normal UR is higher than the actual UR. The normal times to fill vacancies by industries is taken from "DHI-DFH Vacancy Duration Measure" and quantified as the average number of working days taken to fill vacant job positions (http://dicehiringindicators.com, 2015). It represents the US average; the data for ND is not available. It has a reverse effect on the normal hiring time when the normal UR is lower than actual UR. The hiring time controls how quickly a vacancy is filled, hence it controls the hiring rate, which manages the stock of employed people and through which labor demand is satisfied.



Around half of the people laid off in the oil industry in the ND leave the state, the other half rejoins the labor force(personal communication; interview with the Dwight Wendschlag and Kevin Black from May 8, 2015). For the lack of other reliable sources of information, the same is assumed for the rest of the industries. As for the quitting rate as another addition to the labor force, the US Census Bureau estimates that 99% of the quitters represent those who retire, joining the unemployed (the statistics of the labor force division by age group, https://www.census.gov, 2015).

However, as stated in the *Model description* chapter, this structure alone cannot reproduce the job openings rate and a thorough modeling of the workforce supply processes in ND is needed. The modeling is part of the other research of the project, conducted by Babette Bakker.

All the model equations are enclosed further.

Unemployed(t) = Unemployed(t - dt) + (additions_to_LF - hiring_rate[Economic_Sectors] - hiring_rate[Economic_Sectors] - hiring_rate[Economic_Sectors] - hiring_rate[Economic_Sectors] - hiring_rate[Economic_Sectors] - hiring_rate[Economic_Sectors] - hiring_rate[Economic_Sectors] - hiring_rate[Economic_Sectors]) * dt
INIT Unemployed = if Equilibrium__switch=0 then 11663 {initial Unemployment_datam 1995} else equilibrium__unemployment_rate*Initial_LF*8

INFLOWS:

- additions_to_LF = if Equilibrium__switch=0 then Effect_of_unemployment* (SUM(quiting_rate[*])*0.99+ SUM(layoff_rate[*])*0.5) else Equilibrium__additions_to_LF

OUTFLOWS:

- hiring_rate[Economic_Sectors] = vacancy_closure_rate
- hiring_rate[Economic_Sectors] = vacancy_closure_rate
- hiring_rate[Economic_Sectors] = vacancy_closure_rate
- hiring_rate[Economic_Sectors] = vacancy_closure_rate
- hiring_rate[Economic_Sectors] = vacancy_closure_rate
- hiring_rate[Economic_Sectors] = vacancy_closure_rate
- hiring_rate[Economic_Sectors] = vacancy_closure_rate
- hiring_rate[Economic_Sectors] = vacancy_closure_rate

Employed[Agriculture](t) = Employed[Agriculture](t - dt) + (hiring_rate[Economic_Sectors] - layoff_rate[Economic_Sectors] - quiting_rate[Economic_Sectors]) * dt
INIT Employed[Agriculture] = if Equilibrium__switch=0 then 2363.0 else Initial_LF*(1-equilibrium__unemployment_rate)

Employed[Mining](t) = Employed[Mining](t - dt) + (hiring_rate[Economic_Sectors] - layoff_rate[Economic_Sectors] - quiting_rate[Economic_Sectors]) * dt
INIT Employed[Mining] = if Equilibrium__switch=0 then 3686.0 else Initial_LF*(1-equilibrium__unemployment_rate)

Employed[Utilities](t) = Employed[Utilities](t - dt) + (hiring_rate[Economic_Sectors] - layoff_rate[Economic_Sectors] - quiting_rate[Economic_Sectors]) * dt
INIT Employed[Utilities] = if Equilibrium__switch=0 then 3686.0 else Initial_LF*(1-equilibrium__unemployment_rate)

Employed[Construction](t) = Employed[Construction](t - dt) + (hiring_rate[Economic_Sectors] - layoff_rate[Economic_Sectors] - quiting_rate[Economic_Sectors]) * dt
INIT Employed[Construction] = if Equilibrium__switch=0 then 16182.0 else Initial_LF*(1-equilibrium__unemployment_rate)

Employed[Manufacturing](t) = Employed[Manufacturing](t - dt) + (hiring_rate[Economic_Sectors] - layoff_rate[Economic_Sectors] - quiting_rate[Economic_Sectors]) * dt
INIT Employed[Manufacturing] = if Equilibrium__switch=0 then 22547.0 else Initial_LF*(1-equilibrium__unemployment_rate)

Employed[Wholesale_and_Transportation](t) = Employed[Wholesale_and_Transportation](t - dt) + (hiring_rate[Economic_Sectors] - layoff_rate[Economic_Sectors] - quiting_rate[Economic_Sectors]) * dt
INIT Employed[Wholesale_and_Transportation] = if Equilibrium__switch=0 then 28745.0 else Initial_LF*(1-equilibrium__unemployment_rate)

Employed[Retail_Food_and_Lodging](t) = Employed[Retail_Food_and_Lodging](t - dt) + (hiring_rate[Economic_Sectors] - layoff_rate[Economic_Sectors] - quiting_rate[Economic_Sectors]) * dt
INIT Employed[Retail_Food_and_Lodging] = if Equilibrium__switch=0 then 67006.0 else Initial_LF*(1-equilibrium__unemployment_rate)

☐ Employed[Other_Services](t) = Employed[Other_Services](t - dt) + (hiring_rate[Economic_Sectors] - layoff_rate[Economic_Sectors] - quiting_rate[Economic_Sectors]) * dt
INIT Employed[Other_Services] = if Equilibrium__switch=0 then 141197.0 else Initial_LF*(1-equilibrium__unemployment_rate)

INFLOWS:

hiring_rate[Economic_Sectors] = vacancy_closure_rate

OUTFLOWS:

layoff_rate[Economic_Sectors] = Indicated_layoff_rate

quiting_rate[Economic_Sectors] = if Equilibrium__switch=0 then Employed/avg_tenure else Employed/Equilibrium__tenure

☐ Vacancies[Agriculture](t) = Vacancies[Agriculture](t - dt) + (vacancy_opening_rate[Economic_Sectors] + replacement_rate[Economic_Sectors] - vacancy_closure_rate[Economic_Sectors]) * dt
INIT Vacancies[Agriculture] = if Equilibrium__switch=0 then INIT(job_openings_data)*INIT(fraction_AG) else (vacancy_opening_rate[Agriculture]+replacement_rate[Agriculture])*EQ_normal_time_to_fill_vacancies

☐ Vacancies[Mining](t) = Vacancies[Mining](t - dt) + (vacancy_opening_rate[Economic_Sectors] + replacement_rate[Economic_Sectors] - vacancy_closure_rate[Economic_Sectors]) * dt
INIT Vacancies[Mining] = if Equilibrium__switch=0 then INIT(job_openings_data)*INIT(fraction__Mining) else (vacancy_opening_rate[Mining]+replacement_rate[Mining])*EQ_normal_time_to_fill_vacancies

☐ Vacancies[Utilities](t) = Vacancies[Utilities](t - dt) + (vacancy_opening_rate[Economic_Sectors] + replacement_rate[Economic_Sectors] - vacancy_closure_rate[Economic_Sectors]) * dt
INIT Vacancies[Utilities] = if Equilibrium__switch=0 then INIT(job_openings_data)*INIT(fraction__Utilities) ELSE (vacancy_opening_rate[Utilities]+replacement_rate[Utilities])*EQ_normal_time_to_fill_vacancies

☐ Vacancies[Construction](t) = Vacancies[Construction](t - dt) + (vacancy_opening_rate[Economic_Sectors] + replacement_rate[Economic_Sectors] - vacancy_closure_rate[Economic_Sectors]) * dt
INIT Vacancies[Construction] = if Equilibrium__switch=0 then INIT(job_openings_data)*INIT(fraction_con) else (vacancy_opening_rate[Construction]+replacement_rate[Construction])*EQ_normal_time_to_fill_vacancies

☐ Vacancies[Manufacturing](t) = Vacancies[Manufacturing](t - dt) + (vacancy_opening_rate[Economic_Sectors] + replacement_rate[Economic_Sectors] - vacancy_closure_rate[Economic_Sectors]) * dt
INIT Vacancies[Manufacturing] = if Equilibrium__switch=0 then INIT(job_openings_data)*INIT(fraction_MNF) else (vacancy_opening_rate[Manufacturing]+replacement_rate[Manufacturing])*EQ_normal_time_to_fill_vacancies

☐ Vacancies[Wholesale_and_Transportation](t) = Vacancies[Wholesale_and_Transportation](t - dt) + (vacancy_opening_rate[Economic_Sectors] + replacement_rate[Economic_Sectors] - vacancy_closure_rate[Economic_Sectors]) * dt
INIT Vacancies[Wholesale_and_Transportation] = if Equilibrium__switch=0 then INIT(job_openings_data)*INIT(fraction_WT) else (vacancy_opening_rate[Wholesale_and_Transportation]+replacement_rate[Wholesale_and_Transportation])*EQ_normal_time_to_fill_vacancies

☐ Vacancies[Retail_Food_and_Lodging](t) = Vacancies[Retail_Food_and_Lodging](t - dt) + (vacancy_opening_rate[Economic_Sectors] + replacement_rate[Economic_Sectors] - vacancy_closure_rate[Economic_Sectors]) * dt
INIT Vacancies[Retail_Food_and_Lodging] = if Equilibrium__switch=0 then INIT(job_openings_data)*INIT(fractions_RLF) else (vacancy_opening_rate[Retail_Food_and_Lodging]+replacement_rate[Retail_Food_and_Lodging])*EQ_normal_time_to_fill_vacancies

Vacancies[Other_Services](t) = Vacancies[Other_Services](t - dt) + (vacancy_opening_rate[Economic_Sectors] + replacement_rate[Economic_Sectors] - vacancy_closure_rate[Economic_Sectors]) * dt
INIT Vacancies[Other_Services] = if Equilibrium__switch=0 then INIT(job_openings_data)*INIT(fraction_OS) else (vacancy_opening_rate[Other_Services]+replacement_rate[Other_Services])*EQ_normal_time_to_fill_vacancies

INFLOWS:

vacancy_opening_rate[Economic_Sectors] = Indicated_new__vacancy_opening_rate

replacement_rate[Economic_Sectors] = quiting_rate

OUTFLOWS:

vacancy_closure_rate[Economic_Sectors] = SMTH3(Vacancies/hiring_time, 0, 25)

AG_employment = GRAPH(TIME)
(1995, 2224), (1996, 2401), (1997, 2363), (1998, 2338), (1999, 2546), (2000, 2523), (2001, 2634), (2002, 2661), (2003, 2775), (2004, 2873), (2005, 2881), (2006, 2914), (2007, 3088), (2008, 3218), (2009, 3430), (2010, 3667), (2011, 3849), (2012, 4096), (2013, 4273)

AG_Exports_data = GRAPH(time)
(1997, 3125), (2001, 3747), (2006, 2987), (2009, 5584), (2013, 7538)

AG_imports__coefficients = GRAPH(TIME)
(1997, 0.46), (2001, 0.348), (2006, 0.219), (2009, 0.257), (2013, 0.324)

AG_leakage_fraction = GRAPH(TIME)
(1997, -4.22), (2001, -0.304), (2005, 0.347), (2009, 0.671), (2013, 0.495)

Average_wages = SUM(Wages[*])/8

avg_tenure[Agriculture] = 3.7

avg_tenure[Mining] = 5.2

avg_tenure[Utilities] = 13.3

avg_tenure[Construction] = 3.0

avg_tenure[Manufacturing] = 5.8

avg_tenure[Wholesale_and_Transportation] = 4.5

avg_tenure[Retail_Food_and_Lodging] = 2.4

avg_tenure[Other_Services] = 4.0

Civilian__non_institutional_population = GRAPH(TIME)
(1995, 476391), (1995, 476463), (1995, 477535), (1995, 477607), (1995, 477679), (1995, 477751), (1996, 478823), (1996, 478895), (1996, 479967), (1996, 480039), (1996, 480111), (1996, 481183), (1996, 481255), (1996, 481327), (1996, 482399), (1996, 482471), (1996, 482543), (1996, 483615), (1997, 483687), (1997, 483759), (1997, 484831), (1997, 484903), (1997, 484975), (1997, 485047), (1997, 485119), (1997, 485191), (1997, 485263), (1997, 485335), (1997, 485407), (1997, 485478), (1998, 485550), (1998, 485622), (1998, 486694), (1998, 486766), (1998, 486838), (1998, 485910), (1998, 485982), (1998, 486054), (1998, 486126), (1998, 486198), (1998, 486270), (1998, 486342), (1999, 486414), (1999, 486486), (1999, 486558), (1999, 486630), (1999, 486702), (1999, 486774), (1999, 485846), (1999, 485918), (1999, 485990), (1999, 486062), (1999, 486134)...

Construction_Exports_data = GRAPH(TIME)
(1997, 422), (2001, 205), (2006, 398), (2009, 52.5), (2013, 655)

Construction__Employment = GRAPH(TIME)
(1995, 14686), (1996, 16005), (1997, 16182), (1998, 16764), (1999, 17904), (2000, 16908), (2001, 16561), (2002, 16095), (2003, 16911), (2004, 18191), (2005, 18395), (2006, 19431), (2007, 20204), (2008, 21734), (2009, 21714), (2010, 22378), (2011, 25389), (2012, 30533), (2013, 33456)

Construction__imports_coefficents = GRAPH(TIME)
(1997, 0.37), (2001, 0.235), (2006, 0.209), (2009, 0.216), (2013, 0.22)

Construction__leakage_fraction = GRAPH(TIME)
(1997, -0.724), (2001, -1.47), (2006, -0.98), (2009, -1.17), (2013, -1.20)

Crude_oil_production__data = GRAPH(TIME)
(1995, 2.9e+007), (1996, 3.2e+007), (1997, 3.6e+007), (1998, 3.6e+007), (1999, 3.3e+007), (2000, 3.3e+007), (2001, 3.2e+007), (2002, 3.1e+007), (2003, 2.9e+007), (2004, 3.1e+007), (2005, 3.6e+007), (2006, 4e+007), (2007, 4.5e+007), (2008, 6.3e+007), (2009, 8e+007), (2010, 1.1e+008), (2011, 1.5e+008), (2012, 2.4e+008), (2013, 3.1e+008)

Crude_oil__production_switch = 0

Crude_oil__production_volume = if Crude_oil__production_switch=0 then Crude_oil_production__data else if time>= 2015 then Oil_production_volume__scenarios_from_2015_to_2020 else Crude_oil_production__data

Effect_of_unemployment = if Equilibrium__switch=0 then Normal__unemployment__rate_US/UR else SMTH1(equilibrium__unemployment_rate/UR, 0.25)

Employees_adj[Agriculture] = if Equilibrium__switch=0 then (K&L__AG.Indicated_labor-Employed[Agriculture])/empl_adj_time[Agriculture] else (equilibrium__Indicated_labor-Employed[Agriculture])/empl_adj_time[Agriculture]

Employees_adj[Mining] = if Equilibrium__switch=0 then(K&L__Mining.Indicated_labor-Employed[Mining])/empl_adj_time[Mining] ELSE (equilibrium__Indicated_labor-Employed[Mining])/empl_adj_time[Mining]

Employees_adj[Utilities] = if Equilibrium__switch=0 then (K&L__Utilities.Indicated_labor-Employed[Utilities])/empl_adj_time[Utilities] else (equilibrium__Indicated_labor-Employed[Utilities])/empl_adj_time[Utilities]

Employees_adj[Construction] = if Equilibrium__switch=0 then (K&L__Construction.Indicated_labor-Employed[Construction])/empl_adj_time[Construction] else (equilibrium__Indicated_labor-Employed[Construction])/empl_adj_time[Construction]

Employees_adj[Manufacturing] = if Equilibrium__switch=0 then (K&L__MNF.Indicated_labor-Employed[Manufacturing])/empl_adj_time[Manufacturing] else (equilibrium__Indicated_labor-Employed[Manufacturing])/empl_adj_time[Manufacturing]

Employees_adj[Wholesale_and_Transportation] = if Equilibrium__switch=0 then (K&L__WT.Indicated_labor-Employed[Wholesale_and_Transportation])/empl_adj_time[Wholesale_and_Transportation] else (equilibrium__Indicated_labor-Employed[Wholesale_and_Transportation])/empl_adj_time[Wholesale_and_Transportation]

Employees_adj[Retail_Food_and_Lodging] = if Equilibrium__switch=0 then (K&L__RFL.Indicated_labor-Employed[Retail_Food_and_Lodging])/empl_adj_time[Retail_Food_and_Lodging] else (equilibrium__Indicated_labor-Employed[Retail_Food_and_Lodging])/empl_adj_time[Retail_Food_and_Lodging]

- Employees_adj[Other_Services] = if Equilibrium__switch=0 then (K&L__OS.Indicated_labor-Employed[Other_Services])/empl_adj_time[Other_Services] else (equilibrium__Indicated_labor-Employed[Other_Services])/empl_adj_time[Other_Services]
- empl_adj_time[Economic_Sectors] = 0.25
- Equilibrium__additions_to_LF = 57000*8
- equilibrium__Indicated_labor = Initial_LF*(1-equilibrium__unemployment_rate)
- Equilibrium__switch = 0
- Equilibrium__tenure = 5
- equilibrium__unemployment_rate = 0.05 {normal unemployment rate}
- EQ_normal_time_to_fill_vacancies = 21/251
- expected_time_to__open_vacancies[Economic_Sectors] = 7/251
- Exports = (Crude_oil__production_volume)*share_of_the_oil_exported_outside_of_ND*Oil_prices*(1+(1-percentage_of_the__oil_exports_in_total_mining))
- Export_receipts[Agriculture] = AG_Exports_data
- Export_receipts[Mining] = Mining_Exports_data
- Export_receipts[Utilities] = Utilities_Exports_data
- Export_receipts[Construction] = Construction_Exports_data
- Export_receipts[Manufacturing] = MNF_Exports_data
- Export_receipts[Wholesale_and_Transportation] = WT_exports_data
- Export_receipts[Retail_Food_and_Lodging] = RFL_Exports_data
- Export_receipts[Other_Services] = OS_exports_data
- Export_Switch = 0
- Final_demand_at = 3
- fractions_RLF = RFL_employment/Total__Employment_data
- fraction_AG = AG_employment/Total__Employment_data
- fraction_con = Construction__Employment/Total__Employment_data
- fraction_MNF = Manufacturing__employment/Total__Employment_data
- fraction_OS = OS_employment/Total__Employment_data
- fraction_WT = WT_employment/Total__Employment_data
- fraction__Mining = Mining__employment/Total__Employment_data
- fraction__Utilities = Utilities__employment/Total__Employment_data
- GDP[Economic_Sectors] = GSP_Industries*100/PPI
- Gross_AD[Agriculture] = ((ND_demand[Agriculture])+Export_receipts[Agriculture])*100/PPI
- Gross_AD[Mining] = if Export_Switch=0 then (ND_demand[Mining]+Export_receipts[Mining])*100/PPI else if time>=2015 then (ND_demand[Mining]+Exports)*100/PPI else (ND_demand[Mining]+Export_receipts[Mining])*100/PPI
- Gross_AD[Utilities] = (ND_demand[Utilities]+Export_receipts[Utilities])*100/PPI
- Gross_AD[Construction] = (ND_demand[Construction]+Export_receipts[Construction])*100/PPI
- Gross_AD[Manufacturing] = (ND_demand[Manufacturing]+Export_receipts[Manufacturing])*100/PPI
- Gross_AD[Wholesale_and_Transportation] = (ND_demand[Wholesale_and_Transportation]+Export_receipts[Wholesale_and_Transportation])*100/PPI
- Gross_AD[Retail_Food_and_Lodging] = (ND_demand[Retail_Food_and_Lodging]+Export_receipts[Retail_Food_and_Lodging])*100/PPI

