

"HELP WANTED!"

*An analysis of labor supply dynamics
in booming North Dakota*



Babette Bakker

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*A master thesis for the European Master in System Dynamics
University of Bergen
University of Palermo
Radboud University Nijmegen*

*In collaboration with
University of North Dakota*

*Supervision by prof. David Wheat
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Exactly 24 years and 24 minutes after the moment I was born, I completed my master thesis for the European Master in System Dynamics. The most challenging months of my life with lots of joy, frustration and in the end, satisfaction.

Kind regards,

Babette Bakker

Date of birth: 21/08/1991

Date of submission: 21/08/2015

ABSTRACT

North Dakota's oil boom has led to an increase in the level of vacancies, which has gained high attention at the level of state government and businesses. The general thought is that the high level of vacancies could be explained by a shortage in labor supply. In contradiction to this view, this thesis revealed that vacancies are not only a result of the incapability of filling the vacancies posted for job creation, but are also especially relying on the attrition rate. The attrition rate is the result of the labor supply dynamics. This research project aims to understand the level and trends in the supply of labor of each sector in North Dakota and its effect on the vacancy level. It captures (1) the internal dynamics of a sector, (2) the external dynamics with the other sectors and (3) the total labor supply dynamics which allows for immigration and commuters. A combination of these different levels of aggregation creates a new perspective on the labor supply dynamics and its role on the level of vacancies in booming economies.

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1. INTRODUCTION

North Dakota has been the number one growth state of the United States since the beginning of the oil boom in 2007. In 2012, the state has reached an economic growth rate of almost 20%. In 2014, the state was still the fastest growing economy with a growth rate of 6.3% (Bureau of Economic Analysis, 2015). The driver behind this growth is a boom in the oil and gas industry (Hargreaves, 2011). In 2004, the high oil price and the development of new technologies made it profitable for oil and gas companies to start drilling wells in the Bakken area (Davey, 2008). By about 2007, the real oil boom took off. With a payoff time of only half a year, many oil and gas companies were eager to make the journey to North Dakota. Together with the drilling companies, many other businesses came to North Dakota to take their share of the oil boom. According to the news articles, there is not a single business which would not be able to survive. The money earned in North Dakota's growing oil and gas industry lead to a boost in demand for the other sectors. But North Dakota, a small state, was unable to meet the sudden increase in the demands of the fast growing economy. Yes, companies do not need to advertise to drum up demand. Instead, they have to fill the newspapers, local airwaves, magazines and billboards with promises of high wages and bonuses. You cannot drive around without noticing the "help wanted" signs companies hang outside, desperate to attract some workers. While other states are struggling with high unemployment rates, North Dakota is struggling with a labor shortage.

Since the beginning of the oil boom North Dakota has been trying to expand its labor force to meet the growing labor demands. Already in 2007, the Department of Commerce begun to visit job fairs in other states. State officials were trying to recruit prospective workers for the oil and gas industry, mainly targeting those who were former residents of North Dakota (Davey, 2008, January 1). While the recession started in 2008 and thousands of people were getting laid off, North Dakota had different problems. In June 2008, there were 13 000 vacancies on the internet (Online Job Openings Report, 2015). Struggling to fill the vacancies with only the state's limited labor force available, officials and private companies increased efforts to recruit workers from other states. The same people being laid off due to the recession in surrounding states, were offered to work in North Dakota. After a while, the word was spread. The news of high wages and a job within one hour after arrival attracted people from all over the nation. Thousands of workers came to North Dakota to work at the oil field, in the construction or at one of the fast food chains. Between 2007 and 2014, North Dakota's

population grew from 652 822 till 739 482 persons (Census, 2015). While many towns in North Dakota were suffering from a population drain before the boom, the same towns were now experiencing housing shortages. The demand for houses was sky rocketing, and roads were overcrowded. But many local private and public companies were still reluctant to invest in the growing economy. They had not forgotten the last oil boom from the 80s. A boom with a bust, which led to empty houses, barely used new roads and a high governmental debt. With the recent boom and bust in mind, some people were waiting for the current oil boom to collapse. Not only the residents, also economic analysts were debating whether the boom would continue or collapse (Davey, 2008, December 5).