Gross_AD[Other_Services] = (ND_demand[Other_Services]+Export_receipts[Other_Services])*100/PPI

hiring_time[Economic_Sectors] = if Equilibrium__switch=0 then Effect_of_unemployment*Normal_time_to__fill_vacancy else Effect_of_unemployment*EQ_normal_time_to_fill_vacancies

Imports_coefficients[Agriculture] = AG_imports__coefficients

Imports_coefficients[Mining] = Mining__imports_coefficients

Imports_coefficients[Utilities] = Utilities__imports_coefficients

Imports_coefficients[Construction] = Construction__imports_coefficents

Imports_coefficients[Manufacturing] = Manufacturing_imports_coefficients

Imports_coefficients[Wholesale_and_Transportation] = WT_impots_coefficients

Imports_coefficients[Retail_Food_and_Lodging] = RFL_import_coefficients

Imports_coefficients[Other_Services] = OS_imports__coefficents

Indicated_hiring_rate[Economic_Sectors] = Employees_adj+quiting_rate

Indicated_layoff_rate[Economic_Sectors] = if Indicated_hiring_rate<0 then -Indicated_hiring_rate else 0 {MAX(0,-Desired_hiring_rate)}

Indicated_new__vacancy_opening_rate[Economic_Sectors] = SMTH1(Employees_adj, expected_time_to__open_vacancies)

Indicated__employment_data = GRAPH(TIME)
(1995, 294496), (1996, 302115), (1997, 308480), (1998, 313659), (1999, 318568), (2000, 321483), (2001, 323987), (2002, 324170), (2003, 326115), (2005, 333207), (2006, 340484), (2007, 347563), (2008, 353761), (2009, 362806), (2010, 357592), (2011, 368314), (2012, 394799), (2013, 432863), (2014, 447264)

Initial_imports[Agriculture] = 1847.25

Initial_imports[Mining] = 161.33

Initial_imports[Utilities] = 154.45

Initial_imports[Construction] = 871.99

Initial_imports[Manufacturing] = 2295.01

Initial_imports[Wholesale_and_Transportation] = 562.38

Initial_imports[Retail_Food_and_Lodging] = 391.47

Initial_imports[Other_Services] = 1788.68

Initial_LF = 300000

Initlal_GSP_1997[Agriculture] = 824.5861607

Initlal_GSP_1997[Mining] = 289.1069578

Initlal_GSP_1997[Utilities] = 769.5095355

Initlal_GSP_1997[Construction] = 932.9443005

Initlal_GSP_1997[Manufacturing] = 1111.234884

Initlal_GSP_1997[Wholesale_and_Transportation] = 2108.554378

Initlal_GSP_1997[Retail_Food_and_Lodging] = 1622.633786

Initlal_GSP_1997[Other_Services] = 8052.803169

IO_Coefficients[Agriculture, Agriculture] = 0.089

IO_Coefficients[Agriculture, Mining] = 0.000

IO_Coefficients[Agriculture, Utilities] = 0.000

IO_Coefficients[Agriculture, Construction] = 0.001

IO_Coefficients[Agriculture, Manufacturing] = 0.019

IO_Coefficients[Agriculture, Wholesale_and_Transportation] = 0.000

- IO_Coefficients[Agriculture, Retail_Food_and_Lodging] = 0.001
- IO_Coefficients[Agriculture, Other_Services] = 0.000
- IO_Coefficients[Mining, Agriculture] = 0.002
- IO_Coefficients[Mining, Mining] = 0.094
- IO_Coefficients[Mining, Utilities] = 0.059
- IO_Coefficients[Mining, Construction] = 0.012
- IO_Coefficients[Mining, Manufacturing] = 0.086
- IO_Coefficients[Mining, Wholesale_and_Transportation] = 0.003
- IO_Coefficients[Mining, Retail_Food_and_Lodging] = 0.001
- IO_Coefficients[Mining, Other_Services] = 0.002
- IO_Coefficients[Utilities, Agriculture] = 0.007
- IO_Coefficients[Utilities, Mining] = 0.003
- IO_Coefficients[Utilities, Utilities] = 0.171
- IO_Coefficients[Utilities, Construction] = 0.006
- IO_Coefficients[Utilities, Manufacturing] = 0.014
- IO_Coefficients[Utilities, Wholesale_and_Transportation] = 0.015
- IO_Coefficients[Utilities, Retail_Food_and_Lodging] = 0.019
- IO_Coefficients[Utilities, Other_Services] = 0.019
- IO_Coefficients[Construction, Agriculture] = 0.009
- IO_Coefficients[Construction, Mining] = 0.010
- IO_Coefficients[Construction, Utilities] = 0.009
- IO_Coefficients[Construction, Construction] = 0.001
- IO_Coefficients[Construction, Manufacturing] = 0.006
- IO_Coefficients[Construction, Wholesale_and_Transportation] = 0.004
- IO_Coefficients[Construction, Retail_Food_and_Lodging] = 0.006
- IO_Coefficients[Construction, Other_Services] = 0.017
- IO_Coefficients[Manufacturing, Agriculture] = 0.129
- IO_Coefficients[Manufacturing, Mining] = 0.023
- IO_Coefficients[Manufacturing, Utilities] = 0.022
- IO_Coefficients[Manufacturing, Construction] = 0.136
- IO_Coefficients[Manufacturing, Manufacturing] = 0.209
- IO_Coefficients[Manufacturing, Wholesale_and_Transportation] = 0.037
- IO_Coefficients[Manufacturing, Retail_Food_and_Lodging] = 0.037
- IO_Coefficients[Manufacturing, Other_Services] = 0.021
- IO_Coefficients[Wholesale_and_Transportation, Agriculture] = 0.054
- IO_Coefficients[Wholesale_and_Transportation, Mining] = 0.011
- IO_Coefficients[Wholesale_and_Transportation, Utilities] = 0.022
- IO_Coefficients[Wholesale_and_Transportation, Construction] = 0.047
- IO_Coefficients[Wholesale_and_Transportation, Manufacturing] = 0.062
- IO_Coefficients[Wholesale_and_Transportation, Wholesale_and_Transportation] = 0.066
- IO_Coefficients[Wholesale_and_Transportation, Retail_Food_and_Lodging] = 0.040
- IO_Coefficients[Wholesale_and_Transportation, Other_Services] = 0.013
- IO_Coefficients[Retail_Food_and_Lodging, Agriculture] = 0.002
- IO_Coefficients[Retail_Food_and_Lodging, Mining] = 0.001

IO_Coefficients[Retail_Food_and_Lodging, Utilities] = 0.008
IO_Coefficients[Retail_Food_and_Lodging, Construction] = 0.117
IO_Coefficients[Retail_Food_and_Lodging, Manufacturing] = 0.007
IO_Coefficients[Retail_Food_and_Lodging, Wholesale_and_Transportation] = 0.007
IO_Coefficients[Retail_Food_and_Lodging, Retail_Food_and_Lodging] = 0.013
IO_Coefficients[Retail_Food_and_Lodging, Other_Services] = 0.008
IO_Coefficients[Other_Services, Agriculture] = 0.054
IO_Coefficients[Other_Services, Mining] = 0.017
IO_Coefficients[Other_Services, Utilities] = 0.060
IO_Coefficients[Other_Services, Construction] = 0.044
IO_Coefficients[Other_Services, Manufacturing] = 0.049
IO_Coefficients[Other_Services, Wholesale_and_Transportation] = 0.104
IO_Coefficients[Other_Services, Retail_Food_and_Lodging] = 0.137
IO_Coefficients[Other_Services, Other_Services] = 0.128
job_openings_data = GRAPH(TIME)
(1997, 11970), (1998, 12171), (1999, 12361), (2000, 12260), (2001, 12355), (2002, 12362), (2003, 11842), (2004, 12099), (2006, 12363), (2007, 11845), (2008, 12056), (2009, 12364), (2010, 8031), (2011, 9640), (2012, 15366), (2013, 21153), (2014, 20155)

Job_openings_Total = SUM(Vacancies[*])
Labor_force = GRAPH(time)
(1995, 336974), (1995, 336999), (1995, 337310), (1995, 337898), (1995, 338708), (1995, 339669), (1996, 340690), (1996, 341661), (1996, 342533), (1996, 343291), (1996, 343944), (1996, 344485), (1996, 344928), (1996, 345307), (1996, 345677), (1996, 346089), (1996, 346570), (1996, 347123), (1997, 347737), (1997, 348396), (1997, 349046), (1997, 349615), (1997, 350076), (1997, 350477), (1997, 350886), (1997, 351293), (1997, 351641), (1997, 351863), (1997, 351913), (1997, 351782), (1998, 351536), (1998, 351287), (1998, 351124), (1998, 351123), (1998, 351246), (1998, 351378), (1998, 351390), (1998, 351258), (1998, 351014), (1998, 350690), (1998, 350328), (1998, 349975), (1999, 349622), (1999, 349223), (1999, 348755), (1999, 348174), (1999, 347460), (1999, 346665), (1999, 345841), (1999, 345071), (1999, 344397), (1999, 343859), (1999, 343475)...

Leakage_fractions__from_Economy[Agriculture] = AG_leakage_fraction
Leakage_fractions__from_Economy[Mining] = Mining_leakage_fraction
Leakage_fractions__from_Economy[Utilities] = Utilities_leakage_fraction
Leakage_fractions__from_Economy[Construction] = Construction__leakage_fraction
Leakage_fractions__from_Economy[Manufacturing] = MNF_leakage_fraction
Leakage_fractions__from_Economy[Wholesale_and_Transportation] = WT_leakage_fraction
Leakage_fractions__from_Economy[Retail_Food_and_Lodging] = RFL_leakage_fraction
Leakage_fractions__from_Economy[Other_Services] = OS_leakage_fraction
LF = SUM(Employed[*])+Unemployed
LF_DATA = Unemployment_data+Total__Employment_data
Manufacturing_imports_coefficients = GRAPH(time)
(1997, 0.458), (2001, 0.332), (2006, 0.31), (2009, 0.317), (2013, 0.348)

Manufacturing__employment = GRAPH(TIME)
(1995, 20842), (1996, 21007), (1997, 22547), (1998, 23046), (1999, 23189), (2000, 24360), (2001, 24452), (2002, 24032), (2003, 23808), (2004, 25119), (2005, 26413), (2006, 26511), (2007, 26516), (2008, 26818), (2009, 23972), (2010, 22895), (2011, 24064), (2012, 25418), (2013, 25659)

Mining_Exports_data = GRAPH(time)
(1997, 366), (2001, 191), (2006, 83.6), (2009, 147), (2013, 7176)

Mining_leakage_fraction = GRAPH(time)
(1997, 0.788), (2001, -1.09), (2005, -0.665), (2009, -1.19), (2013, 0.59)

Mining__employment = GRAPH(TIME)
(1995, 3372), (1996, 3681), (1997, 3686), (1998, 3519), (1999, 3134), (2000, 3327), (2001, 3487), (2002, 3192), (2003, 3296), (2004, 3538), (2005, 4111), (2006, 4669), (2007, 5099), (2008, 6797), (2009, 6959), (2010, 10661), (2011, 16787), (2012, 24377), (2013, 26198)

Mining__imports_coefficients = GRAPH(TIME)
(1997, 0.305), (2001, 0.248), (2006, 0.169), (2009, 0.194), (2013, 0.0648)

MNF_Exports_data = GRAPH(TIME)
(1997, 3054), (2001, 1158), (2006, 1850), (2009, 2070), (2013, 4157)

MNF_leakage_fraction = GRAPH(TIME)
(1997, -0.745), (2001, -2.19), (2005, -3.28), (2009, -3.10), (2013, -2.75)

ND_demand[Economic_Sectors] = SMTH1(GDP*(1-Leakage_fractions__from_Economy), Final_demand_at)

Normal_time_to__fill_vacancy[Agriculture] = 20.5/251 {working days}

Normal_time_to__fill_vacancy[Mining] = 16.3/ 251

Normal_time_to__fill_vacancy[Utilities] = 21.5/251

Normal_time_to__fill_vacancy[Construction] = 9.9/251

Normal_time_to__fill_vacancy[Manufacturing] = 20.6/251

Normal_time_to__fill_vacancy[Wholesale_and_Transportation] = 21.5/251

Normal_time_to__fill_vacancy[Retail_Food_and_Lodging] = 15.5/251

Normal_time_to__fill_vacancy[Other_Services] = 27.9/251

Normal__unemployment__rate_US = GRAPH(TIME)
(1995, 0.053), (1996, 0.052), (1997, 0.051), (1998, 0.051), (1999, 0.05), (2000, 0.05), (2001, 0.05), (2002, 0.05), (2003, 0.05), (2004, 0.05), (2005, 0.05), (2006, 0.05), (2007, 0.05), (2008, 0.05), (2009, 0.051), (2010, 0.052), (2011, 0.053), (2012, 0.053), (2013, 0.055), (2014, 0.055), (2015, 0.054)

Oil_prices = if Price_switch=0 then (Oil_prices_WTI_data)/1000000 else (if time>=2015 then (Oil_price_WTI_scenarios__from_2015_to_2020/1000000) else (Oil_prices_WTI_data)/1000000)

Oil_prices_WTI_data = GRAPH(TIME)
(1995, 18.0), (1995, 18.6), (1995, 18.5), (1995, 19.9), (1995, 19.7), (1995, 18.4), (1996, 17.3), (1996, 18.0), (1996, 18.2), (1996, 17.4), (1996, 18.0), (1996, 19.0), (1996, 18.9), (1996, 19.1), (1996, 21.3), (1996, 23.5), (1996, 21.2), (1996, 20.4), (1997, 21.3), (1997, 21.9), (1997, 24.0), (1997, 24.9), (1997, 23.7), (1997, 25.2), (1997, 25.1), (1997, 22.2), (1997, 21.0), (1997, 19.7), (1997, 20.8), (1997, 19.3), (1998, 19.7), (1998, 19.9), (1998, 19.8), (1998, 21.3), (1998, 20.2), (1998, 18.3), (1998, 16.7), (1998, 16.1), (1998, 15.1), (1998, 15.4), (1998, 14.9), (1998, 13.7), (1999, 14.2), (1999, 13.5), (1999, 15.0), (1999, 14.5), (1999, 13.0), (1999, 11.4), (1999, 12.5), (1999, 12.0), (1999, 14.7), (1999, 17.3), (1999, 17.7)...

Oil_price_WTI_scenarios__from_2015_to_2020 = GRAPH(TIME)
(2015, 61.9), (2015, 61.5), (2016, 61.1), (2016, 61.1), (2016, 60.7), (2016, 59.1), (2017, 58.7), (2017, 57.9), (2017, 56.7), (2017, 56.3), (2018, 57.1), (2018, 58.7), (2018, 59.1), (2018, 59.1), (2019, 58.3), (2019, 58.3), (2019, 58.3), (2019, 58.3), (2020, 58.3), (2020, 58.3), (2020, 58.3)

Oil_production_volume__scenarios_from_2015_to_2020 = GRAPH(time)
(2015, 3.1e+008), (2016, 3.1e+008), (2017, 3.1e+008), (2018, 3.1e+008), (2019, 3.1e+008), (2020, 3.1e+008)

OS_employment = GRAPH(TIME)
(1995, 135030), (1996, 137745), (1997, 141197), (1998, 144622), (1999, 148086), (2000, 150321), (2001, 151746), (2002, 153505), (2003, 155867), (2004, 157938), (2005, 160167), (2006, 163702), (2007, 166428), (2008, 169652), (2009, 171539), (2010, 175026), (2011, 177027), (2012, 182126), (2013, 186721)

OS_exports_data = GRAPH(TIME)
(1997, 2073), (2001, 3184), (2006, 4486), (2009, 5019), (2013, 5884)

OS_imports__coefficents = GRAPH(time)
(1997, 0.136), (2001, 0.162), (2005, 0.167), (2009, 0.151), (2013, 0.149)

OS_leakage_fraction = GRAPH(TIME)
(1997, -0.193), (2001, -0.213), (2005, -0.246), (2009, -0.251), (2013, -0.31)

Percentage_of_the__oil_exports_in_total_mining = 0.85

Population = GRAPH(TIME)
(1995, 637685), (1996, 635753), (1997, 638223), (1997, 641216), (1998, 644804), (1999, 647832), (2000, 650382), (2001, 649716), (2001, 647532), (2002, 644259), (2003, 642023), (2004, 639062), (2005, 638168), (2005, 638817), (2006, 644705), (2007, 646089), (2008, 649422), (2008, 652822), (2009, 657569), (2010, 664968), (2011, 674345), (2012, 685242), (2012, 701705), (2013, 723857), (2014, 739482)

PPI = GRAPH(TIME)
(1997, 100), (1998, 97.5), (1999, 98.4), (2000, 104), (2001, 105), (2002, 103), (2003, 108), (2004, 115), (2005, 123), (2006, 129), (2007, 135), (2008, 149), (2009, 136), (2010, 145), (2011, 158), (2012, 158), (2013, 159), (2014, 161)

Price_switch = 0

Production_ATs = .75

RFL_employment = GRAPH(TIME)
(1995, 65227), (1996, 66356), (1997, 67006), (1998, 67589), (1999, 67483), (2000, 67727), (2001, 67509), (2002, 67662), (2003, 67933), (2004, 68945), (2005, 70325), (2006, 71829), (2007, 72770), (2008, 73274), (2009, 73367), (2010, 74439), (2011, 76859), (2012, 81551), (2013, 84447)

RFL_Exports_data = GRAPH(TIME)
(1997, 450), (2001, 567), (2006, 624), (2009, 686), (2013, 1136)

RFL_import_coefficients = GRAPH(TIME)
(1997, 0.0916), (2001, 0.232), (2005, 0.176), (2009, 0.117), (2013, 0.156)

RFL_leakage_fraction = GRAPH(TIME)
(1997, -0.212), (2001, -0.8), (2006, -0.474), (2009, -0.201), (2013, -0.411)

Share_of_the_oil_exported_outside_of_ND = Volumes_of_oil_exported/Crude_oil_production__data

Total_Employed = sum(Employed[*])

Total_indicated_employment =
K&L__Construction.Indicated_labor+K&L__MNF.Indicated_labor+K&L__Mining.Indicated_labor+K&L__WT.Indicated_labor+K&L__AG.Indicated_labor+K&L__RFL.Indicated_labor+K&L__OS.Indicated_labor+K&L__Utilities.Indicated_labor

Total__Employment_data = GRAPH(TIME)
(1995, 282447), (1996, 289755), (1997, 296510), (1998, 301488), (1999, 306207), (2000, 309223), (2001, 311632), (2002, 311808), (2003, 314273), (2004, 321108), (2005, 328121), (2006, 335718), (2007, 341705), (2008, 350442), (2009, 349561), (2010, 358674), (2011, 379433), (2012, 411710), (2013, 427109), (2014, 444658)

Unemployment_data = GRAPH(TIME)
(1995, 11663), (1995, 11447), (1995, 11206), (1995, 10979), (1995, 10812), (1995, 10741), (1996, 10758), (1996, 10797), (1996, 10805), (1996, 10756), (1996, 10683), (1996, 10605), (1996, 10524), (1996, 10442), (1996, 10357), (1996, 10268), (1996, 10159), (1996, 10036), (1997, 9937), (1997, 9904), (1997, 9930), (1997, 9951), (1997, 9909), (1997, 9840), (1997, 9842), (1997, 9947), (1997, 10114), (1997, 10264), (1997, 10308), (1997, 10179), (1998, 9867), (1998, 9445), (1998, 9033), (1998, 8770), (1998, 8700), (1998, 8753), (1998, 8854), (1998, 8987), (1998, 9153), (1998, 9357), (1998, 9602), (1998, 9890), (1999, 10208), (1999, 10523), (1999, 10821), (1999, 11094), (1999, 11327), (1999, 11519), (1999, 11629), (1999, 11646), (1999, 11585), (1999, 11472), (1999, 11364)...