Nevertheless, the current labor market situation was obvious, the supply of labor was not enough. The amount of vacancies continued to increase as did the stream of workers entering North Dakota's borders. Competition for experienced workers grew so fierce that companies had to offer extraordinary benefits, like free housing, food, housecleaning and flat screen tvs (Wethe and Gilblom, 2015, April 15). To be able to host workers from outside of the state, companies were starting to build so called "man camps". Temporary, portable housing units, housed by mainly man workers. Other workers were staying in recreational vehicles in new camps, which have been pullulated in the areas around the oil field (Bjorke, 2009, October 18). Although a large part of the oil field workers were used to move from one oil patch to another, bringing their mobile houses with them, others were desperate looking for a permanent place to live. The shortage in the housing market forced people who had family back in North Dakota to live with them. Other workers had to leave their families back home and move into man camps. The growth in the housing market was not able to keep up. Not only did the oil and gas industry suffer from a labor shortage, also did the construction sector. Workers in the construction were running off to the better paid jobs at the oilfield (Bjorke, 2009, October 18). As did many workers from other lower paid sectors.

Even in the years after 2009, the boom did not go bust. The amount of vacancies continued to rise and in May 2014, the Online Job Openings Report announced that North Dakota had reached a level of over 27 000 online vacancies. The oil and gas industry was responsible for one-third of those job openings. North Dakota was even expected to add another 76 000 jobs between 2010 and 2020 (North Dakota Job Service, 2014), which would lead to even more pressure on the labor market. With an unemployment rate of only 2,7% in 2014 (Local Area Unemployment Statistics), North Dakota defeated all other states. Although this was good

news for the job seekers in North Dakota, it meant bad news for the businesses. The shortage in labor supply was assumed to be one of the biggest constraints for North Dakota's growing economy.

The high pressure on the labor market has led to escalating wages in all sectors of the labor market. Those wages would erode project profits (Arnsdorf, Murtaugh and Kaskey, 2004) and hamper further investments. Companies unable to find workers for new positions, were unable to expand their production. 'Securing skilled workforce to meet the needs of the state's business community' (North Dakota Department of Commerce, 2014, p. 8) became a high priority for North Dakota's State Government. Enlarging North Dakota's labor supply by stimulating labor immigration, improving the educational system and improving the infrastructure have remained the key focus areas in strategic plans throughout the years (i.a. North Dakota Workforce Leadership Team, 2014). Policy programs arose to attract workers to North Dakota, under which the "Find the Good Life in North Dakota" campaign founded in May 2014 by the North Dakota Economic Development Foundation and the "Program of Work for 2015" launched by Williston's new Economic Development Director Shawn Wenko (Killelea, 2014). Although a labor shortage exists within every sector, efforts to support a long-term workforce growth are mainly centered around the energy sector. Many of the high-demand position in the energy sector rely heavily on skills in science, technology, engineering and mathematics (S.T.E.M.) (Department of Commerce, 2012). New training programs (such as TrainND) emerged and campaigns were organized to motivate people to invest in these S.T.E.M. qualities. But how do these policies affect the labor supply dynamics? This is one of the questions being addressed in this research project.

When the research project started off in October 2014, the research questions were centered around policies aiming to increase North Dakota's labor supply in order to meet North Dakota continuous growing labor demand. However, at the end of 2014, the oil price plunged in just a few months from over \$100 a barrel to \$45 a barrel in January 2015. The fall in oil prices led to stifling exploration and production of crude oil. As a result, the continuous growing energy sector and the increase in labor demand could not be taken as given anymore. Fewer wells are getting drilled and workers in the oil sector are getting laid off. While in the beginning of the oil boom, workers from the construction sector were running off to the oil field, the same workers are now turning their heads towards the construction sector. "We're seeing oil workers that are laid off transition into construction work," said Kyle Tennesen of Command

Center, a temporary work agency in an article in Reuters (Scheijder, 2015, March 13). The plunge in oil prices also lowers North Dakota's labor market position compared to other states in the U.S..The latest news release of the Bureau of Labor Statistics' Regional and State Employment and Unemployment report showed that in May 2015, North Dakota was the only state with a significant increase in unemployment rate (plus 0.4%). It also had the largest over-the-month percentage decline in employment.

In June 2015, the state officials were still convinced that although the energy sectors experiences a slow down, the economy was still booming (Killelea, 2015, June 18). The oil price has already increased to over \$60 a barrel in June 2015. A further increase in oil price was expected. And although oil-related jobs have been cut, North Dakota still has a high number of vacancies. Together with the increasing oil price since January, also the vacancies started to increase again. Also, in other parts of the state, where the oil price does not have an immediate impact, they are still suffering from a labor shortage. In Grand Forks, businesses are complaining to have an instable workforce due to job-hoppers. The business leaders there want to create more stability by launching a "Fresh Start" program aimed at "energizing the work ethic in individuals having difficulty maintaining employment." (Wilfhart in Grand Forks Herald, 2015, June 16). Also Fargo suffers from a labor shortage.

The plunge in the oil price forced businesses to cut down hours and additional benefits. Housing and travel expenditures are no longer secured. For many temporary workers at the oil field, the reason of why they got there in the first place, the high earnings, slowly disappears. This is for some workers a reason to quit their jobs, pack their cars and move back to their home state (article). Some believe that this development threatens future growth. Workers from outside the state, who are leaving North Dakota either because they are getting fired or because the job does not pay off anymore, are not assumed to return quickly after the economy catches up again (personal conversation).

By August 2015, the state officials expectations of an increasing oil price turned out to be too optimistic. The price of crude oil decreased to \$44 dollars a barrel at August 8 2015 (oilprice.com). All over the world, oil related companies are adjusting their expectation to a low level of the oil price and diminish their workforce. The reduction in oil price has led to about 176 100 layoffs worldwide, as estimated by Houston-based oil industry recruiter Swift Worldwide Resources (Eaton and Grattan, 2015, August 3). Remarkably, the vacancies in

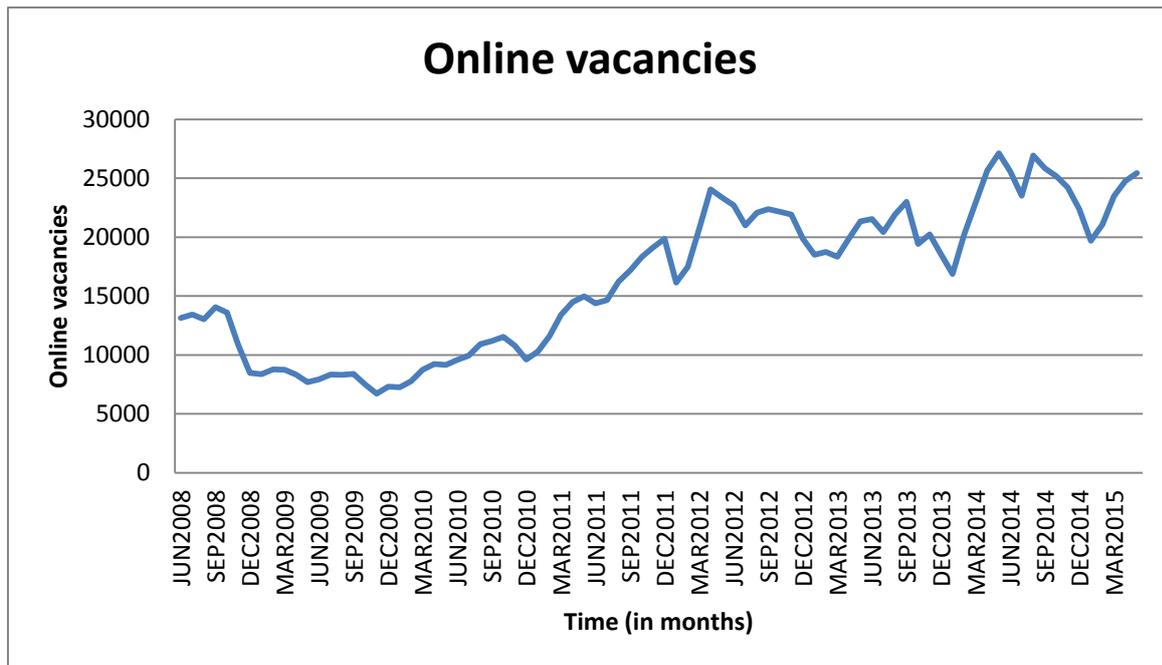
North Dakota are still increasing (Online Job Openings Report, 2015, July). No one really knows whether North Dakota's economy will continue to grow or will collapse. Different growth scenarios are sketched by different news articles, state officials and analyst.