UR = Unemployed/LF

Utilities_Exports_data = GRAPH(TIME)
(1997, 459), (2001, 613), (2006, 1154), (2009, 1533), (2013, 2058)

Utilities_leakage_fraction = GRAPH(TIME)
(1997, 0.266), (2001, -0.965), (2005, -0.0122), (2009, -0.124), (2013, -0.295)

Utilities__employment = GRAPH(TIME)
(1995, 12926), (1996, 14015), (1997, 14785), (1998, 14738), (1999, 14825), (2000, 15376), (2001, 16418), (2002, 16105), (2003, 15089), (2004, 15381), (2005, 16184), (2006, 16496), (2007, 16920), (2008, 16971), (2009, 16225), (2010, 15598), (2011, 16687), (2012, 17614), (2013, 17821)

Utilities__imports_coefficients = GRAPH(TIME)
(1997, 0.15), (2001, 0.161), (2006, 0.152), (2009, 0.158), (2013, 0.212)

Volumes_of_oil_exported =
Mining_Exports_data*percentage_of_the__oil_exports_in_total_mining/(Oil_prices_WTI_data/1000000)

Wages[Agriculture] = K&L__AG.wages

Wages[Mining] = K&L__Mining.wages
Wages[Utilities] = K&L__Utilities.wages
Wages[Construction] = K&L__Construction.wages1
Wages[Manufacturing] = K&L__MNF.wages
Wages[Wholesale_and_Transportation] = K&L__WT.wages
Wages[Retail_Food_and_Lodging] = K&L__RFL.wages
Wages[Other_Services] = K&L__OS.wages
Wages_AG__data = GRAPH(TIME)
(1995, 17476), (1996, 18311), (1997, 18848), (1998, 20167), (1999, 20673), (2000, 22453), (2001, 23459), (2002, 25829), (2003, 25213), (2004, 27029), (2005, 27378), (2006, 27930), (2007, 29739), (2008, 31711), (2009, 34576), (2010, 35007), (2011, 36188), (2012, 39504), (2013, 39876)

Wages_Mnf__data = GRAPH(TIME)
(1995, 25210), (1996, 26685), (1997, 27552), (1998, 29147), (1999, 29909), (2000, 30641), (2001, 31562), (2002, 32450), (2003, 33990), (2004, 35845), (2005, 36246), (2006, 38143), (2007, 40050), (2008, 41551), (2009, 41477), (2010, 43421), (2011, 44801), (2012, 46729), (2013, 48134)

Wages_switch = 0
Wages_WT_data = GRAPH(TIME)
(1995, 25879), (1996, 26946), (1997, 28098), (1998, 29346), (1999, 30206), (2000, 31494), (2001, 32302), (2002, 33352), (2003, 34665), (2004, 36782), (2005, 38109), (2006, 39728), (2007, 41795), (2008, 45123), (2009, 45879), (2010, 48809), (2011, 54964), (2012, 61179), (2013, 62913)

Wages__construction_data = GRAPH(TIME)
(1995, 24903), (1996, 26580), (1997, 27303), (1998, 28717), (1999, 31299), (2000, 31257), (2001, 31903), (2002, 31951), (2003, 32622), (2004, 34273), (2005, 35641), (2006, 37831), (2007, 40430), (2008, 43928), (2009, 45397), (2010, 46616), (2011, 51224), (2012, 56410), (2013, 60207)

Wages__mining_data = GRAPH(TIME)
(1995, 37152), (1996, 37908), (1997, 40263), (1998, 41691), (1999, 44432), (2000, 45018), (2001, 48531), (2002, 49153), (2003, 50970), (2004, 52998), (2005, 57054), (2006, 64642), (2007, 70004), (2008, 74916), (2009, 73031), (2010, 79970), (2011, 89726), (2012, 96570), (2013, 98042)

Wages__OS_data = GRAPH(TIME)
(1995, 21853), (1996, 22503), (1997, 23314), (1998, 24199), (1999, 24877), (2000, 26096), (2001, 27347), (2002, 28423), (2003, 29600), (2004, 31010), (2005, 32090), (2006, 33485), (2007, 35380), (2008, 36948), (2009, 38186), (2010, 39788), (2011, 42046), (2012, 44445), (2013, 46186)

Wages__RFL_data = GRAPH(TIME)
(1995, 11743), (1996, 12119), (1997, 12719), (1998, 13184), (1999, 13570), (2000, 14029), (2001, 14592), (2002, 15044), (2003, 15464), (2004, 15816), (2005, 16177), (2006, 16655), (2007, 17400), (2008, 18297), (2009, 18611), (2010, 19453), (2011, 20724), (2012, 22396), (2013, 23331)

Wages__utilities_data = GRAPH(TIME)
(1995, 22266), (1996, 22163), (1997, 22265), (1998, 23548), (1999, 23583), (2000, 24396), (2001, 25211), (2002, 26411), (2003, 28415), (2004, 29878), (2005, 30601), (2006, 30758), (2007, 31985), (2008, 32962), (2009, 34923), (2010, 37514), (2011, 39584), (2012, 42035), (2013, 43261)

WT_employment = GRAPH(TIME)
(1995, 28141), (1996, 28544), (1997, 28745), (1998, 28871), (1999, 29042), (2000, 28682), (2001, 28827), (2002, 28557), (2003, 28594), (2004, 29126), (2005, 29645), (2006, 30169), (2007, 30681), (2008, 31978), (2009, 32356), (2010, 34009), (2011, 38771), (2012, 45995), (2013, 48534)

WT_exports_data = GRAPH(TIME)
(1997, 1686), (2001, 1126), (2006, 2018), (2009, 2284), (2013, 6181)

WT_impots_coefficients = GRAPH(TIME)
(1997, 0.16), (2001, 0.169), (2006, 0.151), (2009, 0.155), (2013, 0.141)

WT_leakage_fraction = GRAPH(TIME)
(1997, -0.126), (2001, -0.159), (2006, 0.0372), (2009, -0.0375), (2013, 0.267)

GSP_Industries[Agriculture] = SMTH1(
Gross_AD[Agriculture]*(1-Imports_coefficients[Agriculture]-SUM(IO_Coefficients[*, Agriculture])), Production_ATs, Initlal_GSP_1997[Agriculture])

GSP_Industries[Mining] = SMTH1(Gross_AD[Mining]*(1-Imports_coefficients[Mining]-SUM(IO_Coefficients[*, Mining])), Production_ATs, Initlal_GSP_1997[Mining])

GSP_Industries[Utilities] = SMTH1(Gross_AD[Utilities]*(1-Imports_coefficients[Utilities]-SUM(IO_Coefficients[*, Utilities])), Production_ATs, Initlal_GSP_1997[Utilities])

GSP_Industries[Construction] =
SMTH1(Gross_AD[Construction]*(1-Imports_coefficients[Construction]-SUM(IO_Coefficients[*, Construction])), Production_ATs, Initlal_GSP_1997[Construction])

GSP_Industries[Manufacturing] =
SMTH1(Gross_AD[Manufacturing]*(1-Imports_coefficients[Manufacturing]-SUM(IO_Coefficients[*, Manufacturing])), Production_ATs, Initlal_GSP_1997[Manufacturing])

GSP_Industries[Wholesale_and_Transportation] =
SMTH1(Gross_AD[Wholesale_and_Transportation]*(1-Imports_coefficients[Wholesale_and_Transportation]-SUM(IO_Coefficients[*, Wholesale_and_Transportation])), Production_ATs, Initlal_GSP_1997[Wholesale_and_Transportation])

GSP_Industries[Retail_Food_and_Lodging] =
SMTH1(Gross_AD[Retail_Food_and_Lodging]*(1-Imports_coefficients[Retail_Food_and_Lodging]-SUM(IO_Coefficients[*, Retail_Food_and_Lodging])), Production_ATs, Initlal_GSP_1997[Retail_Food_and_Lodging])

GSP_Industries[Other_Services] =
SMTH1(Gross_AD[Other_Services]*(1-Imports_coefficients[Other_Services]-SUM(IO_Coefficients[*, Other_Services])), Production_ATs, Initlal_GSP_1997[Other_Services])

Agriculture:

Agriculture__inventory(t) = Agriculture__inventory(t - dt) + (Production_rate + Imports_rate - sales_rate) * dt
INIT Agriculture__inventory = Initial_sales*Indicated_inventory__coverage

INFLOWS:

Production_rate = Actual_production

Imports_rate = .Imports_coefficients[Agriculture]*MIN(Indicated__production_rate, K&L__AG.Potential_output)

OUTFLOWS:

sales_rate = Min (Max_sales, SUM(Indicated_sales[*]))

Intermediate[Economic_Sectors](t) = Intermediate[Economic_Sectors](t - dt) + (Intermediate_additions[Economic_Sectors] - Intermediate__input_rate[Economic_Sectors]) * dt
INIT Intermediate[Economic_Sectors] = Indicated__intermediates__rate*Indicated__intermediate_coverage

INFLOWS:

- Intermediate_additions[Agriculture] = Sales_to_Ag[Agriculture]
- Intermediate_additions[Mining] = Sales_to_Ag[Mining]
- Intermediate_additions[Utilities] = Sales_to_Ag[Utilities]
- Intermediate_additions[Construction] = Sales_to_Ag[Construction]
- Intermediate_additions[Manufacturing] = Sales_to_Ag[Manufacturing]
- Intermediate_additions[Wholesale_and_Transportation] =
- Intermediate_additions[Retail_Food_and_Lodging] = Sales_to_Ag[Retail_Food_and_Lodging]
- Intermediate_additions[Other_Services] = Sales_to_Ag[Other_Services]

OUTFLOWS:

- Intermediate__input_rate[Agriculture] = MIN(Max_input_rate[Agriculture], Indicated__intermediates__rate[Agriculture])
- Intermediate__input_rate[Mining] = MIN(Max_input_rate[Mining],
- Intermediate__input_rate[Utilities] = MIN(Max_input_rate[Utilities], Indicated__intermediates__rate[Utilities])
- Intermediate__input_rate[Construction] = MIN(Max_input_rate[Construction], Indicated__intermediates__rate[Construction])
- Intermediate__input_rate[Manufacturing] = MIN(Max_input_rate[Manufacturing], Indicated__intermediates__rate[Manufacturing])
- Intermediate__input_rate[Wholesale_and_Transportation] = MIN(Max_input_rate[Wholesale_and_Transportation], Indicated__intermediates__rate[Wholesale_and_Transportation])
- Intermediate__input_rate[Retail_Food_and_Lodging] = MIN(Indicated__intermediates__rate[Retail_Food_and_Lodging], Max_input_rate[Retail_Food_and_Lodging])
- Intermediate__input_rate[Other_Services] = MIN(Max_input_rate[Other_Services], Indicated__intermediates__rate[Other_Services])

Actual_production = (Intermediate__input_capacity)*
AG_coefficients[Economic_Sectors] = .IO_Coefficients[Economic_Sectors, Agriculture]
AG_sales_to_AG = sales_rate*(Indicated_sales[Agriculture]/SUM(Indicated_sales[*]))
AG_sales_to_Construction = sales_rate*(Indicated_sales[Construction]/SUM(Indicated_sales[*]))
AG_sales_to_Mining = sales_rate*(Indicated_sales[Mining]/SUM(Indicated_sales))
AG_sales_to_MNF = sales_rate*(Indicated_sales[Manufacturing]/SUM(Indicated_sales[*]))
AG_sales_to_OS = sales_rate*(Indicated_sales[Other_Services]/SUM(Indicated_sales[*]))
AG_sales_to_RFL = sales_rate*(Indicated_sales[Retail_Food_and_Lodging]/SUM(Indicated_sales[*]))
AG_sales_to_Utilities = sales_rate*(Indicated_sales[Utilities]/SUM(Indicated_sales[*]))
AG_sales_to_WT = sales_rate*(Indicated_sales[Wholesale_and_Transporation]/SUM(Indicated_sales[*]))
final_sales = (.Gross_AD[Agriculture]-SUM(Intermediate_sales[*]))
Indicated_input__order_rate[Economic_Sectors] = Indicated__intermediates__rate+(Indicated__intermediates__rate*Indicated__intermediate_coverage-Intermediate)/Intermediate_at

Indicated_inventory__coverage = 4/12

- Indicated_orders__from_AG_to_AG = Indicated_input__order_rate[Agriculture]
- Indicated_sales[Agriculture] = Intermediate_sales[Agriculture]
- Indicated_sales[Mining] = Intermediate_sales[Mining]
- Indicated_sales[Utilities] = Intermediate_sales[Utilities]
- Indicated_sales[Construction] = Intermediate_sales[Construction]
- Indicated_sales[Manufacturing] = Intermediate_sales[Manufacturing]
- Indicated_sales[Wholesale_and_Transporation] = Intermediate_sales[Wholesale_and_Transportation]
- Indicated_sales[Retail_Food_and_Lodging] = Intermediate_sales[Retail_Food_and_Lodging]
- Indicated_sales[Other_Services] = Intermediate_sales[Other_Services]
- Indicated_sales[Final_Consumption] = final_sales
- Indicated__intermediates__rate[Economic_Sectors] = Min (Indicated__production_rate, K&L__AG.Potential_output)*AG_coefficients
- Indicated__intermediate_coverage = 1/12
- Indicated__production_rate = expected_order_rate+(expected_order_rate*Indicated_inventory__coverage-Agriculture__inventory)/inventor
- Initial_intermediate_sales = 4148.051272
- Initial_production = 4014.017398 {1997}
- Initial_sales = 7427.91286
- Intermediate_at = 1
- Intermediate_sales[Agriculture] = Indicated_orders__from_AG_to_AG
- Intermediate_sales[Mining] = Mining.Indicated_input__order_rate[Agriculture]
- Intermediate_sales[Utilities] = Utilities.Indicated_input__order_rate[Agriculture]
- Intermediate_sales[Construction] = Construction.Indicated_input__order_rate[Agriculture]
- Intermediate_sales[Manufacturing] = Manufacturing.Indicated_input__order_rate[Agriculture]
- Intermediate_sales[Wholesale_and_Transportation] = Wholesale_and_Transportation.Indicated_input__order_rate[Agriculture]
- Intermediate_sales[Retail_Food_and_Lodging] =
- Intermediate_sales[Other_Services] = Other_Services.Indicated_input__order_rate[Agriculture]
- Intermediate__input_capacity = SMTH1(MIN(Min_AMUC, Min_MWRO), 1, 1)
- inventory_AT = 1
- Max_input_rate[Agriculture] = Intermediate[Agriculture]/Min_time__for_input
- Max_input_rate[Mining] = Intermediate[Mining]/Min_time__for_input
- Max_input_rate[Utilities] = Intermediate[Utilities]/Min_time__for_input
- Max_input_rate[Construction] = Intermediate[Construction]/Min_time__for_input
- Max_input_rate[Manufacturing] = Intermediate[Manufacturing]/Min_time__for_input
- Max_input_rate[Wholesale_and_Transportation] =
- Max_input_rate[Retail_Food_and_Lodging] = Intermediate[Retail_Food_and_Lodging]/Min_time__for_input
- Max_input_rate[Other_Services] = Intermediate[Other_Services]/Min_time__for_input
- Max_sales = if Agriculture__inventory< 0 then 0 ELSE Agriculture__inventory/Min_time__sales
- Min_AG_and_Mining = MIN(Possible_Fraction_of_intermediates[Agriculture], Possible_Fraction_of_intermediates[Mining])
- Min_AMUC = MIN(min_AG_and_Mining, Min_Utilities_and_Construction)
- Min_MNF_and_WT = MIN(Possible_Fraction_of_intermediates[Manufacturing], Possible_Fraction_of_intermediates[Wholesale_and_Transportation])

◯ Min_MWRO = MIN(Min_MNF_and_WT, Min_RFL_and_OS)

◯ Min_RFL_and_OS = MIN(Possible_Fraction_of_intermediates[Retail_Food_and_Lodging], Possible_Fraction_of_intermediates[Other_Services])

◯ Min_time__for_input = 1/12

◯ Min_time__sales = 1/52

◯ Min_Utilities_and_Construction = MIN(Possible_Fraction_of_intermediates[Utilities], Possible_Fraction_of_intermediates[Construction])

◯ perception_time = 0.25

◯ Possible_Fraction_of_intermediates[Economic_Sectors] = smth1 (if Indicated__intermediates__rate=0 then 0 else Intermediate__input_rate/Indicated__intermediates__rate, 1/12, 1)

◯ Sales_to_Ag[Agriculture] = AG_sales_to_AG

◯ Sales_to_Ag[Mining] = Mining.Mining_sales_to_AG

◯ Sales_to_Ag[Utilities] = Utilities.Utililties_sales_to_AG

◯ Sales_to_Ag[Construction] = Construction.Construction__sales_to_AG

◯ Sales_to_Ag[Manufacturing] = Manufacturing.MNF_sales_to_AG

◯ Sales_to_Ag[Wholesale_and_Transportation] = Wholesale_and_Transportation.WT_sales_to_AG

◯ Sales_to_Ag[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.RFL_sales_to_AG

◯ Sales_to_Ag[Other_Services] = Other_Services.OS_sales_to_AG

◯ Total_indicated_sales = SUM(Indicated_sales[*])

◯ expected_order_rate = SMTH1(SUM(Indicated_sales[*]), perception_time,{initial sales}7427.91286)

Construction:

☐ Construction__inventory(t) = Construction__inventory(t - dt) + (production_rate + imports_rate - sales_rate) * dt
INIT Construction__inventory = Initial_sales*Indicated_invent

INFLOWS:

- production_rate = Actual_production
- imports_rate = .Imports_coefficients[Construction]*min(Indicated__production_rate, K&L__Construction.Potential_output)

OUTFLOWS:

- sales_rate = MIN(Max_sales, SUM(Indicated_sales[*]))

☐ Intermediate[Economic_Sectors](t) = Intermediate[Economic_Sectors](t - dt) + (Intermediate_additions[Economic_Sectors] - Intermediate__input_rate[Economic_Sectors]) * dt
INIT Intermediate[Economic_Sectors] = Indicated__intermediates__rate*Indicated__intermediate_coverage