Despite the different scenarios for North Dakota's economy, one thing becomes clear, a growing labor demand cannot be taken as given anymore. Therefore, this research will include the effect of different labor demand scenarios on North Dakota's labor supply. A study on the labor demand dynamics is done by Adiba Mumoniva, a fellow master student. Adiba Muminova will create a simulation model, which uses the labor per sector as an input for the production. Her model will produce the growth in production on industry level and the revolving desired number of jobs. Our research projects are complementary to each other. The primary aim of this research is to understand the level and trends in the supply of labor of each sector in North Dakota. The main contribution to scientific research lies within the combination of labor supply dynamics and migration and commuting patterns. This research will include the dynamics within the sectors which drives the inflow of other workers. It will also contribute to the understanding of the flows of workers between the different sectors. Special attention is being drawn to the inflow workers from outside the state. A differentiation is made between the effect of the commuting workforce and the migrating workforce on North Dakota's total labor supply. The commuting workforce is that part of the workforce who has the primary residence in another state and can leave North Dakota as quickly as they came.

2. PROBLEMATIC BEHAVIOR

The reference period of this research from 2000 to 2014. The starting year 2000 is chosen in collaboration with the Department of Commerce. Data experts explained that many of the data measure methodologies change at the start of a new decennium. Data from before 2000 are therefore hard to compare with data from after 2000. Another reason to take 2000 as the starting year, is that the flood of the red river in 1997 disrupted the historical patterns. The flood has destroyed many houses in North Dakota and had a major impact on the economy. This is an event which cannot be simulated with the model and those years will thus not be able to serve the purpose of validation of the model structure.

In figure 1, the online vacancies in Nord Dakota are presented. The Online Job Openings Report is updated every month, since June 2008. Data on vacancies from before June 2008 are not available. The amount of online vacancies grew from 13 138 jobs in June 2008 till 23 496 jobs in March 2015. In 2009, the graph shows a drop in total online vacancies, probably as a response to the recession. Early 2010 the amount of vacancies begun to grow again and they continued to increase. The increase in online vacancies is steepest in the year 2011. The amount of online vacancies has reached its top in May 2014, with a number of 27 218 jobs. Since the oil price begun to drop late 2014, also the amount of online vacancies declined. The amount of vacancies fluctuates with the season. North Dakota has extremely cold winters, which results in a decline in possible working hours for occupations which should be exercised outside. Those occupations are represented in sectors such as agriculture, construction and mining. A small decline in vacancies is thus noticed each year around December and January.



JUN2008	13138	MAR2010	8752	DEC2011	19841	SEP2013	23006
JUL2008	13443	APR2010	9217	JAN2012	16136	OCT2013	19420
AUG2008	13035	MAY2010	9139	FEB2012	17480	NOV2013	20220
SEP2008	14044	JUN2010	9589	MAR2012	20748	DEC2013	18558
OCT2008	13588	JUL2010	9929	APR2012	24059	JAN2014	16877
NOV2008	10831	AUG2010	10920	MAY2012	23350	FEB2014	20205
DEC2008	8472	SEP2010	11189	JUN2012	22695	MAR2014	22932
JAN2009	8360	OCT2010	11530	JUL2012	20979	APR2014	25653
FEB2009	8766	NOV2010	10764	AUG2012	22072	MAY2014	27128
MAR2009	8737	DEC2010	9616	SEP2012	22369	JUN2014	25602
APR2009	8326	JAN2011	10280	OCT2012	22161	JUL2014	23501
MAY2009	7687	FEB2011	11581	NOV2012	21927	AUG2014	26929
JUN2009	7930	MAR2011	13403	DEC2012	19863	SEP2014	25837
JUL2009	8339	APR2011	14475	JAN2013	18501	OCT2014	25154
AUG2009	8311	MAY2011	14988	FEB2013	18749	NOV2014	24226
SEP2009	8393	JUN2011	14374	MAR2013	18324	DEC2014	22371
OCT2009	7496	JUL2011	14642	APR2013	19874	JAN2015	19695
NOV2009	6719	AUG2011	16212	MAY2013	21336	FEB2015	21081
DEC2009	7310	SEP2011	17173	JUN2013	21521	MAR2015	23496
JAN2010	7253	OCT2011	18307	JUL2013	20436	APR2015	24758
FEB2010	7779	NOV2011	19112	AUG2013	21911	MAY2015	25440

Figure 1 - Online Vacancies

Source: Online Job Openings Report May 2015

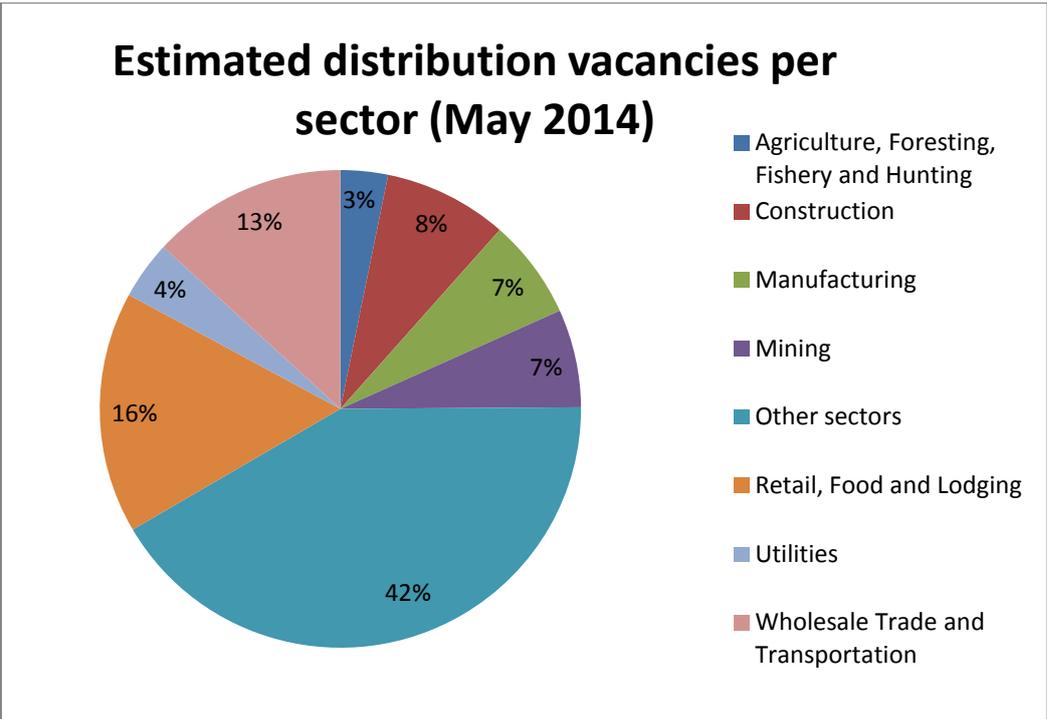
One should note that the data above does only reflect the online vacancies from the online job opening board from Job Service ND. Vacancies in magazines, newspapers, billboards and vacancies filled through mouth-by-mouth are not counted. This would imply that the

reference data used for vacancies probably underestimates the real values. Because this is the only data available and because we assume that most of the vacancies will be placed online, we will still take the data published by the Online Job Openings Report as our reference mode.

This research divides the labor market into eight different sectors, namely:

1. Agriculture, Forestry, Fishery and Hunting
2. Construction
3. Manufacturing
4. Mining
5. Other sectors
6. Retail, Food and Lodging
7. Utilities, Administrative and Waste Services
8. Wholesale, trade and transportation

This division is made to complement Abida Muminova's research project on the demand side of the labor market. For the simulation of the production by sector, she has based her structure on an input and output model. The input-output coefficients were required from input-output data files. The sectors distinguished in these data files determined the final division of sectors in both our research projects.