INFLOWS:

- Intermediate_additions[Agriculture] = Sales_to_Construction[Agriculture]
- Intermediate_additions[Mining] = Sales_to_Construction[Mining]
- Intermediate_additions[Utilities] = Sales_to_Construction[Utilities]
- Intermediate_additions[Construction] = Sales_to_Construction[Construction]
- Intermediate_additions[Manufacturing] = Sales_to_Construction[Manufacturing]
- Intermediate_additions[Wholesale_and_Transportation] = Sales_to_Construction[Wholesale_and_Transportation]
- Intermediate_additions[Retail_Food_and_Lodging] =
- Intermediate_additions[Other_Services] = Sales_to_Construction[Other_Services]

OUTFLOWS:

- Intermediate__input_rate[Agriculture] = MIN(Max_input_rate[Agriculture], Indicated__intermediates__rate[Agriculture])
- Intermediate__input_rate[Mining] = MIN(Max_input_rate[Mining],
- Intermediate__input_rate[Utilities] = MIN(Max_input_rate[Utilities], Indicated__intermediates__rate[Utilities])
- Intermediate__input_rate[Construction] = MIN(Max_input_rate[Construction], Indicated__intermediates__rate[Construction])
- Intermediate__input_rate[Manufacturing] = MIN(Max_input_rate[Manufacturing], Indicated__intermediates__rate[Manufacturing])
- Intermediate__input_rate[Wholesale_and_Transportation] = MIN(Max_input_rate[Wholesale_and_Transportation], Indicated__intermediates__rate[Wholesale_and_Transportation])
- Intermediate__input_rate[Retail_Food_and_Lodging] = MIN(Indicated__intermediates__rate[Retail_Food_and_Lodging], Max_input_rate[Retail_Food_and_Lodging])
- Intermediate__input_rate[Other_Services] = MIN(Max_input_rate[Other_Services], Indicated__intermediates__rate[Other_Services])

- Actual_production = (Intermediate__input_capacity)*MIN(K&L__Construction.Potential_output, Indicated__production_rate)
- Construciton_coefficients[Economic_Sectors] = .IO_Coefficients[Economic_Sectors, Construction]
- Construction_sales_to_Construction = sales_rate*(Indicated_sales[Construction]/SUM(Indicated_sales[*]))
- Construction_sales_to_Mining = sales_rate*(Indicated_sales[Mining]/SUM(Indicated_sales))
- Construction_sales_to_MNF = sales_rate*(Indicated_sales[Manufacturing]/SUM(Indicated_sales[*]))
- Construction_sales_to_RFL =
- Construction__sales_to_AG = sales_rate*(Indicated_sales[Agriculture]/SUM(Indicated_sales[*]))
- Construction__sales_to_OS = sales_rate*(Indicated_sales[Other_Services]/SUM(Indicated_sales[*]))
- Construction__sales_to_Utilities = sales_rate*(Indicated_sales[Utilities]/SUM(Indicated_sales[*]))
- Construction__sales_to_WT =
- final_sales = .Gross_AD[Construction]-SUM(Intermediate_sales[*])
- Indicated_input__order_rate[Economic_Sectors] = Indicated__intermediates__rate+(Indicated__intermediates__rate*Indicated__intermediate_coverage-Intermediate)/Intermediate_at
- Indicated_inventory__coverage = 1/12
- Indicated_orders__for__Construction_to_construction = Indicated_input__order_rate[Construction]
- Indicated_sales[Agriculture] = Intermediate_sales[Agriculture]
- Indicated_sales[Mining] = Intermediate_sales[Mining]
- Indicated_sales[Utilities] = Intermediate_sales[Utilities]
- Indicated_sales[Construction] = Intermediate_sales[Construction]
- Indicated_sales[Manufacturing] = Intermediate_sales[Manufacturing]
- Indicated_sales[Wholesale_and_Transporation] = Intermediate_sales[Wholesale_and_Transportation]
- Indicated_sales[Retail_Food_and_Lodging] = Intermediate_sales[Retail_Food_and_Lodging]
- Indicated_sales[Other_Services] = Intermediate_sales[Other_Services]
- Indicated_sales[Final_Consumption] = final_sales
- Indicated__intermediates__rate[Economic_Sectors] = MIN (Indicated__production_rate, K&L__Construction.Potential_output)*Construciton_coefficients

- Indicated__intermediate_coverage = 1/12
- Indicated__production_rate = expected_order_rate+(expected_order_rate*Indicated_inventory__coverage-Construction__inventory)/invent
- Initial_intermediate_sales = 4148.051272
- Initial_sales = 2337.511167
- Intermediate_at = 1
- Intermediate_sales[Agriculture] = Agriculture.Indicated_input__order_rate[Construction]
- Intermediate_sales[Mining] = Mining.Indicated_input__order_rate[Construction]
- Intermediate_sales[Utilities] = Utilities.Indicated_input__order_rate[Construction]
- Intermediate_sales[Construction] = Indicated_orders__for__Construction_to_construction
- Intermediate_sales[Manufacturing] = Manufacturing.Indicated_input__order_rate[Construction]
- Intermediate_sales[Wholesale_and_Transportation] = Wholesale_and_Transportation.Indicated_input__order_rate[Construction]
- Intermediate_sales[Retail_Food_and_Lodging] =
- Intermediate_sales[Other_Services] = Other_Services.Indicated_input__order_rate[Construction]
- Intermediate__input_capacity = SMTH1(MIN(Min_AMUC, Min_MWRO), 1, 1)
- inventory_AT = 1/12
- Max_input_rate[Economic_Sectors] = Intermediate/Min_time__for_input
- Max_sales = Construction__inventory/Min_time__sales
- Min_AG_and_Mining = MIN(Possible_Fraction_of_intermediates[Agriculture], Possible_Fraction_of_intermediates[Mining])
- Min_AMUC = MIN(min_AG_and_Mining, Min_Utilities_and_Construction)
- Min_MNF_and_WT = MIN(Possible_Fraction_of_intermediates[Manufacturing], Possible_Fraction_of_intermediates[Wholesale_and_Transportation])
- Min_MWRO = MIN(Min_MNF_and_WT, Min_RFL_and_OS)
- Min_RFL_and_OS = MIN(Possible_Fraction_of_intermediates[Retail_Food_and_Lodging], Possible_Fraction_of_intermediates[Other_Services])
- Min_time__for_input = 1/52
- Min_time__sales = 1/52
- Min_Utilities_and_Construction = MIN(Possible_Fraction_of_intermediates[Utilities], Possible_Fraction_of_intermediates[Construction])
- Possible_Fraction_of_intermediates[Economic_Sectors] = smth1 (if Indicated__intermediates__rate=0 then 0 else Intermediate__input_rate/Indicated__intermediates__rate, 1/12, 1)
- Sales_to_Construction[Agriculture] = Agriculture.AG_sales_to_Construction
- Sales_to_Construction[Mining] = Mining.Mining_sales_to_Construction
- Sales_to_Construction[Utilities] = Utilities.Utilities_sales_to_Construction
- Sales_to_Construction[Construction] = Construction_sales_to_Construction
- Sales_to_Construction[Manufacturing] = Manufacturing.MNF_sales_to_Construction
- Sales_to_Construction[Wholesale_and_Transportation] =
- Sales_to_Construction[Retail_Food_and_Lodging] =
- Sales_to_Construction[Other_Services] = Other_Services.OS_sales_to_Construction
- expected_order_rate = SMTH1(SUM(Indicated_sales[*]), 0.5,2337.511167)

Manufacturing:

Intermediate[Economic_Sectors](t) = Intermediate[Economic_Sectors](t - dt) + (Intermediate_additions[Economic_Sectors] - Intermediate__input_rate[Economic_Sectors]) * dt
INIT Intermediate[Economic_Sectors] = Indicated__intermediates__rate*Indicated__intermediate_coverage

INFLOWS:

- Intermediate_additions[Agriculture] = Sales_to_MNF[Agriculture]
- Intermediate_additions[Mining] = Sales_to_MNF[Mining]
- Intermediate_additions[Utilities] = Sales_to_MNF[Utilities]
- Intermediate_additions[Construction] = Sales_to_MNF[Construction]
- Intermediate_additions[Manufacturing] = Sales_to_MNF[Manufacturing]
- Intermediate_additions[Wholesale_and_Transportation] =
- Intermediate_additions[Retail_Food_and_Lodging] = Sales_to_MNF[Retail_Food_and_Lodging]
- Intermediate_additions[Other_Services] = Sales_to_MNF[Other_Services]

OUTFLOWS:

- Intermediate__input_rate[Agriculture] = MIN(Indicated__intermediates__rate[Agriculture], Max_input_rate[Agriculture])
- Intermediate__input_rate[Mining] = MIN(Indicated__intermediates__rate[Mining],
- Intermediate__input_rate[Utilities] = MIN(Indicated__intermediates__rate[Utilities], Max_input_rate[Utilities])
- Intermediate__input_rate[Construction] = MIN(Indicated__intermediates__rate[Construction], Max_input_rate[Construction])
- Intermediate__input_rate[Manufacturing] = MIN(Indicated__intermediates__rate[Manufacturing], Max_input_rate[Manufacturing])
- Intermediate__input_rate[Wholesale_and_Transportation] = MIN(Indicated__intermediates__rate[Wholesale_and_Transportation], Max_input_rate[Wholesale_and_Transportation])
- Intermediate__input_rate[Retail_Food_and_Lodging] = MIN(Indicated__intermediates__rate[Retail_Food_and_Lodging],
- Intermediate__input_rate[Other_Services] = MIN(Indicated__intermediates__rate[Other_Services], Max_input_rate[Other_Services])

Manufacturing__inventory(t) = Manufacturing__inventory(t - dt) + (production_rate + Imports_rate - sales_rate) * dt

INFLOWS:

- production_rate = Actual_production
- Imports_rate = .Imports_coefficients[Manufacturing]*MIN(Indicated__production_rate, K&L__MNF.Potential_output)

OUTFLOWS:

- sales_rate = MIN(Max_sales, SUM(Indicated_sales[*]))

Actual_production = (Intermediate__input_capacity)*MIN(K&L__MNF.Potential_output, Indicated__production_rate)

final_sales = .Gross_AD[Manufacturing]-SUM(Intermediate_sales[*])

Indicated_input__order_rate[Economic_Sectors] = Indicated__intermediates__rate+(Indicated__intermediates__rate*Indicated__intermediate_coverage-Intermediate)/Intermediate_at

Indicated_inventory__coverage = 1/12

- Indicated_orders__from_MNF_to_MNF = Indicated_input__order_rate[Manufacturing]
- Indicated_sales[Agriculture] = Intermediate_sales[Agriculture]
- Indicated_sales[Mining] = Intermediate_sales[Mining]
- Indicated_sales[Utilities] = Intermediate_sales[Utilities]
- Indicated_sales[Construction] = Intermediate_sales[Construction]
- Indicated_sales[Manufacturing] = Intermediate_sales[Manufacturing]
- Indicated_sales[Wholesale_and_Transporation] = Intermediate_sales[Wholesale_and_Transportation]
- Indicated_sales[Retail_Food_and_Lodging] = Intermediate_sales[Retail_Food_and_Lodging]
- Indicated_sales[Other_Services] = Intermediate_sales[Other_Services]
- Indicated_sales[Final_Consumption] = final_sales
- Indicated__intermediates__rate[Economic_Sectors] = MIN (Indicated__production_rate, K&L__MNF.Potential_output)*Mnf_coefficients
- Indicated__intermediate_coverage = 1/12
- Indicated__production_rate = expected_order_rate+(expected_order_rate*Indicated_inventory__coverage-Manufacturing__inventory)/inve
- Initial_intermediate_sales = 4148.051272
- Initial_sales = 4992.87
- Intermediate_at = 1
- Intermediate_sales[Agriculture] = Agriculture.Indicated_input__order_rate[Manufacturing]
- Intermediate_sales[Mining] = Mining.Indicated_input__order_rate[Manufacturing]
- Intermediate_sales[Utilities] = Utilities.Indicated_input__order_rate[Manufacturing]
- Intermediate_sales[Construction] = Construction.Indicated_input__order_rate[Manufacturing]
- Intermediate_sales[Manufacturing] = Indicated_orders__from_MNF_to_MNF
- Intermediate_sales[Wholesale_and_Transportation] = Wholesale_and_Transportation.Indicated_input__order_rate[Manufacturing]
- Intermediate_sales[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.Indicated_input__order_rate[Manufacturing]
- Intermediate_sales[Other_Services] = Other_Services.Indicated_input__order_rate[Manufacturing]
- Intermediate__input_capacity = SMTH1(MIN(Min_AMUC, Min_MWRO), 1, 1)
- inventory_AT = 1/12
- Max_input_rate[Economic_Sectors] = Intermediate/Min_time__for_input
- Max_sales = Manufacturing__inventory/Min_time__sales
- Min_AG_and_Mining = MIN(Possible_Fraction_of_intermediates[Agriculture], Possible_Fraction_of_intermediates[Mining])
- Min_AMUC = MIN(min_AG_and_Mining, Min_Utilities_and_Construction)
- Min_MNF_and_WT = MIN(Possible_Fraction_of_intermediates[Manufacturing], Possible_Fraction_of_intermediates[Wholesale_and_Transportation])
- Min_MWRO = MIN(Min_MNF_and_WT, Min_RFL_and_OS)
- Min_RFL_and_OS = MIN(Possible_Fraction_of_intermediates[Retail_Food_and_Lodging], Possible_Fraction_of_intermediates[Other_Services])
- Min_time__for_input = 1/52
- Min_time__sales = 1/52
- Min_Utilities_and_Construction = MIN(Possible_Fraction_of_intermediates[Utilities], Possible_Fraction_of_intermediates[Construction])

- MNFsales_to_Utilities = sales_rate*(Indicated_sales[Utilities]/SUM(Indicated_sales[*]))
- Mnf_coefficients[Economic_Sectors] = .IO_Coefficients[Economic_Sectors, Manufacturing]
- MNF_sales_to_AG = sales_rate*(Indicated_sales[Agriculture]/SUM(Indicated_sales[*]))
- MNF_sales_to_Construction = sales_rate*(Indicated_sales[Construction]/SUM(Indicated_sales[*]))
- MNF_sales_to_Mining = sales_rate*(Indicated_sales[Mining]/SUM(Indicated_sales))
- MNF_sales_to_MNF = sales_rate*(Indicated_sales[Manufacturing]/SUM(Indicated_sales[*]))
- MNF_sales_to_OS = sales_rate*(Indicated_sales[Other_Services]/SUM(Indicated_sales[*]))
- MNF_sales_to_RFL = sales_rate*(Indicated_sales[Retail_Food_and_Lodging]/SUM(Indicated_sales[*]))
- MNF_sales_to_WT = sales_rate*(Indicated_sales[Wholesale_and_Transporation]/SUM(Indicated_sales[*]))
- Possible_Fraction_of_intermediates[Economic_Sectors] = smth1 (if Indicated__intermediates__rate=0 then 0 else Intermediate__input_rate/Indicated__intermediates__rate, 1/12, 1)
- Sales_to_MNF[Agriculture] = Agriculture.AG_sales_to_MNF
- Sales_to_MNF[Mining] = Mining.Mining_sales_to_MNF
- Sales_to_MNF[Utilities] = Utilities.Utilities_sales_to_MNF
- Sales_to_MNF[Construction] = Construction.Construction_sales_to_MNF
- Sales_to_MNF[Manufacturing] = MNF_sales_to_MNF
- Sales_to_MNF[Wholesale_and_Transportation] = Wholesale_and_Transportation.WT_sales_to_MNF
- Sales_to_MNF[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.RFL_sales_to_MNF
- Sales_to_MNF[Other_Services] = Other_Services.OS_sales_to_MNF
- expected_order_rate = SMTH1(SUM(Indicated_sales[*]), 0.5, 4992.87)

Mining:

Mining__inventory(t) = Mining__inventory(t - dt) + (production_rate + imports_rate - sales_rate) * dt
INIT Mining__inventory = Initial_sales*Indicated_inventory__coverage

INFLOWS:

- production_rate = Actual_production
- imports_rate = .Imports_coefficients[Mining]*MIN(Indicated__production_rate, K&L__Mining.Potential_output)

OUTFLOWS:

- sales_rate = MIN(Max_sales, SUM(Indicated_sales[*]))

Intermediate[Economic_Sectors](t) = Intermediate[Economic_Sectors](t - dt) + (Intermediate_additions[Economic_Sectors] - Intermediate__input_rate[Economic_Sectors]) * dt
INIT Intermediate[Economic_Sectors] = Indicated__intermediates__rate*Indicated__intermediate_coverage

INFLOWS:

- Intermediate_additions[Agriculture] = Sales_to_Mining[Agriculture]
- Intermediate_additions[Mining] = Sales_to_Mining[Mining]
- Intermediate_additions[Utilities] = Sales_to_Mining[Utilities]
- Intermediate_additions[Construction] = Sales_to_Mining[Construction]
- Intermediate_additions[Manufacturing] = Sales_to_Mining[Manufacturing]
- Intermediate_additions[Wholesale_and_Transportation] = Sales_to_Mining[Wholesale_and_Transportation]
- Intermediate_additions[Retail_Food_and_Lodging] = Sales_to_Mining[Retail_Food_and_Lodging]
- Intermediate_additions[Other_Services] = Sales_to_Mining[Other_Services]

OUTFLOWS:

- Intermediate__input_rate[Agriculture] = MIN(Max_input_rate[Agriculture], Indicated__intermediates__rate[Agriculture])
- Intermediate__input_rate[Mining] = MIN(Max_input_rate[Mining], Indicated__intermediates__rate[Mining])
- Intermediate__input_rate[Utilities] = MIN(Max_input_rate[Utilities], Indicated__intermediates__rate[Utilities])
- Intermediate__input_rate[Construction] = MIN(Max_input_rate[Construction], Indicated__intermediates__rate[Construction])
- Intermediate__input_rate[Manufacturing] = MIN(Max_input_rate[Manufacturing], Indicated__intermediates__rate[Manufacturing])
- Intermediate__input_rate[Wholesale_and_Transportation] = MIN(Max_input_rate[Wholesale_and_Transportation], Indicated__intermediates__rate[Wholesale_and_Transportation])
- Intermediate__input_rate[Retail_Food_and_Lodging] = MIN(Max_input_rate[Retail_Food_and_Lodging], Indicated__intermediates__rate[Retail_Food_and_Lodging])
- Intermediate__input_rate[Other_Services] = MIN(Max_input_rate[Other_Services], Indicated__intermediates__rate[Other_Services])