Agriculture, Forestry, Fishery and Hunting	779
Construction	2041
Manufacturing	1650
Mining	1625
Other sectors	10204
Retail, Food and Lodging	4004
Utilities	962
Wholesale Trade and Transportation	3221

Figure 2 - estimated distribution vacancies per sector

Source: Based on the Online Job Openings Report May 2015

One of the big disadvantages of data sets published in the Online Job Openings Report is that they do not measure the vacancies per sector, but per occupation. A rearrangement of the data from occupation to sector has been made to make an estimation of the vacancies per sector. Many occupations can, however, be practiced in different sectors. To be able to make a realistic rearrangement of the data, we use the occupational employment distribution per industry from the ND Workforce Intelligence Network. On this webpage there is a profile created for each industry with the top 10 occupations and the estimated employment for the year 2012. We reorganized this data per occupation. For each occupation, the sectors in which that occupation is active, are presented with the estimated employment. After that a weighted factor is assigned for the representation of that occupation in each sector. Per occupation, the vacancies are now redistributed over the sectors using these weighted factors. This will result in an estimation of the total vacancies per sector. This estimation is used for initialization of the model and a rough validation of the model behavior. Figure 2 presents a distribution of the vacancies over the eight sectors.

In Empower North Dakota, Policy Updates and Recommendations, the oil and gas industry was responsible for approximately one-third of North Dakota's vacancies (North Dakota Department of Commerce, 2014). Although the mining industry only accounts for 7% of the total job openings in this estimation, many other sectors are heavily relying on the oil and gas industry. A high fraction of the transportation business is for example driven by the need to transport oil and gas products.

The level of vacancies is affected both by the demand and the supply of labor. In this research we will focus on the supply of labor. Normally, the supply of labor is assumed to be equal to

the labor force. The labor force is the sum of the unemployed and the employed workers who are residents in a selected area, North Dakota in this case. Persons are classified as unemployed if they currently do not have a job, are available for work and have actively been looking for work during the last 4 weeks. Persons are classified as employed if they hold a job for pay or profit, or if unpaid they should work at least 15 hours per week for family-operated enterprises (Bureau of Labor Statistics). Figure 3 present the historical behavior of the labor force.