- Actual_production = (Intermediate__input_capacity)*MIN(K&L__Mining.Potential_output, Indicated__production_rate)
- final_sales = .Gross_AD[Mining]-SUM(Intermediate_sales[*])
- Indicated_input__order_rate[Economic_Sectors] = Indicated__intermediates__rate+(Indicated__intermediates__rate*Indicated__intermediate_coverage-Intermediate)/Intermediate_at
- Indicated_inventory__coverage = 1/12
- Indicated_orders__from_Mining_to_Mining = Indicated_input__order_rate[Mining]
- Indicated_sales[Agriculture] = Intermediate_sales[Agriculture]
- Indicated_sales[Mining] = Intermediate_sales[Mining]
- Indicated_sales[Utilities] = Intermediate_sales[Utilities]
- Indicated_sales[Construction] = Intermediate_sales[Construction]
- Indicated_sales[Manufacturing] = Intermediate_sales[Manufacturing]
- Indicated_sales[Wholesale_and_Transporation] = Intermediate_sales[Wholesale_and_Transportation]
- Indicated_sales[Retail_Food_and_Lodging] = Intermediate_sales[Retail_Food_and_Lodging]
- Indicated_sales[Other_Services] = Intermediate_sales[Other_Services]
- Indicated_sales[Final_Consumption] = final_sales
- Indicated__intermediates__rate[Economic_Sectors] = MIN (K&L__Mining.Potential_output, Indicated__production_rate)*Mining_coefficients
- Indicated__intermediate_coverage = 1/12
- Indicated__production_rate = expected_order_rate+(expected_order_rate*Indicated_inventory__coverage-Mining__inventory)/inventory_AT
- Initial_intermediate_sales = 4148.051272
- Initial_sales = 529.0664299
- Intermediate_at = 1
- Intermediate_sales[Agriculture] = Agriculture.Indicated_input__order_rate[Mining]
- Intermediate_sales[Mining] = Indicated_orders__from_Mining_to_Mining
- Intermediate_sales[Utilities] = Utilities.Indicated_input__order_rate[Mining]

- Intermediate_sales[Construction] = Construction.Indicated_input__order_rate[Mining]
- Intermediate_sales[Manufacturing] = Manufacturing.Indicated_input__order_rate[Mining]
- Intermediate_sales[Wholesale_and_Transportation] = Wholesale_and_Transportation.Indicated_input__order_rate[Mining]
- Intermediate_sales[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.Indicated_input__order_rate[Mining]
- Intermediate_sales[Other_Services] = Other_Services.Indicated_input__order_rate[Mining]
- Intermediate__input_capacity = SMTH1(MIN(Min_AMUC, Min_MWRO), 1, 1)
- inventory_AT = 1/12
- Max_input_rate[Economic_Sectors] = Intermediate/Min_time__for_input
- Max_sales = Mining__inventory/Min_time__sales
- Mining_coefficients[Economic_Sectors] = .IO_Coefficients[Economic_Sectors, Mining]
- Mining_sales_to_AG = sales_rate*(Indicated_sales[Agriculture]/SUM(Indicated_sales[*]))
- Mining_sales_to_Construction = sales_rate*(Indicated_sales[Construction]/SUM(Indicated_sales[*]))
- Mining_sales_to_Mining = sales_rate*(Indicated_sales[Mining]/SUM(Indicated_sales))
- Mining_sales_to_MNF = sales_rate*(Indicated_sales[Manufacturing]/SUM(Indicated_sales[*]))
- Mining_sales_to_OS = sales_rate*(Indicated_sales[Other_Services]/SUM(Indicated_sales[*]))
- Mining_sales_to_RFL = sales_rate*(Indicated_sales[Retail_Food_and_Lodging]/SUM(Indicated_sales[*]))
- Mining_sales_to_WT = sales_rate*(Indicated_sales[Wholesale_and_Transporation]/SUM(Indicated_sales[*]))
- Mining__sales_to_Utilities = sales_rate*(Indicated_sales[Utilities]/SUM(Indicated_sales[*]))
- Min_AG_and_Mining = MIN(Possible_Fraction_of_intermediates[Agriculture], Possible_Fraction_of_intermediates[Mining])
- Min_AMUC = MIN(min_AG_and_Mining, Min_Utilities_and_Construction)
- Min_MNF_and_WT = MIN(Possible_Fraction_of_intermediates[Manufacturing], Possible_Fraction_of_intermediates[Wholesale_and_Transportation])
- Min_MWRO = MIN(Min_MNF_and_WT, Min_RFL_and_OS)
- Min_RFL_and_OS = MIN(Possible_Fraction_of_intermediates[Retail_Food_and_Lodging], Possible_Fraction_of_intermediates[Other_Services])
- Min_time__for_input = 1/52
- Min_time__sales = 1/52
- Min_Utilities_and_Construction = MIN(Possible_Fraction_of_intermediates[Utilities], Possible_Fraction_of_intermediates[Construction])
- Possible_Fraction_of_intermediates[Agriculture] = 1
- Possible_Fraction_of_intermediates[Mining] = SMTH1(if Indicated__intermediates__rate[Mining]=0 then 0 else Intermediate__input_rate[Mining]/Indicated__intermediates__rate[Mining], 1/12, 1)
- Possible_Fraction_of_intermediates[Utilities] = SMTH1(if Indicated__intermediates__rate[Utilities]=0 then 0 else Intermediate__input_rate[Utilities]/Indicated__intermediates__rate[Utilities], 1/12, 1)
- Possible_Fraction_of_intermediates[Construction] = SMTH1(if Indicated__intermediates__rate[Utilities]=0 then 0 else Intermediate__input_rate[Construction]/Indicated__intermediates__rate[Construction], 1/12, 1)
- Possible_Fraction_of_intermediates[Manufacturing] = SMTH1(if Indicated__intermediates__rate[Manufacturing]=0 then 0 else Intermediate__input_rate[Manufacturing]/Indicated__intermediates__rate[Manufacturing], 1/12, 1)
- Possible_Fraction_of_intermediates[Wholesale_and_Transportation] = SMTH1(if Indicated__intermediates__rate[Wholesale_and_Transportation]=0 then 0 else Intermediate__input_rate[Wholesale_and_Transportation]/Indicated__intermediates__rate[Wholesale_and_Transportatio n], 1/12, 1)

- Possible_Fraction_of_intermediates[Retail_Food_and_Lodging] = SMTH1(if Indicated__intermediates__rate[Retail_Food_and_Lodging]=0 then 0 else Intermediate__input_rate[Retail_Food_and_Lodging]/Indicated__intermediates__rate[Retail_Food_and_Lodging], 1/12, 1)
- Possible_Fraction_of_intermediates[Other_Services] = SMTH1(if Indicated__intermediates__rate[Other_Services]=0 then 0 else Intermediate__input_rate[Other_Services]/Indicated__intermediates__rate[Other_Services], 1/112, 1)
- Sales_to_Mining[Agriculture] = Agriculture.AG_sales_to_Mining
- Sales_to_Mining[Mining] = Mining_sales_to_Mining
- Sales_to_Mining[Utilities] = Utilities.Utilities_sales_to_Mining
- Sales_to_Mining[Construction] = Construction.Construction_sales_to_Mining
- Sales_to_Mining[Manufacturing] = Manufacturing.MNF_sales_to_Mining
- Sales_to_Mining[Wholesale_and_Transportation] = Wholesale_and_Transportation.WT_sales_to_Mining
- Sales_to_Mining[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.RFL_sales_to_Mining
- Sales_to_Mining[Other_Services] = Other_Services.OS_sales_to_Mining
- Total_indicated_sales = SUM(Indicated_sales[*])
- expected_order_rate = SMTH1(SUM(Indicated_sales[*]), 0.5, 529.07)

Other Services:

Intermediate[Economic_Sectors](t) = Intermediate[Economic_Sectors](t - dt) + (Intermediate_additions[Economic_Sectors] - Intermediate__input_rate[Economic_Sectors]) * dt
INIT Intermediate[Economic_Sectors] = Indicated__intermediates__rate*Indicated__intermediate_coverage

INFLOWS:

- Intermediate_additions[Agriculture] = Sales_to_OS[Agriculture]
- Intermediate_additions[Mining] = Sales_to_OS[Mining]
- Intermediate_additions[Utilities] = Sales_to_OS[Utilities]
- Intermediate_additions[Construction] = Sales_to_OS[Construction]
- Intermediate_additions[Manufacturing] = Sales_to_OS[Manufacturing]
- Intermediate_additions[Wholesale_and_Transportation] =
- Intermediate_additions[Retail_Food_and_Lodging] = Sales_to_OS[Retail_Food_and_Lodging]
- Intermediate_additions[Other_Services] = Sales_to_OS[Other_Services]

OUTFLOWS:

- Intermediate__input_rate[Agriculture] = MIN(Indicated__intermediates__rate[Agriculture], Max_input_rate[Agriculture])
- Intermediate__input_rate[Mining] = MIN(Indicated__intermediates__rate[Mining],
- Intermediate__input_rate[Utilities] = MIN(Indicated__intermediates__rate[Utilities], Max_input_rate[Utilities])
- Intermediate__input_rate[Construction] = MIN(Indicated__intermediates__rate[Construction], Max_input_rate[Construction])
- Intermediate__input_rate[Manufacturing] = MIN(Indicated__intermediates__rate[Manufacturing], Max_input_rate[Manufacturing])
- Intermediate__input_rate[Wholesale_and_Transportation] = MIN(Indicated__intermediates__rate[Wholesale_and_Transportation], Max_input_rate[Wholesale_and_Transportation])

Intermediate__input_rate[Retail_Food_and_Lodging] = MIN(Indicated__intermediates__rate[Retail_Food_and_Lodging], Max_input_rate[Retail_Food_and_Lodging])

Intermediate__input_rate[Other_Services] = MIN(Indicated__intermediates__rate[Other_Services], Max_input_rate[Other_Services])

OS__inventory(t) = OS__inventory(t - dt) + (production_rate + Imports_rate - sales_rate) * dt
INIT OS__inventory = Initial_sales*Indicated_inventory__coverage

INFLOWS:

production_rate = Actual_production

Imports_rate = .Imports_coefficients[Other_Services]*MIN(K&L__OS.Potential_output, Indicated__production_rate)

OUTFLOWS:

sales_rate = MIN(Max_sales, SUM(Indicated_sales[*]))

Actual_production = (Intermediate__input_capacity)*MIN(K&L__OS.Potential_output,

final_sales = .Gross_AD[Other_Services]-SUM(Intermediate_sales[*])

Indicated_input__order_rate[Economic_Sectors] = Indicated__intermediates__rate+(Indicated__intermediates__rate*Indicated__intermediate_coverage-Intermediate)/Intermediate_at

Indicated_inventory__coverage = 1/52

Indicated_orders__from_OS_to_OS = Indicated_input__order_rate[Other_Services]

Indicated_sales[Agriculture] = Intermediate_sales[Agriculture]

Indicated_sales[Mining] = Intermediate_sales[Mining]

Indicated_sales[Utilities] = Intermediate_sales[Utilities]

Indicated_sales[Construction] = Intermediate_sales[Construction]

Indicated_sales[Manufacturing] = Intermediate_sales[Manufacturing]

Indicated_sales[Wholesale_and_Transporation] = Intermediate_sales[Wholesale_and_Transportation]

Indicated_sales[Retail_Food_and_Lodging] = Intermediate_sales[Retail_Food_and_Lodging]

Indicated_sales[Other_Services] = Intermediate_sales[Other_Services]

Indicated_sales[Final_Consumption] = final_sales

Indicated__intermediates__rate[Economic_Sectors] = MIN (Indicated__production_rate, K&L__OS.Potential_output)*OS_coefficients

Indicated__intermediate_coverage = 1/12

Indicated__production_rate = expected_order_rate+(expected_order_rate*Indicated_inventory__coverage-OS__inventory)/inventory_AT

Initial_intermediate_sales = 4148.051272

Initial_sales = 11683.09

Intermediate_at = 1

Intermediate_sales[Agriculture] = Agriculture.Indicated_input__order_rate[Other_Services]

Intermediate_sales[Mining] = Mining.Indicated_input__order_rate[Other_Services]

Intermediate_sales[Utilities] = Utilities.Indicated_input__order_rate[Other_Services]

Intermediate_sales[Construction] = Construction.Indicated_input__order_rate[Other_Services]

Intermediate_sales[Manufacturing] = Manufacturing.Indicated_input__order_rate[Other_Services]

Intermediate_sales[Wholesale_and_Transportation] = Wholesale_and_Transportation.Indicated_input__order_rate[Other_Services]

- Intermediate_sales[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.Indicated_input__order_rate[Other_Services]
- Intermediate_sales[Other_Services] = Indicated_orders__from_OS_to_OS
- Intermediate__input_capacity = SMTH1(MIN(Min_AMUC, Min_MWRO), 1, 1)
- inventory_AT = 1/12
- Max_input_rate[Economic_Sectors] = Intermediate/Min_time__for_input
- Max_sales = OS__inventory/Min_time__sales
- Min_AG_and_Mining = MIN(Possible_Fraction_of_intermediates[Agriculture], Possible_Fraction_of_intermediates[Mining])
- Min_AMUC = MIN(min_AG_and_Mining, Min_Utilities_and_Construction)
- Min_MNF_and_WT = MIN(Possible_Fraction_of_intermediates[Manufacturing], Possible_Fraction_of_intermediates[Wholesale_and_Transportation])
- Min_MWRO = MIN(Min_MNF_and_WT, Min_RFL_and_OS)
- Min_RFL_and_OS = MIN(Possible_Fraction_of_intermediates[Retail_Food_and_Lodging], Possible_Fraction_of_intermediates[Other_Services])
- Min_time__for_input = 1/52
- Min_time__sales = 1/52
- Min_Utilities_and_Construction = MIN(Possible_Fraction_of_intermediates[Utilities], Possible_Fraction_of_intermediates[Construction])
- OS_coefficients[Economic_Sectors] = .IO_Coefficients[Economic_Sectors, Other_Services]
- OS_sales_to_AG = sales_rate*(Indicated_sales[Agriculture]/SUM(Indicated_sales[*]))
- OS_sales_to_Construction = sales_rate*(Indicated_sales[Construction]/SUM(Indicated_sales[*]))
- OS_sales_to_Mining = sales_rate*(Indicated_sales[Mining]/SUM(Indicated_sales))
- OS_sales_to_MNF = sales_rate*(Indicated_sales[Manufacturing]/SUM(Indicated_sales[*]))
- OS_sales_to_OS = sales_rate*(Indicated_sales[Other_Services]/SUM(Indicated_sales[*]))
- OS_sales_to_RFL = sales_rate*(Indicated_sales[Retail_Food_and_Lodging]/SUM(Indicated_sales[*]))
- OS_sales_to_Utilities = sales_rate*(Indicated_sales[Utilities]/SUM(Indicated_sales[*]))
- OS_sales_to_WT = sales_rate*(Indicated_sales[Wholesale_and_Transporation]/SUM(Indicated_sales[*]))
- Possible_Fraction_of_intermediates[Agriculture] = 1
- Possible_Fraction_of_intermediates[Mining] = SMTH1(if Indicated__intermediates__rate[Mining]=0 then 0 else Intermediate__input_rate[Mining]/Indicated__intermediates__rate[Mining], 1/12, 1)
- Possible_Fraction_of_intermediates[Utilities] = SMTH1(if Indicated__intermediates__rate[Utilities]=0 then 0 else Intermediate__input_rate[Utilities]/Indicated__intermediates__rate[Utilities], 1/12, 1)
- Possible_Fraction_of_intermediates[Construction] = SMTH1(if Indicated__intermediates__rate[Construction]=0 then 0 else
- Possible_Fraction_of_intermediates[Manufacturing] = SMTH1(if Indicated__intermediates__rate[Manufacturing]=0 then 0 else
- Possible_Fraction_of_intermediates[Wholesale_and_Transportation] = SMTH1(if Indicated__intermediates__rate[Wholesale_and_Transportation]=0 then 0 else Intermediate__input_rate[Wholesale_and_Transportation]/Indicated__intermediates__rate[Wholesale_and_Transportation], 1/12, 1)

- Possible_Fraction_of_intermediates[Retail_Food_and_Lodging] = SMTH1(if Indicated__intermediates__rate[Retail_Food_and_Lodging]=0 then 0 else Intermediate__input_rate[Retail_Food_and_Lodging]/Indicated__intermediates__rate[Retail_Food_and_Lodging], 1/12, 1)
- Possible_Fraction_of_intermediates[Other_Services] = SMTH1(if Indicated__intermediates__rate[Other_Services]=0 then 0 else
- Sales_to_OS[Agriculture] = Agriculture.AG_sales_to_OS
- Sales_to_OS[Mining] = Mining.Mining_sales_to_OS
- Sales_to_OS[Utilities] = Utilities.Utiities_sales_to_OS
- Sales_to_OS[Construction] = Construction.Construction__sales_to_OS
- Sales_to_OS[Manufacturing] = Manufacturing.MNF_sales_to_OS
- Sales_to_OS[Wholesale_and_Transportation] = Wholesale_and_Transportation.WT_sales_to_OS
- Sales_to_OS[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.RFL_sales_to_OS
- Sales_to_OS[Other_Services] = OS_sales_to_OS
- Total_indicated_sales = SUM(Indicated_sales[*])
- expected_order_rate = SMTH1(SUM(Indicated_sales[*]), 0.5, 11683.09)

Retaill Food and Lodging:

Intermediate[Economic_Sectors](t) = Intermediate[Economic_Sectors](t - dt) + (Intermediate_additions[Economic_Sectors] - Intermediate__input_rate[Economic_Sectors]) * dt
INIT Intermediate[Economic_Sectors] = Indicated__intermediates__rate*Indicated__intermediate_coverage

INFLOWS:

- Intermediate_additions[Agriculture] = Sales_to_RFL[Agriculture]
- Intermediate_additions[Mining] = Sales_to_RFL[Mining]
- Intermediate_additions[Utilities] = Sales_to_RFL[Utilities]
- Intermediate_additions[Construction] = Sales_to_RFL[Construction]
- Intermediate_additions[Manufacturing] = Sales_to_RFL[Manufacturing]
- Intermediate_additions[Wholesale_and_Transportation] =
- Intermediate_additions[Retail_Food_and_Lodging] = Sales_to_RFL[Retail_Food_and_Lodging]
- Intermediate_additions[Other_Services] = Sales_to_RFL[Other_Services]

OUTFLOWS:

- Intermediate__input_rate[Agriculture] = MIN(Indicated__intermediates__rate[Agriculture], Max_input_rate[Agriculture])
- Intermediate__input_rate[Mining] = MIN(Indicated__intermediates__rate[Mining],
- Intermediate__input_rate[Utilities] = MIN(Indicated__intermediates__rate[Utilities], Max_input_rate[Utilities])
- Intermediate__input_rate[Construction] = MIN(Indicated__intermediates__rate[Construction], Max_input_rate[Construction])
- Intermediate__input_rate[Manufacturing] = MIN(Indicated__intermediates__rate[Manufacturing], Max_input_rate[Manufacturing])
- Intermediate__input_rate[Wholesale_and_Transportation] = MIN(Indicated__intermediates__rate[Wholesale_and_Transportation], Max_input_rate[Wholesale_and_Transportation])

Intermediate__input_rate[Retail_Food_and_Lodging] = MIN(Indicated__intermediates__rate[Retail_Food_and_Lodging],
Max_input_rate[Retail_Food_and_Lodging])

Intermediate__input_rate[Other_Services] = MIN(Indicated__intermediates__rate[Other_Services], Max_input_rate[Other_Services])

RFL__inventory(t) = RFL__inventory(t - dt) + (production_rate + Imports_rate - sales_rate) * dt
INIT RFL__inventory = Initial_sales*Indicated_inventory__coverage

INFLOWS:

production_rate = Actual_production

Imports_rate = .Imports_coefficients[Retail_Food_and_Lodging]*MIN(Indicated__production_rate, K&L__RFL.Potential_output)

OUTFLOWS:

sales_rate = MIN(Max_sales, SUM(Indicated_sales[*]))

Actual_production = (Intermediate__input_capacity)*MIN(K&L__RFL.Potential_output,

final_sales = .Gross_AD[Retail_Food_and_Lodging]-SUM(Intermediate_sales[*])

Indicated_input__order_rate[Economic_Sectors] = Indicated__intermediates__rate+(Indicated__intermediates__rate*Indicated__intermediate_coverage-Intermediate)/Intermediate_at

Indicated_inventory__coverage = 1/12

Indicated_orders__from_RFL_to_RFL = Indicated_input__order_rate[Retail_Food_and_Lodging]

Indicated_sales[Agriculture] = Intermediate_sales[Agriculture]

Indicated_sales[Mining] = Intermediate_sales[Mining]

Indicated_sales[Utilities] = Intermediate_sales[Utilities]

Indicated_sales[Construction] = Intermediate_sales[Construction]

Indicated_sales[Manufacturing] = Intermediate_sales[Manufacturing]

Indicated_sales[Wholesale_and_Transporation] = Intermediate_sales[Wholesale_and_Transportation]

Indicated_sales[Retail_Food_and_Lodging] = Intermediate_sales[Retail_Food_and_Lodging]

Indicated_sales[Other_Services] = Intermediate_sales[Other_Services]

Indicated_sales[Final_Consumption] = final_sales

Indicated__intermediates__rate[Economic_Sectors] = MIN (Indicated__production_rate, K&L__RFL.Potential_output)*RFL_coefficients

Indicated__intermediate_coverage = 1/12

Indicated__production_rate = expected_order_rate+(expected_order_rate*Indicated_inventory__coverage-RFL__inventory)/inventory_AT

Initial_intermediate_sales = 4148.051272

Initial_sales = 2416.32

Intermediate_at = 1

Intermediate_sales[Agriculture] = Agriculture.Indicated_input__order_rate[Retail_Food_and_Lodging]

Intermediate_sales[Mining] = Mining.Indicated_input__order_rate[Retail_Food_and_Lodging]

Intermediate_sales[Utilities] = Utilities.Indicated_input__order_rate[Retail_Food_and_Lodging]

Intermediate_sales[Construction] = Construction.Indicated_input__order_rate[Retail_Food_and_Lodging]

Intermediate_sales[Manufacturing] = Manufacturing.Indicated_input__order_rate[Retail_Food_and_Lodging]

Intermediate_sales[Wholesale_and_Transportation] = Wholesale_and_Transportation.Indicated_input__order_rate[Retail_Food_and_Lodging]

Intermediate_sales[Retail_Food_and_Lodging] = Indicated_orders__from_RFL_to_RFL

○ Intermediate_sales[Other_Services] =

○ Intermediate__input_capacity = SMTH1(MIN(Min_AMUC, Min_MWRO), 1, 1)

○ inventory_AT = 1/12

○ Max_input_rate[Economic_Sectors] = Intermediate/Min_time__for_input

○ Max_sales = RFL__inventory/Min_time__sales

○ Min_AG_and_Mining = MIN(Possible_Fraction_of_intermediates[Agriculture], Possible_Fraction_of_intermediates[Mining])

○ Min_AMUC = MIN(min_AG_and_Mining, Min_Utilities_and_Construction)

○ Min_MNF_and_WT = MIN(Possible_Fraction_of_intermediates[Manufacturing], Possible_Fraction_of_intermediates[Wholesale_and_Transportation])

○ Min_MWRO = MIN(Min_MNF_and_WT, Min_RFL_and_OS)

○ Min_RFL_and_OS = MIN(Possible_Fraction_of_intermediates[Retail_Food_and_Lodging], Possible_Fraction_of_intermediates[Other_Services])

○ Min_time__for_input = 1/52

○ Min_time__sales = 1/52

○ Min_Utilities_and_Construction = MIN(Possible_Fraction_of_intermediates[Utilities], Possible_Fraction_of_intermediates[Construction])

○ Possible_Fraction_of_intermediates[Economic_Sectors] = smth1 (if Indicated__intermediates__rate=0 then 0 else Intermediate__input_rate/Indicated__intermediates__rate, 1/12, 1)

○ RFL_coefficients[Economic_Sectors] = .IO_Coefficients[Economic_Sectors, Retail_Food_and_Lodging]

○ RFL_sales_to_AG = sales_rate*(Indicated_sales[Agriculture]/SUM(Indicated_sales[*]))

○ RFL_sales_to_Construction = sales_rate*(Indicated_sales[Construction]/SUM(Indicated_sales[*]))

○ RFL_sales_to_Mining = sales_rate*(Indicated_sales[Mining]/SUM(Indicated_sales))

○ RFL_sales_to_MNF = sales_rate*(Indicated_sales[Manufacturing]/SUM(Indicated_sales[*]))

○ RFL_sales_to_OS = sales_rate*(Indicated_sales[Other_Services]/SUM(Indicated_sales[*]))

○ RFL_sales_to_RFL = sales_rate*(Indicated_sales[Retail_Food_and_Lodging]/SUM(Indicated_sales[*]))

○ RFL_sales_to_Utilities = sales_rate*(Indicated_sales[Utilities]/SUM(Indicated_sales[*]))

○ RFL_sales_to_WT = sales_rate*(Indicated_sales[Wholesale_and_Transporation]/SUM(Indicated_sales[*]))

○ Sales_to_RFL[Agriculture] = Agriculture.AG_sales_to_RFL

○ Sales_to_RFL[Mining] = Mining.Mining_sales_to_RFL

○ Sales_to_RFL[Utilities] = Utilities.Utiities_sales_to_RFL

○ Sales_to_RFL[Construction] = Construction.Construction_sales_to_RFL

○ Sales_to_RFL[Manufacturing] = Manufacturing.MNF_sales_to_RFL

○ Sales_to_RFL[Wholesale_and_Transportation] = Wholesale_and_Transportation.WT_sales_to_RFL

○ Sales_to_RFL[Retail_Food_and_Lodging] = RFL_sales_to_RFL

○ Sales_to_RFL[Other_Services] = Other_Services.OS_sales_to_RFL

○ expected_order_rate = SMTH1(SUM(Indicated_sales[*]), 0.5, 2416.32)

Utilities:

▭ Intermediate[Economic_Sectors](t) = Intermediate[Economic_Sectors](t - dt) + (Intermediate_additions[Economic_Sectors] - Intermediate__input_rate[Economic_Sectors]) * dt
INIT Intermediate[Economic_Sectors] = Indicated__intermediates__rate*Indicated__intermediate_coverage

INFLOWS:

Intermediate_additions[Agriculture] = Sales_to_Utilities[Agriculture]

- Intermediate_additions[Mining] = Sales_to_Utilities[Mining]
- Intermediate_additions[Utilities] = Sales_to_Utilities[Utilities]
- Intermediate_additions[Construction] = Sales_to_Utilities[Construction]
- Intermediate_additions[Manufacturing] = Sales_to_Utilities[Manufacturing]
- Intermediate_additions[Wholesale_and_Transportation] =
- Intermediate_additions[Retail_Food_and_Lodging] = Sales_to_Utilities[Retail_Food_and_Lodging]
- Intermediate_additions[Other_Services] = Sales_to_Utilities[Other_Services]

OUTFLOWS:

- Intermediate__input_rate[Agriculture] = MIN(Indicated__intermediates__rate[Agriculture], Max_input_rate[Agriculture])
- Intermediate__input_rate[Mining] = MIN(Indicated__intermediates__rate[Mining],
- Intermediate__input_rate[Utilities] = MIN(Indicated__intermediates__rate[Utilities], Max_input_rate[Utilities])
- Intermediate__input_rate[Construction] = MIN(Indicated__intermediates__rate[Construction], Max_input_rate[Construction])
- Intermediate__input_rate[Manufacturing] = MIN(Indicated__intermediates__rate[Manufacturing], Max_input_rate[Manufacturing])
- Intermediate__input_rate[Wholesale_and_Transportation] = MIN(Indicated__intermediates__rate[Wholesale_and_Transportation], Max_input_rate[Wholesale_and_Transportation])
- Intermediate__input_rate[Retail_Food_and_Lodging] = MIN(Indicated__intermediates__rate[Retail_Food_and_Lodging], Max_input_rate[Retail_Food_and_Lodging])
- Intermediate__input_rate[Other_Services] = MIN(Indicated__intermediates__rate[Other_Services], Max_input_rate[Other_Services])

Utilities_inventory(t) = Utilities_inventory(t - dt) + (production_rate + Imports_rate - sales_rate) * dt
INIT Utilities_inventory = Initial_sales*Indicated_inventory__coverage

INFLOWS:

- production_rate = Actual_production
- Imports_rate = MIN(Indicated__production_rate, K&L__Utilities.Potential_output)*.Imports_coefficients[Utilities]

OUTFLOWS:

- sales_rate = MIN(Max_sales, SUM(Indicated_sales[*]))

Actual_production = (Intermediate__input_capacity)*MIN(K&L__Utilities.Potential_output, Indicated__production_rate)

final_sales = .Gross_AD[Utilities]-SUM(Intermediate_sales[*]) {ND demand is already including PPI}

Indicated_input__order_rate[Economic_Sectors] = Indicated__intermediates__rate+(Indicated__intermediates__rate*Indicated__intermediate_coverage-Intermediate)/Intermediate_at

Indicated_inventory__coverage = 1/12

Indicated_orders__from_Utilities_to_utilities = Indicated_input__order_rate[Utilities]

Indicated_sales[Agriculture] = Intermediate_sales[Agriculture]

Indicated_sales[Mining] = Intermediate_sales[Mining]

Indicated_sales[Utilities] = Intermediate_sales[Utilities]

Indicated_sales[Construction] = Intermediate_sales[Construction]

- Indicated_sales[Manufacturing] = Intermediate_sales[Manufacturing]
- Indicated_sales[Wholesale_and_Transporation] = Intermediate_sales[Wholesale_and_Transportation]
- Indicated_sales[Retail_Food_and_Lodging] = Intermediate_sales[Retail_Food_and_Lodging]
- Indicated_sales[Other_Services] = Intermediate_sales[Other_Services]
- Indicated_sales[Final_Consumption] = final_sales
- Indicated__intermediates__rate[Economic_Sectors] = MIN (Indicated__production_rate, K&L__Utilities.Potential_output)*Utilities_coefficients
- Indicated__intermediate_coverage = 1/12
- Indicated__production_rate = expected_order_rate+(expected_order_rate*Indicated_inventory__coverage-Utilities_inventory)/inventory_AT
- Initial_intermediate_sales = 4148.051272
- Initial_sales = 1024.064995
- Intermediate_at = 1
- Intermediate_sales[Agriculture] = Agriculture.Indicated_input__order_rate[Utilities]
- Intermediate_sales[Mining] = Mining.Indicated_input__order_rate[Agriculture.Indicated_input__order_rate]
- Intermediate_sales[Utilities] = Indicated_orders__from_Utilities_to_utilities
- Intermediate_sales[Construction] = Construction.Indicated_input__order_rate[Utilities]
- Intermediate_sales[Manufacturing] = Manufacturing.Indicated_input__order_rate[Agriculture.Indicated_input__order_rate]
- Intermediate_sales[Wholesale_and_Transportation] = Wholesale_and_Transportation.Indicated_input__order_rate[Agriculture.Indicated_input__order_rate]
- Intermediate_sales[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.Indicated_input__order_rate[Agriculture.Indicated_input__order_rate]
- Intermediate_sales[Other_Services] = Other_Services.Indicated_input__order_rate[Agriculture.Indicated_input__order_rate]
- Intermediate__input_capacity = SMTH1(MIN(Min_AMUC, Min_MWRO), 1, 1)
- inventory_AT = 1/12
- Max_input_rate[Economic_Sectors] = Intermediate/Min_time__for_input
- Max_sales = Utilities_inventory/Min_time__sales
- Min_AG_and_Mining = MIN(Possible_Fraction_of_intermediates[Agriculture], Possible_Fraction_of_intermediates[Mining])
- Min_AMUC = MIN(min_AG_and_Mining, Min_Utilities_and_Construction)
- Min_MNF_and_WT = MIN(Possible_Fraction_of_intermediates[Manufacturing], Possible_Fraction_of_intermediates[Wholesale_and_Transportation])
- Min_MWRO = MIN(Min_MNF_and_WT, Min_RFL_and_OS)
- Min_RFL_and_OS = MIN(Possible_Fraction_of_intermediates[Retail_Food_and_Lodging], Possible_Fraction_of_intermediates[Other_Services])
- Min_time__for_input = 1/52
- Min_time__sales = 1/52
- Min_Utilities_and_Construction = MIN(Possible_Fraction_of_intermediates[Utilities], Possible_Fraction_of_intermediates[Construction])
- Possible_Fraction_of_intermediates[Agriculture] = 1
- Possible_Fraction_of_intermediates[Mining] = SMTH1(if Indicated__intermediates__rate[Mining]=0.0000 then 0 else Intermediate__input_rate[Mining]/Indicated__intermediates__rate[Mining], 1/12, 1)

Possible_Fraction_of_intermediates[Utilities] = SMTH1(if Indicated__intermediates__rate[Utilities]=0 then 0 else Intermediate__input_rate[Utilities]/Indicated__intermediates__rate[Utilities], 1/12, 1)

Possible_Fraction_of_intermediates[Construction] = SMTH1(if Indicated__intermediates__rate[Construction]=0 then 0 else

Possible_Fraction_of_intermediates[Manufacturing] = SMTH1(if Indicated__intermediates__rate[Manufacturing]=0 then 0 else

Possible_Fraction_of_intermediates[Wholesale_and_Transportation] = SMTH1(if Indicated__intermediates__rate[Wholesale_and_Transportation]=0 then 0 else Intermediate__input_rate[Wholesale_and_Transportation]/Indicated__intermediates__rate[Wholesale_and_Transportation], 1/12, 1)

Possible_Fraction_of_intermediates[Retail_Food_and_Lodging] = SMTH1(if Indicated__intermediates__rate[Retail_Food_and_Lodging]=0 then 0 else Intermediate__input_rate[Retail_Food_and_Lodging]/Indicated__intermediates__rate[Retail_Food_and_Lodging], 1/12, 1)

Possible_Fraction_of_intermediates[Other_Services] = SMTH1(if Indicated__intermediates__rate[Other_Services]=0 then 0 else

Sales_to_Utilities[Agriculture] = Agriculture.AG_sales_to_Utilities

Sales_to_Utilities[Mining] = Mining.Mining__sales_to_Utilities

Sales_to_Utilities[Utilities] = Utilities_sales_to_Utilities

Sales_to_Utilities[Construction] = Construction.Construction__sales_to_Utilities

Sales_to_Utilities[Manufacturing] = Manufacturing.MNFsales_to_Utilities

Sales_to_Utilities[Wholesale_and_Transportation] = Wholesale_and_Transportation.WT_sales_to_Utilities

Sales_to_Utilities[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.RFL_sales_to_Utilities

Sales_to_Utilities[Other_Services] = Other_Services.OS_sales_to_Utilities

Utiities_sales_to_OS = sales_rate*(Indicated_sales[Other_Services]/SUM(Indicated_sales[*]))

Utiities_sales_to_RFL = sales_rate*(Indicated_sales[Retail_Food_and_Lodging]/SUM(Indicated_sales[*]))

Utililties_sales_to_AG = sales_rate*(Indicated_sales[Agriculture]/SUM(Indicated_sales[*]))

Utilities_coefficients[Economic_Sectors] = .IO_Coefficients[Economic_Sectors, Utilities]

Utilities_sales_to_Construction = sales_rate*(Indicated_sales[Construction]/SUM(Indicated_sales[*]))

Utilities_sales_to_Mining = sales_rate*(Indicated_sales[Mining]/SUM(Indicated_sales))

Utilities_sales_to_MNF = sales_rate*(Indicated_sales[Manufacturing]/SUM(Indicated_sales[*]))

Utilities_sales_to_Utilities = sales_rate*(Indicated_sales[Utilities]/SUM(Indicated_sales[*]))

Utilities_sales_to_WT =

expected_order_rate = SMTH1(SUM(Indicated_sales[*]), 0.5, 1024.064995)

Wholesale and Transportation:

Intermediate[Economic_Sectors](t) = Intermediate[Economic_Sectors](t - dt) + (Intermediate_additions[Economic_Sectors] - Intermediate__input_rate[Economic_Sectors]) * dt
INIT Intermediate[Economic_Sectors] = Indicated__intermediates__rate*Indicated__intermediate_coverage

INFLOWS:

Intermediate_additions[Agriculture] = Sales_to_WT[Agriculture]

Intermediate_additions[Mining] = Sales_to_WT[Mining]

Intermediate_additions[Utilities] = Sales_to_WT[Utilities]

Intermediate_additions[Construction] = Sales_to_WT[Construction]

Intermediate_additions[Manufacturing] = Sales_to_WT[Manufacturing]
Intermediate_additions[Wholesale_and_Transportation] =
Intermediate_additions[Retail_Food_and_Lodging] = Sales_to_WT[Retail_Food_and_Lodging]
Intermediate_additions[Other_Services] = Sales_to_WT[Other_Services]

OUTFLOWS:

Intermediate__input_rate[Agriculture] = MIN(Indicated__intermediates__rate[Agriculture], Max_input_rate[Agriculture])

Intermediate__input_rate[Mining] = MIN(Indicated__intermediates__rate[Mining],

Intermediate__input_rate[Utilities] = MIN(Indicated__intermediates__rate[Utilities], Max_input_rate[Utilities])

Intermediate__input_rate[Construction] = MIN(Indicated__intermediates__rate[Construction], Max_input_rate[Construction])

Intermediate__input_rate[Manufacturing] = MIN(Indicated__intermediates__rate[Manufacturing], Max_input_rate[Manufacturing])

Intermediate__input_rate[Wholesale_and_Transportation] = MIN(Indicated__intermediates__rate[Wholesale_and_Transportation], Max_input_rate[Wholesale_and_Transportation])

Intermediate__input_rate[Retail_Food_and_Lodging] = MIN(Indicated__intermediates__rate[Retail_Food_and_Lodging], Max_input_rate[Retail_Food_and_Lodging])

Intermediate__input_rate[Other_Services] = MIN(Indicated__intermediates__rate[Other_Services], Indicated__intermediates__rate[Other_Services])

WT_inventory(t) = WT_inventory(t - dt) + (production_rate + Imports_rate - sales_rate) * dt
INIT WT_inventory = Initial_sales*Indicated_inventory__coverage

INFLOWS:

production_rate = Actual_production

Imports_rate = MIN(K&L__WT.Potential_output, Indicated__production_rate)*.Imports_coefficients[Wholesale_and_Transportation]

OUTFLOWS:

sales_rate = MIN(Max_sales, SUM(Indicated_sales[*]))