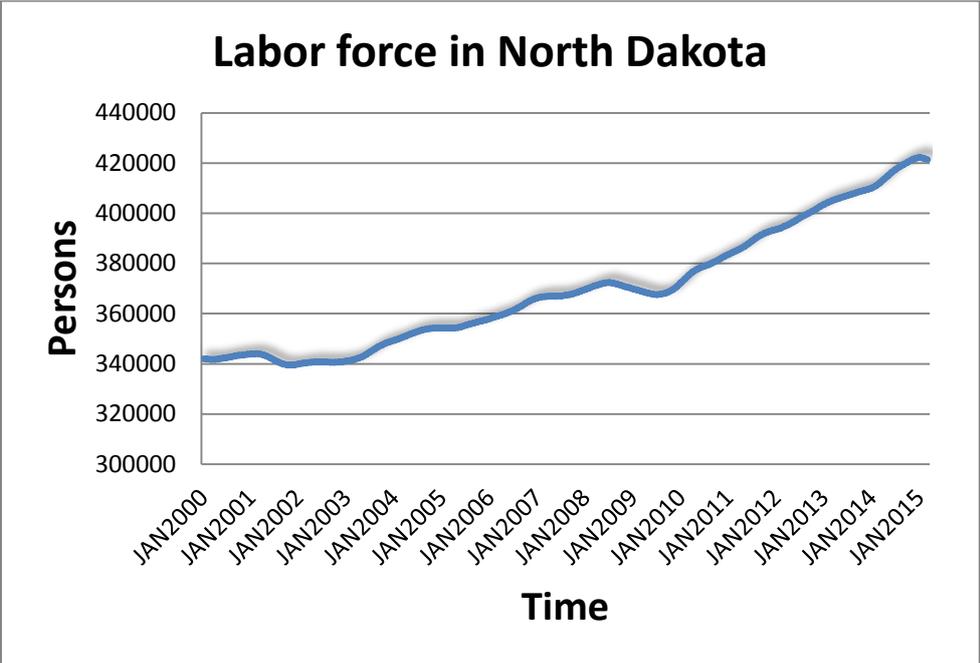
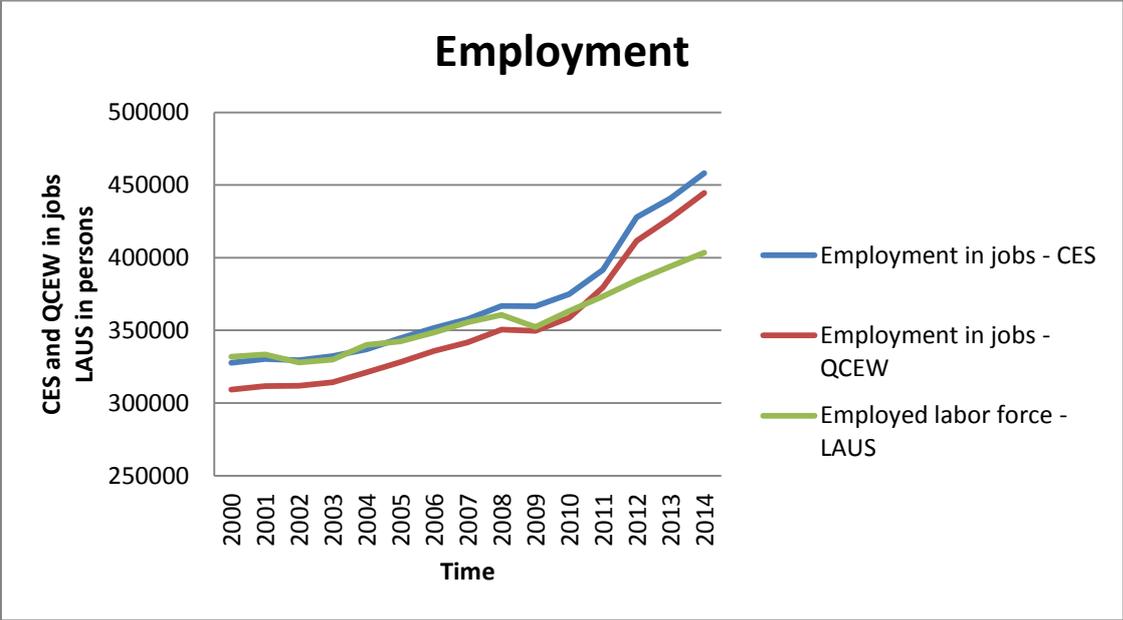


Figure 3 - labor force
Source: Local Area Unemployment Statistics (for data see figure 5)

The labor force has increased from 341 940 persons in 2000 to 414 873 persons in 2014. The labor force decreases in the beginning of the 00s and shows a steady increase from 2003 to 2008. During 2008-2009 the labor force decreases due to the national recession. After 2009 the labor force starts to increase again at a relative steady rate. The time steps of the historical data in figure 3 is month. The figure is therefore able to reveal the beginning of a decrease in labor force in 2015.

The labor force alone is, however, not a good representation of the labor supply. The labor force does only reflect the supply of labor which stems from North Dakota residents. It does not include the job seekers/workers in North Dakota, who are originally resident outside the

state. Figure 4 presents different measurements of the employment in North Dakota, which is larger than the labor force as traditionally measured in the state.



	Employment in jobs - CES	Employment in jobs - QCEW	Employed labor force - LAUS	Labor force	Unemployed labor force
2000	327700	309224	331939	341940	10001
2001	330300	311634	333328	342985	9657
2002	329400	311809	327911	340765	12854
2003	332300	314273	329847	342883	13036
2004	336900	321111	339925	351759	11834
2005	344700	328121	342420	354507	12087
2006	351700	335721	348589	360104	11515
2007	357800	341706	355496	366980	11484
2008	366800	350442	360598	371949	11351
2009	366600	349562	352387	368041	15654
2010	375000	358673	363297	377636	14339
2011	391700	379433	373385	386831	13446
2012	427800	411710	384435	396336	11901
2013	440900	427109	393999	406079	12080
2014	458200	444658	403539	414873	11334

Figure 4 - employment

Source: Current Employment Statistics; Quarterly Census of Employment and Wages; Local Area Unemployment Statistics

Three datasets are available which measure the employment in North Dakota, illustrated in figure 4, which are: (1) the Quarterly Census Employment and Wages, (2) the Current Employment Statistics, (3) Local Area Employment Statistics.