Actual_production = (Intermediate__input_capacity)*MIN(K&L__WT.Potential_output,

final_sales = .Gross_AD[Wholesale_and_Transportation]-SUM(Intermediate_sales[*]) {ND demand already includes PPI}

Indicated_input__order_rate[Economic_Sectors] = Indicated__intermediates__rate+(Indicated__intermediates__rate*Indicated__intermediate_coverage-Intermediate)/Intermediate_at

Indicated_inventory__coverage = 1/12
Indicated_orders__from_WT_to_WT = Indicated_input__order_rate[Wholesale_and_Transportation]
Indicated_sales[Agriculture] = Intermediate_sales[Agriculture]
Indicated_sales[Mining] = Intermediate_sales[Mining]
Indicated_sales[Utilities] = Intermediate_sales[Utilities]
Indicated_sales[Construction] = Intermediate_sales[Construction]
Indicated_sales[Manufacturing] = Intermediate_sales[Manufacturing]
Indicated_sales[Wholesale_and_Transporation] = Intermediate_sales[Wholesale_and_Transportation]
Indicated_sales[Retail_Food_and_Lodging] = Intermediate_sales[Retail_Food_and_Lodging]

- Indicated_sales[Other_Services] = Intermediate_sales[Other_Services]
- Indicated_sales[Final_Consumption] = final_sales
- Indicated__intermediates__rate[Economic_Sectors] = MIN (Indicated__production_rate, K&L__WT.Potential_output)*WT_coefficients
- Indicated__intermediate_coverage = 1/12
- Indicated__production_rate = expected_order_rate+(expected_order_rate*Indicated_inventory__coverage-WT_inventory)/inventory_AT
- Initial_intermediate_sales = 4148.051272
- Initial_sales = 3513.35
- Intermediate_at = 1
- Intermediate_sales[Agriculture] = Agriculture.Indicated_input__order_rate[Wholesale_and_Transportation]
- Intermediate_sales[Mining] = Mining.Indicated_input__order_rate[Wholesale_and_Transportation]
- Intermediate_sales[Utilities] = Utilities.Indicated_input__order_rate[Wholesale_and_Transportation]
- Intermediate_sales[Construction] =
- Intermediate_sales[Manufacturing] =
- Intermediate_sales[Wholesale_and_Transportation] = Indicated_orders__from_WT_to_WT
- Intermediate_sales[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.Indicated_input__order_rate[Wholesale_and_Transportation]
- Intermediate_sales[Other_Services] =
- Intermediate__input_capacity = SMTH1(MIN(Min_AMUC, Min_MWRO), 1, 1)
- inventory_AT = 1/12
- Max_input_rate[Economic_Sectors] = Intermediate/Min_time__for_input
- Max_sales = WT_inventory/Min_time__sales
- Min_AG_and_Mining = MIN(Possible_Fraction_of_intermediates[Agriculture], Possible_Fraction_of_intermediates[Mining])
- Min_AMUC = MIN(min_AG_and_Mining, Min_Utilities_and_Construction)
- Min_MNF_and_WT = MIN(Possible_Fraction_of_intermediates[Manufacturing], Possible_Fraction_of_intermediates[Wholesale_and_Transportation])
- Min_MWRO = MIN(Min_MNF_and_WT, Min_RFL_and_OS)
- Min_RFL_and_OS = MIN(Possible_Fraction_of_intermediates[Retail_Food_and_Lodging], Possible_Fraction_of_intermediates[Other_Services])
- Min_time__for_input = 1/52
- Min_time__sales = 1/52
- Min_Utilities_and_Construction = MIN(Possible_Fraction_of_intermediates[Utilities], Possible_Fraction_of_intermediates[Construction])
- Possible_Fraction_of_intermediates[Agriculture] = 1
- Possible_Fraction_of_intermediates[Mining] = SMTH1(if Indicated__intermediates__rate[Mining]=0 then 0 else Intermediate__input_rate[Mining]/Indicated__intermediates__rate[Mining], 1/12, 1)
- Possible_Fraction_of_intermediates[Utilities] = SMTH1(if Indicated__intermediates__rate[Utilities]=0 then 0 else Intermediate__input_rate[Utilities]/Indicated__intermediates__rate[Utilities], 1/12, 1)
- Possible_Fraction_of_intermediates[Construction] = SMTH1(if Indicated__intermediates__rate[Construction]=0 then 0 else
- Possible_Fraction_of_intermediates[Manufacturing] = SMTH1(if Indicated__intermediates__rate[Manufacturing]=0 then 0 else

Possible_Fraction_of_intermediates[Wholesale_and_Transportation] = SMTH1(if Indicated__intermediates__rate[Wholesale_and_Transportation]=0 then 0 else Intermediate__input_rate[Wholesale_and_Transportation]/Indicated__intermediates__rate[Wholesale_and_Transportation], 1/12, 1)

Possible_Fraction_of_intermediates[Retail_Food_and_Lodging] = SMTH1(if Indicated__intermediates__rate[Retail_Food_and_Lodging]=0 then 0 else Intermediate__input_rate[Retail_Food_and_Lodging]/Indicated__intermediates__rate[Retail_Food_and_Lodging], 1/12, 1)

Possible_Fraction_of_intermediates[Other_Services] = SMTH1(if Indicated__intermediates__rate[Other_Services] then 0 else Intermediate__input_rate[Other_Services]/Indicated__intermediates__rate[Other_Services], 1/12, 1)

Sales_to_WT[Agriculture] = Agriculture.AG_sales_to_WT

Sales_to_WT[Mining] = Mining.Mining_sales_to_WT

Sales_to_WT[Utilities] = Utilities.Utilities_sales_to_WT

Sales_to_WT[Construction] = Construction.Construction__sales_to_WT

Sales_to_WT[Manufacturing] = Manufacturing.MNF_sales_to_WT

Sales_to_WT[Wholesale_and_Transportation] = WT_sales_to_WT

Sales_to_WT[Retail_Food_and_Lodging] = Retaill_Food__and_Lodging.RFL_sales_to_WT

Sales_to_WT[Other_Services] = Other_Services.OS_sales_to_WT

WT_coefficients[Economic_Sectors] = .IO_Coefficients[Economic_Sectors, Wholesale_and_Transportation]

WT_sales_to_AG = sales_rate*(Indicated_sales[Agriculture]/SUM(Indicated_sales[*]))

WT_sales_to_Construction = sales_rate*(Indicated_sales[Construction]/SUM(Indicated_sales[*]))

WT_sales_to_Mining = sales_rate*(Indicated_sales[Mining]/SUM(Indicated_sales))

WT_sales_to_MNF = sales_rate*(Indicated_sales[Manufacturing]/SUM(Indicated_sales[*]))

WT_sales_to_OS = sales_rate*(Indicated_sales[Other_Services]/SUM(Indicated_sales[*]))

WT_sales_to_RFL = sales_rate*(Indicated_sales[Retail_Food_and_Lodging]/SUM(Indicated_sales[*]))

WT_sales_to_Utilities = sales_rate*(Indicated_sales[Utilities]/SUM(Indicated_sales[*]))

WT_sales_to_WT = sales_rate*(Indicated_sales[Wholesale_and_Transporation]/SUM(Indicated_sales[*]))

expected_order_rate = SMTH1(SUM(Indicated_sales[*]), 0.5, 3513.35)

Agriculture.K&L AG:

Capital(t) = Capital(t - dt) + (Capital__investments - Capital__depreciation) * dt
INIT Capital = if .Equilibrium__switch=0 then 28891.029616978 else Indicated_capital

INFLOWS:

Capital__investments = Capital__depreciation+Capital__gap/capital_AT {Sterman: delay 3}

OUTFLOWS:

Capital__depreciation = Capital/Average_life__of_capital

wages(t) = wages(t - dt) + (change_in_wage) * dt
INIT wages = 18847.7/1000000

INFLOWS:

change_in_wage = if .Equilibrium__switch=0 then Fractional_change*wages*per_year else Equilibrium__fractional_change*wages*per_year

Agriculture_wages = wages*1000000

Average_life__of_capital = 14

Average_wages = GRAPH(TIME)
(1995, 20493), (1996, 21236), (1997, 22046), (1998, 22993), (1999, 23750), (2000, 24683), (2001, 25707), (2002, 26550), (2003, 27629), (2004, 28987), (2005, 29955), (2006, 31316), (2007, 33086), (2008, 35075), (2009, 35970), (2010, 38127), (2011, 41778), (2012, 45909), (2013, 47779), (2014, 50855)

Average_wages_switch = 0

capital_AT = 1

Capital_Intensity__in_production = 0.98915

Capital__gap = DELAY3 (Indicated_capital-Capital, 3)

Cost__of_capital = if .Equilibrium__switch=0 then (Real_Interest_rate+1/Average_life__of_capital) else (Equilibrium__interest_rate+1/Average_life__of_capital)

Effect_from_relative_wages = (perceived_relative_wages-wages)/wages

Equilibrium__fractional_change = 0

Equilibrium__interest_rate = 0.07

Fractional_change = .Effect_of_unemployment*Effect_from_relative_wages

Indicated_capital = Longterm_expected__production*Capital_Intensity__in_production/Cost__of_capital

Indicated_labor = (1-Capital_Intensity__in_production)*Short_term__expected_production/real_wage

Initial_production = 4014.017398 {1997}

Longterm_expected__production = if .Equilibrium__switch=0 then SMTH3(Agriculture.Indicated__production_rate, 3, Initial_production) else Initial_production

perceived_relative_wages = if Average_wages_switch=0 then SMTH1(.Average_wages, 0.5) else SMTH1(Average_wages/1000000, 0.5)

per_year = 1

Potential_output = Initial_production*((Capital/INIT(Capital))^Capital_Intensity__in_production)*((.Employed[Agriculture]/INIT(.Employed[Agriculture]))^(1-Capital_Intensity__in_production)){production function}

PPI = GRAPH(TIME)
(1997, 100), (1998, 97.5), (1999, 98.4), (2000, 104), (2001, 105), (2002, 103), (2003, 108), (2004, 115), (2005, 123), (2006, 129), (2007, 135), (2008, 149), (2009, 136), (2010, 145), (2011, 158), (2012, 158), (2013, 159), (2014, 161)

Real_Interest_rate = GRAPH(time)
(1995, 0.066), (1996, 0.063), (1997, 0.066), (1998, 0.072), (1999, 0.064), (2000, 0.068), (2001, 0.045), (2002, 0.031), (2003, 0.021), (2004, 0.015), (2005, 0.029), (2006, 0.047), (2007, 0.052), (2008, 0.031), (2009, 0.025), (2010, 0.02), (2011, 0.012), (2012, 0.014), (2013, 0.017), (2014, 0.018)

real_wage = if .Equilibrium__switch=0 then (if .Wages_switch=0 then 100*wages/PPI else wage_data__in_millions*100/PPI) else wages

Short_term__expected_production = if .Equilibrium__switch=0 then SMTH1(Agriculture.Indicated__production_rate, 1, Initial_production) else Initial_production

Wages_AG_data = GRAPH(TIME)
(1995, 17476), (1996, 18311), (1997, 18848), (1998, 20167), (1999, 20673), (2000, 22453), (2001, 23459), (2002, 25829), (2003, 25213), (2004, 27029), (2005, 27378), (2006, 27930), (2007, 29739), (2008, 31711), (2009, 34576), (2010, 35007), (2011, 36188), (2012, 39504), (2013, 39876)

wage_data__in_millions = Wages_AG_data/1000000

Construction.K&L Construction:

Capital(t) = Capital(t - dt) + (Capital__investments - Capital__depreciation) * dt
INIT Capital = 11579.354506679

INFLOWS:

Capital__investments = Capital__depreciation+Capital__adjustment/capital_AT

OUTFLOWS:

Capital__depreciation = Capital/Average_life__of_capital

wages1(t) = wages1(t - dt) + (change_in_wage) * dt
INIT wages1 = 27302.6/1000000

INFLOWS:

change_in_wage = if .Equilibrium__switch=0 then wages1*Fractional_change*per_year else Equilibrium__fractional_change*wages1*per_year

Average_life__of_capital = 10

Average_wages = GRAPH(TIME)
(1995, 20493), (1996, 21236), (1997, 22046), (1998, 22993), (1999, 23750), (2000, 24683), (2001, 25707), (2002, 26550), (2003, 27629), (2004, 28987), (2005, 29955), (2006, 31316), (2007, 33086), (2008, 35075), (2009, 35970), (2010, 38127), (2011, 41778), (2012, 45909), (2013, 47779), (2014, 50855)

Average_wages_switch = 0

capital_AT = 3

Capital_intensity = .8165764864

Capital__adjustment = DELAY3(Indicated_capital-Capital,3)

Cost__of_capital = (Interest_rate+1/Average_life__of_capital)

Effect_from_relative_wages = (perceived_relative_wages-wages1)/wages1

Equilibrium__fractional_change = 0

Fractional_change = .Effect_of_unemployment*Effect_from_relative_wages

Indicated_capital = Longterm_expected__production*Capital_intensity/Cost__of_capital

Indicated_labor = (1-Capital_intensity)*Short_term__expected_production/real_wage

Initial_production = 2353.940972

Interest_rate = GRAPH(TIME)
(1995, 0.066), (1996, 0.063), (1997, 0.066), (1998, 0.072), (1999, 0.064), (2000, 0.068), (2001, 0.045), (2002, 0.031), (2003, 0.021), (2004, 0.015), (2005, 0.029), (2006, 0.047), (2007, 0.052), (2008, 0.031), (2009, 0.025), (2010, 0.02), (2011, 0.012), (2012, 0.014), (2013, 0.017), (2014, 0.018)

Longterm_expected__production = if .Equilibrium__switch=0 then SMTH1(Construction.Indicated__production_rate, 3, Initial_production) else Initial_production

perceived_relative_wages = if Average_wages_switch=0 then SMTH1(.Average_wages, 0.5) else SMTH1(Average_wages/1000000, 0.5)

per_year = 1

Potential_output = Initial_production*((Capital/INIT(Capital))^Capital_intensity)*((.Employed[Construction]/INIT(.Employed[Construction]))^(1-Capital_intensity)){production function}

PPI = GRAPH(TIME)
(1997, 100), (1998, 97.5), (1999, 98.4), (2000, 104), (2001, 105), (2002, 103), (2003, 108), (2004, 115), (2005, 123), (2006, 129), (2007, 135), (2008, 149), (2009, 136), (2010, 145), (2011, 158), (2012, 158), (2013, 159), (2014, 161)

real_wage = if .Equilibrium__switch=0 then (if .Wages_switch=0 then wages1*100/PPI else wage_data__in_millions*100/PPI) ELSE wages1

Short_term__expected_production = if .Equilibrium__switch=0 then SMTH1(Construction.Indicated__production_rate, 0.5, Initial_production) else Initial_production

Wages__construction_data = GRAPH(TIME)
(1995, 24903), (1996, 26580), (1997, 27303), (1998, 28717), (1999, 31299), (2000, 31257), (2001, 31903), (2002, 31951), (2003, 32622), (2004, 34273), (2005, 35641), (2006, 37831), (2007, 40430), (2008, 43928), (2009, 45397), (2010, 46616), (2011, 51224), (2012, 56410), (2013, 60207)

wage_data__in_millions = Wages__construction_data/1000000

Manufacturing.K&L MNF:

Capital(t) = Capital(t - dt) + (Capital__investments - Capital__depreciation) * dt
INIT Capital = 33203.318392323

INFLOWS:

Capital__investments = Capital__depreciation+Capital__gap/capital_AT

OUTFLOWS:

Capital__depreciation = Capital/Average_life__of_capital

wages(t) = wages(t - dt) + (change_in_wage) * dt
INIT wages = 27551.7/1000000

INFLOWS:

change_in_wage = if .Equilibrium__switch=0 then wages*Fractional_change*per_year else Equilibrium__fractional_change*wages*per_year

Average_life__of_capital = 15

Average_wages = GRAPH(TIME)
(1995, 20493), (1996, 21236), (1997, 22046), (1998, 22993), (1999, 23750), (2000, 24683), (2001, 25707), (2002, 26550), (2003, 27629), (2004, 28987), (2005, 29955), (2006, 31316), (2007, 33086), (2008, 35075), (2009, 35970), (2010, 38127), (2011, 41778), (2012, 45909), (2013, 47779), (2014, 50855)

Average_wages_switch = 0

capital_AT = 3

Capital_intensity = 0.878876618

Capital__gap = DELAY3(Indicated_capital-Capital, 3)

Cost__of_capital = (real_Interest_rate+1/Average_life__of_capital)

Effect_from_relative_wages = (perceived_relative_wages-wages)/wages

Equilibrium__fractional_change = 0

Fractional_change = .Effect_of_unemployment*Effect_from_relative_wages

Indicated_capital = Longterm_expected__production*Capital_intensity/Cost__of_capital

Indicated_labor = (1-Capital_intensity)*Short_term__expected_production/real_wage

Initial_production = 5012.062616

Longterm_expected__production = if .Equilibrium__switch =0 then SMTH1(Manufacturing.Indicated__production_rate, 3, Initial_production) else Initial_production

perceived_relative_wages = if Average_wages_switch=0 then SMTH1(.Average_wages, 0.5) else SMTH1(Average_wages/1000000, 0.5)

per_year = 1

Potential_output = Initial_production*((Capital/INIT(Capital))^Capital_intensity)*((.Employed[Manufacturing]/INIT(.Employed[Manufacturing]))^(1-Capital_intensity)){production function}

PPI = GRAPH(TIME)
(1997, 100), (1998, 97.5), (1999, 98.4), (2000, 104), (2001, 105), (2002, 103), (2003, 108), (2004, 115), (2005, 123), (2006, 129), (2007, 135), (2008, 149), (2009, 136), (2010, 145), (2011, 158), (2012, 158), (2013, 159), (2014, 161)

real_Interest_rate = GRAPH(time)
(1995, 0.066), (1996, 0.063), (1997, 0.066), (1998, 0.072), (1999, 0.064), (2000, 0.068), (2001, 0.045), (2002, 0.031), (2003, 0.021), (2004, 0.015), (2005, 0.029), (2006, 0.047), (2007, 0.052), (2008, 0.031), (2009, 0.025), (2010, 0.02), (2011, 0.012), (2012, 0.014), (2013, 0.017), (2014, 0.018)

real_wage = if .Equilibrium__switch =0 then (if .Wages_switch=0 then wages*100/PPI else wage_data__in_millions*100/PPI) else wages

Short_term__expected_production = if .Equilibrium__switch=0 then SMTH1(Manufacturing.Indicated__production_rate, 0.5, Initial_production) else Initial_production

Wages_Mnf__data = GRAPH(TIME)
(1995, 25210), (1996, 26685), (1997, 27552), (1998, 29147), (1999, 29909), (2000, 30641), (2001, 31562), (2002, 32450), (2003, 33990), (2004, 35845), (2005, 36246), (2006, 38143), (2007, 40050), (2008, 41551), (2009, 41477), (2010, 43421), (2011, 44801), (2012, 46729), (2013, 48134)

wage_data__in_millions = Wages_Mnf__data/1000000

Mining.K&L Mining:

Capital(t) = Capital(t - dt) + (Capital__investments - Capital__depreciation) * dt
INIT Capital = 2445.6593565365

INFLOWS:

Capital__investments = Capital__depreciation+Capital__adjustment/capital_AT

OUTFLOWS:

Capital__depreciation = Capital/Average_life__of_capital

wages(t) = wages(t - dt) + (change_in_wage) * dt
INIT wages = 40263.3/1000000

INFLOWS:

change_in_wage = if .Equilibrium__switch=0 then wages*Fractional_change*Per_year else Equilibrium_fractional_change*wages*Per_year

Average_life__of_capital = 11

Average_wages = GRAPH(TIME)
(1995, 20493), (1996, 21236), (1997, 22046), (1998, 22993), (1999, 23750), (2000, 24683), (2001, 25707), (2002, 26550), (2003, 27629), (2004, 28987), (2005, 29955), (2006, 31316), (2007, 33086), (2008, 35075), (2009, 35970), (2010, 38127), (2011, 41778), (2012, 45909), (2013, 47779), (2014, 50855)

Average_wages_switch = 0

capital_AT = 3

Capital_intensity = 0.7257158182

Capital__adjustment = DELAY3 (Indicated_capital-Capital, 3)

Cost__of_capital = (Interest_rate+1/Average_life__of_capital)

Effect_from_relative_wages = (perceived_relative_wages-wages)/wages

Equilibrium_fractional_change = 0

Fractional_change = .Effect_of_unemployment*Effect_from_relative_wages

Indicated_capital = Longterm_expected__production*Capital_intensity/Cost__of_capital

Indicated_labor = (1-Capital_intensity)*Short_term__expected_production/real_wage

Initial_production = 528.782692 {1997}

Interest_rate = GRAPH(TIME)
(1995, 0.066), (1996, 0.063), (1997, 0.066), (1998, 0.072), (1999, 0.064), (2000, 0.068), (2001, 0.045), (2002, 0.031), (2003, 0.021), (2004, 0.015), (2005, 0.029), (2006, 0.047), (2007, 0.052), (2008, 0.031), (2009, 0.025), (2010, 0.02), (2011, 0.012), (2012, 0.014), (2013, 0.017), (2014, 0.018)

Longterm_expected__production = if .Equilibrium__switch=0 then SMTH1(Mining.Indicated__production_rate, 3, Initial_production) else Initial_production

Mining_wages = wages*1000000

perceived_relative_wages = if Average_wages_switch=0 then SMTH1(.Average_wages, 0.5) else SMTH1(Average_wages/1000000, 0.5)

Per_year = 1

Potential_output = Initial_production*((Capital/INIT(Capital))^Capital_intensity)*((.Employed[Mining]/(INIT(.Employed[Mining])))^(1-Capital_intensity)){production function}

PPI = GRAPH(TIME)
(1997, 100), (1998, 97.5), (1999, 98.4), (2000, 104), (2001, 105), (2002, 103), (2003, 108), (2004, 115), (2005, 123), (2006, 129), (2007, 135), (2008, 149), (2009, 136), (2010, 145), (2011, 158), (2012, 158), (2013, 159), (2014, 161)

real_wage = if .Equilibrium__switch=0 then (if .Wages_switch=0 then wages*100/PPI else wage_data__in_millions*100/PPI) else wages

Short_term__expected_production = if .Equilibrium__switch=0 then SMTH1(Mining.Indicated__production_rate, 0.5, Initial_production) else Initial_production

Wages__mining_data = GRAPH(TIME)
(1995, 37152), (1996, 37908), (1997, 40263), (1998, 41691), (1999, 44432), (2000, 45018), (2001, 48531), (2002, 49153), (2003, 50970), (2004, 52998), (2005, 57054), (2006, 64642), (2007, 70004), (2008, 74916), (2009, 73031), (2010, 79970), (2011, 89726), (2012, 96570), (2013, 98042)

wage_data__in_millions = Wages__mining_data/1000000

Other Services.K&L OS:

Capital(t) = Capital(t - dt) + (Capital__investments - Capital__depreciation) * dt
INIT Capital = 59908.08681819

INFLOWS:

Capital__investments = Capital__depreciation+Capital__adjustment/capital_AT

OUTFLOWS:

Capital__depreciation = Capital/Average_life__of_capital

wages(t) = wages(t - dt) + (change_in_wage) * dt
INIT wages = 23313.8/1000000

INFLOWS:

change_in_wage = if .Equilibrium__switch=0 then wages*Fractional_change*per_year else Equilibrium__fractional_change*wages*per_year

Average_life__of_capital = 10

Average_wages = GRAPH(TIME)
(1995, 20493), (1996, 21236), (1997, 22046), (1998, 22993), (1999, 23750), (2000, 24683), (2001, 25707), (2002, 26550), (2003, 27629), (2004, 28987), (2005, 29955), (2006, 31316), (2007, 33086), (2008, 35075), (2009, 35970), (2010, 38127), (2011, 41778), (2012, 45909), (2013, 47779), (2014, 50855)

Average_wages_switch = 0

capital_AT = 3

Capital_intensity = 0.7555776115

Capital__adjustment = DELAY3(Indicated_capital-Capital, 3)

Cost__of_capital = (Interest_rate+1/Average_life__of_capital)

Effect_from_relative_wages = (perceived_relative_wages-wages)/wages

Equilibrium__fractional_change = 0

Fractional_change = .Effect_of_unemployment*Effect_from_relative_wages

Indicated_capital = Longterm_expected__production*Capital_intensity/Cost__of_capital

Indicated_labor = (1-Capital_intensity)*Short_term__expected_production/real_wage

Initial_production = 13161.77486

Interest_rate = GRAPH(TIME)
(1995, 0.066), (1996, 0.063), (1997, 0.066), (1998, 0.072), (1999, 0.064), (2000, 0.068), (2001, 0.045), (2002, 0.031), (2003, 0.021), (2004, 0.015), (2005, 0.029), (2006, 0.047), (2007, 0.052), (2008, 0.031), (2009, 0.025), (2010, 0.02), (2011, 0.012), (2012, 0.014), (2013, 0.017), (2014, 0.018)

Longterm_expected__production = if .Equilibrium__switch =0 then SMTH1(Other_Services.Indicated__production_rate, 3, Initial_production) else Initial_production

perceived_relative_wages = if Average_wages_switch=0 then SMTH1(.Average_wages, 0.5) else SMTH1(Average_wages/1000000, 0.5)

per_year = 1

Potential_output = Initial_production*((Capital/INIT(Capital))^Capital_intensity)*((.Employed[Other_Services]/INIT(.Employed[Other_Services]))^(1-Capital_intensity)){production function}

PPI = GRAPH(TIME)
(1997, 100), (1998, 97.5), (1999, 98.4), (2000, 104), (2001, 105), (2002, 103), (2003, 108), (2004, 115), (2005, 123), (2006, 129), (2007, 135), (2008, 149), (2009, 136), (2010, 145), (2011, 158), (2012, 158), (2013, 159), (2014, 161)

real_wage = if .Equilibrium__switch=0 then (if .Wages_switch=0 then wages*100/PPI else wage_data__in_millions*100/PPI) else wages

Short_term__expected_production = if .Equilibrium__switch=0 then SMTH1(Other_Services.Indicated__production_rate, 0.5, Initial_production) else Initial_production

Wages__OS_data = GRAPH(TIME)
(1995, 21853), (1996, 22503), (1997, 23314), (1998, 24199), (1999, 24877), (2000, 26096), (2001, 27347), (2002, 28423), (2003, 29600), (2004, 31010), (2005, 32090), (2006, 33485), (2007, 35380), (2008, 36948), (2009, 38186), (2010, 39788), (2011, 42046), (2012, 44445), (2013, 46186)

wage_data__in_millions = Wages__OS_data/1000000

Retaill Food and Lodging.K&L RFL:

Capital(t) = Capital(t - dt) + (Capital__investments - Capital__depreciation) * dt
INIT Capital = 20722.055987775

INFLOWS:

Capital__investments = Capital__depreciation+Capital__adjustment/capital_AT

OUTFLOWS:

Capital__depreciation = Capital/Average_life__of_capital

wages(t) = wages(t - dt) + (change_in_wage) * dt
INIT wages = 12718.8/1000000

INFLOWS:

change_in_wage = if .Equilibrium__switch=0 then wages*Fractional_change*per_year else Equilibrium__fractional_change*wages*per_year

Average_life__of_capital = 10

Average_wages = GRAPH(TIME)
(1995, 20493), (1996, 21236), (1997, 22046), (1998, 22993), (1999, 23750), (2000, 24683), (2001, 25707), (2002, 26550), (2003, 27629), (2004, 28987), (2005, 29955), (2006, 31316), (2007, 33086), (2008, 35075), (2009, 35970), (2010, 38127), (2011, 41778), (2012, 45909), (2013, 47779), (2014, 50855)

Average_wages_switch = 0

capital_AT = 3

Capital_intensity = 0.805070415

Capital__adjustment = DELAY3(Indicated_capital-Capital, 3)

Cost__of_capital = (Interest_rate+1/Average_life__of_capital)

Effect_from_relative_wages = (perceived_relative_wages-wages)/wages

Equilibrium__fractional_change = 0

Fractional_change = .Effect_of_unemployment*Effect_from_relative_wages

Indicated_capital = Longterm_expected__production*Capital_intensity/Cost__of_capital

Indicated_labor = (1-Capital_intensity)*Short_term__expected_production/real_wage

Initial_production = 4272.745874

Interest_rate = GRAPH(TIME)
(1995, 0.066), (1996, 0.063), (1997, 0.066), (1998, 0.072), (1999, 0.064), (2000, 0.068), (2001, 0.045), (2002, 0.031), (2003, 0.021), (2004, 0.015), (2005, 0.029), (2006, 0.047), (2007, 0.052), (2008, 0.031), (2009, 0.025), (2010, 0.02), (2011, 0.012), (2012, 0.014), (2013, 0.017), (2014, 0.018)

Longterm_expected__production = if .Equilibrium__switch =0 then SMTH1(Retaill_Food__and_Lodging.Indicated__production_rate, 3, Initial_production) else Initial_production

perceived_relative_wages = if Average_wages_switch=0 then SMTH1(.Average_wages, 0.5) else SMTH1(Average_wages/1000000, 0.5)

per_year = 1

Potential_output = Initial_production*((Capital/INIT(Capital))^Capital_intensity)*((.Employed[Retail_Food_and_Lodging]/INIT(.Employed[Retail_Food_and_Lodging]))^(1-Capital_intensity)){production function}

PPI = GRAPH(TIME)
(1997, 100), (1998, 97.5), (1999, 98.4), (2000, 104), (2001, 105), (2002, 103), (2003, 108), (2004, 115), (2005, 123), (2006, 129), (2007, 135), (2008, 149), (2009, 136), (2010, 145), (2011, 158), (2012, 158), (2013, 159), (2014, 161)

real_wage = if .Equilibrium__switch=0 then (if .Wages_switch=0 then wages*100/PPI else wage_data__in_millions*100/PPI) else wages

Short_term__expected_production = if .Equilibrium__switch=0 then SMTH1(Retaill_Food__and_Lodging.Indicated__production_rate, 0.5, Initial_production) else Initial_production

Wages__RFL_data = GRAPH(TIME)
(1995, 11743), (1996, 12119), (1997, 12719), (1998, 13184), (1999, 13570), (2000, 14029), (2001, 14592), (2002, 15044), (2003, 15464), (2004, 15816), (2005, 16177), (2006, 16655), (2007, 17400), (2008, 18297), (2009, 18611), (2010, 19453), (2011, 20724), (2012, 22396), (2013, 23331)

wage_data__in_millions = Wages__RFL_data/1000000

Utilities.K&L Utilities:

Capital(t) = Capital(t - dt) + (Capital__investments - Capital__depreciation) * dt
INIT Capital = 7094.2238231795

INFLOWS:

Capital__investments = Capital__depreciation+Capital__adjustment/capital_AT

OUTFLOWS:

Capital__depreciation = Capital/Average_life__of_capital

wages(t) = wages(t - dt) + (change_in_wage) * dt
INIT wages = 22265.1/1000000

INFLOWS:

change_in_wage = if .Equilibrium__switch =0 then wages*Fractional_change*per_year else Equilibrium__fractional_change*per_year*wages

Average_life__of_capital = 30

Average_wages = GRAPH(TIME)
(1995, 20493), (1996, 21236), (1997, 22046), (1998, 22993), (1999, 23750), (2000, 24683), (2001, 25707), (2002, 26550), (2003, 27629), (2004, 28987), (2005, 29955), (2006, 31316), (2007, 33086), (2008, 35075), (2009, 35970), (2010, 38127), (2011, 41778), (2012, 45909), (2013, 47779), (2014, 50855)

Average_wages_swith = 0

capital_AT = 3

Capital_intensity = 0.686566986

Capital__adjustment = DELAY3(Indicated_capital-Capital, 3)

Cost__of_capital = (Interest_rate+1/Average_life__of_capital)

Effect_from_relative_wages = (perceived_relative_wages-wages)/wages

Equilibrium__fractional_change = 0

Fractional_change = .Effect_of_unemployment*Effect_from_relative_wages

Indicated_capital = Longterm_expected__production*Capital_intensity/Cost__of_capital

Indicated_labor = (1-Capital_intensity)*Short_term__expected_production/real_wage

Initial_production = 1026.39735

Interest_rate = GRAPH(TIME)
(1995, 0.066), (1996, 0.063), (1997, 0.066), (1998, 0.072), (1999, 0.064), (2000, 0.068), (2001, 0.045), (2002, 0.031), (2003, 0.021), (2004, 0.015), (2005, 0.029), (2006, 0.047), (2007, 0.052), (2008, 0.031), (2009, 0.025), (2010, 0.02), (2011, 0.012), (2012, 0.014), (2013, 0.017), (2014, 0.018)

Longterm_expected__production = if .Equilibrium__switch=0 then SMTH1(Utilities.Indicated__production_rate, 3, Initial_production) else Initial_production

perceived_relative_wages = if Average_wages_swith=0 then SMTH1(.Average_wages, 0.5) else SMTH1(Average_wages/1000000, 0.5)

per_year = 1

Potential_output =
Initial_production*((Capital/INIT(Capital))^Capital_intensity)*((.Employed[Utilities]/INIT(.Employed[Utilities]))^(1-Capital_intensity)){production function}

PPI = GRAPH(TIME)
(1997, 100), (1998, 97.5), (1999, 98.4), (2000, 104), (2001, 105), (2002, 103), (2003, 108), (2004, 115), (2005, 123), (2006, 129), (2007, 135), (2008, 149), (2009, 136), (2010, 145), (2011, 158), (2012, 158), (2013, 159), (2014, 161)

real_wage = if .Equilibrium__switch=0 then (if .Wages_switch=0 then wages*100/PPI else wage_data__in_millions*100/PPI) else wages

Short_term__expected_production = if .Equilibrium__switch=0 then SMTH1(Utilities.Indicated__production_rate, 0.5, Initial_production) else Initial_production

Wages__utilities_data = GRAPH(TIME)
(1995, 22266), (1996, 22163), (1997, 22265), (1998, 23548), (1999, 23583), (2000, 24396), (2001, 25211), (2002, 26411), (2003, 28415), (2004, 29878), (2005, 30601), (2006, 30758), (2007, 31985), (2008, 32962), (2009, 34923), (2010, 37514), (2011, 39584), (2012, 42035), (2013, 43261)

wage_data__in_millions = Wages__utilities_data/1000000

Wholesale and Transportation.K&L WT:

Capital(t) = Capital(t - dt) + (Capital__investments - Capital__depreciation) * dt
INIT Capital = 16436.24524611

INFLOWS:

Capital__investments = Capital__depreciation+Capital__adjustment/capital_AT

OUTFLOWS:

Capital__depreciation = Capital/Average_life__of_capital

wages(t) = wages(t - dt) + (change_in_wage) * dt
INIT wages = 28098.2/1000000

INFLOWS:

change_in_wage = if .Equilibrium__switch=0 then wages*Fractional_change*per_year else Equilibrium__fractional_change*wages*per_year

Average_life__of_capital = 10

Average_wages = GRAPH(TIME)
(1995, 20493), (1996, 21236), (1997, 22046), (1998, 22993), (1999, 23750), (2000, 24683), (2001, 25707), (2002, 26550), (2003, 27629), (2004, 28987), (2005, 29955), (2006, 31316), (2007, 33086), (2008, 35075), (2009, 35970), (2010, 38127), (2011, 41778), (2012, 45909), (2013, 47779), (2014, 50855)

Average_wages_switch = 0

capital_AT = 3

Capital_intensity = 0.7756131873

Capital__adjustment = DELAY3(Indicated_capital-Capital, 3)

Cost__of_capital = (Interest_rate+1/Average_life__of_capital)

Effect_from_relative_wages = (perceived_relative_wages-wages)/wages

Equilibrium__fractional_change = 0

Fractional_change = .Effect_of_unemployment*Effect_from_relative_wages

Indicated_capital = Longterm_expected__production*Capital_intensity/Cost__of_capital

Indicated_labor = Short_term__expected_production*(1-Capital_intensity)/real_wage

Initial_production = 3517.754411

Interest_rate = GRAPH(time)
(1995, 0.066), (1996, 0.063), (1997, 0.066), (1998, 0.072), (1999, 0.064), (2000, 0.068), (2001, 0.045), (2002, 0.031), (2003, 0.021), (2004, 0.015), (2005, 0.029), (2006, 0.047), (2007, 0.052), (2008, 0.031), (2009, 0.025), (2010, 0.02), (2011, 0.012), (2012, 0.014), (2013, 0.017), (2014, 0.018)

Longterm_expected__production = if .Equilibrium__switch=0 then SMTH1(Wholesale_and_Transportation.Indicated__production_rate, 3, Initial_production) else Initial_production

perceived_relative_wages = if Average_wages_switch=0 then SMTH1(.Average_wages, 0.5) else SMTH1(Average_wages/1000000, 0.5)

per_year = 1

Potential_output = Initial_production*((Capital/INIT(Capital))^Capital_intensity)*((.Employed[Wholesale_and_Transportation]/INIT(.Employed[Wholesale_and_Transportation]))^(1-Capital_intensity)){production function}

PPI = GRAPH(TIME)
(1997, 100), (1998, 97.5), (1999, 98.4), (2000, 104), (2001, 105), (2002, 103), (2003, 108), (2004, 115), (2005, 123), (2006, 129), (2007, 135), (2008, 149), (2009, 136), (2010, 145), (2011, 158), (2012, 158), (2013, 159), (2014, 161)

real_wage = if .Equilibrium__switch=0 then (if .Wages_switch=0 then wages*100/PPI else wage_data__in_millions*100/PPI) else wages

Short_term__expected_production = if .Equilibrium__switch=0 then SMTH1(Wholesale_and_Transportation.Indicated__production_rate, 0.5, Initial_production) else Initial_production

Wages_WT_data = GRAPH(TIME)
(1995, 25879), (1996, 26946), (1997, 28098), (1998, 29346), (1999, 30206), (2000, 31494), (2001, 32302), (2002, 33352), (2003, 34665), (2004, 36782), (2005, 38109), (2006, 39728), (2007, 41795), (2008, 45123), (2009, 45879), (2010, 48809), (2011, 54964), (2012, 61179), (2013, 62913)

wage_data__in_millions = Wages_WT_data/1000000