The Quarterly Census Employment and Wages (QCEW) reflects an increase from 309 224 filled jobs in 2000 to 444 658 in 2014. Until 2003 a small decrease in the employment can be noticed, after 2004 the employment has a steady growth of employment, until the year 2008. 2009 shows a slowdown in the employment, which can be assigned to the economic crisis. After 2009 the employment grows with an increasing growth rate, reaching its peak in 2012. After 2012 the growth rate of the employment starts to decline, but the employment is still growing at a high level. Recent information indicates that the growth in employment in 2015 has been slowdown due to lower activities at the oil field, caused by the low oil price. Data revealing this slowdown was, however, not yet available by industry at the time of data gathering, so unfortunately this input cannot be used. The employment estimated by the Current Employment Statistics starts at a higher level of 327 700 filled jobs in 2000. The behavior follows the same trend as that of the QCEW measurements of employment. The behavior of the total employment in the CES only reflects a slightly higher growth rate after 2009.

The employed labor force as estimated by the Local Area Unemployment Statistics reflects a different trend in employment growth. The employment as estimated by the LAUS represents the employment in persons, instead of in jobs. The employed labor force starts with 331 939 persons in 2000 and shows the same trend in behavior as the employment measured by LAUS and QCEW until 2008. During the recession, the decrease in number of employed North Dakota workers is higher than the decrease in number of jobs. After the economic crisis, the employed labor force starts growing again, but the employed labor force has a significant lower growth rate than the employment measured in jobs. To understand the differences in trends, one first needs to understand the methodology behind the datasets. This will contribute to the understanding of the reference behavior we are trying to explain with the model.

The Quarterly Census Employment and Wages (QCEW) and the Current Employment Statistics (CES) count only the filled jobs, whether full-time or part-time, temporary or permanent, by place of work (technical notes QCEW, Bureau of Labor Statistics). It excludes proprietors, the unincorporated self-employed, unpaid family members and domestic workers.

The QCEW excludes most agricultural workers on small farms, the CES excludes all workers in the agriculture sector. Both employment counts also excludes workers who earned no wages during the entire applicable pay period because of work stoppages, temporary layoffs, illness, or unpaid vacations. The difference between the two databases is that the Quarterly Census Employment and Wages derives the employment counts from quarterly contribution reports filled by almost every employer. The Current Employment Statistics, on the other hand, is retrieved from a national employer survey of approximately 554 000 nonfarm establishments. CES dataset is thus an estimation while QCEW is a count, CES adjusts the numbers of the month prior to the reference month with the ratio derived from the survey to get the current employment statistics. To develop the state employment estimations, a state specific portion of the national sample is taken (technical notes CES, Bureau of Labor Statistics). An remarkable difference in output between the two datasets is that the QCEW statistics counts presents a consistent lower numbers of total employment than the CES does, although the QCEW includes agriculture. A plausible explanation is that QCEW covers only the insured employment, the employees of establishments with an Unemployment Insurance coverage, while the CES also makes an adjustment for the 'presumed not covered' (Bureau of Labor Statistics, technical notes CES). Unfortunately, data on the coverage rate of insured employment in North Dakota compared to other states is not available online, so this hypothesis could not further be examined. Overall, the two datasets show the same behavioral patterns, which is most relevant for the validation of this simulation mode. As input for this simulation model, the QCEW statistics are used. Most official governmental institutes use the QCEW statistics for analysis and the usage of this database would therefore be more consistent with other research projects. Furthermore, only the QCEW includes employment for the agriculture sector.

The most noticeable observation from figure 4 is that, since 2009, the behavioral pattern of the Local Area Unemployment Statistics differentiates significant from the behavioral patterns of the other two datasets. The LAUS publishes employment data on state wide level, based on a household survey. In the Local Area and Unemployment Statistics someone is assumed to be employed, if that persons did any work for pay or profit during the survey reference week; did at least 15 hours of unpaid work in a family-operated enterprise; or was temporarily absent from their regular jobs because of illness, vacation, bad weather, industrial dispute, or various personal reasons. If a person holds two jobs, that persons is only counted once. In contradiction to the QCEW and CE Statistics, where multiple job holders are counted

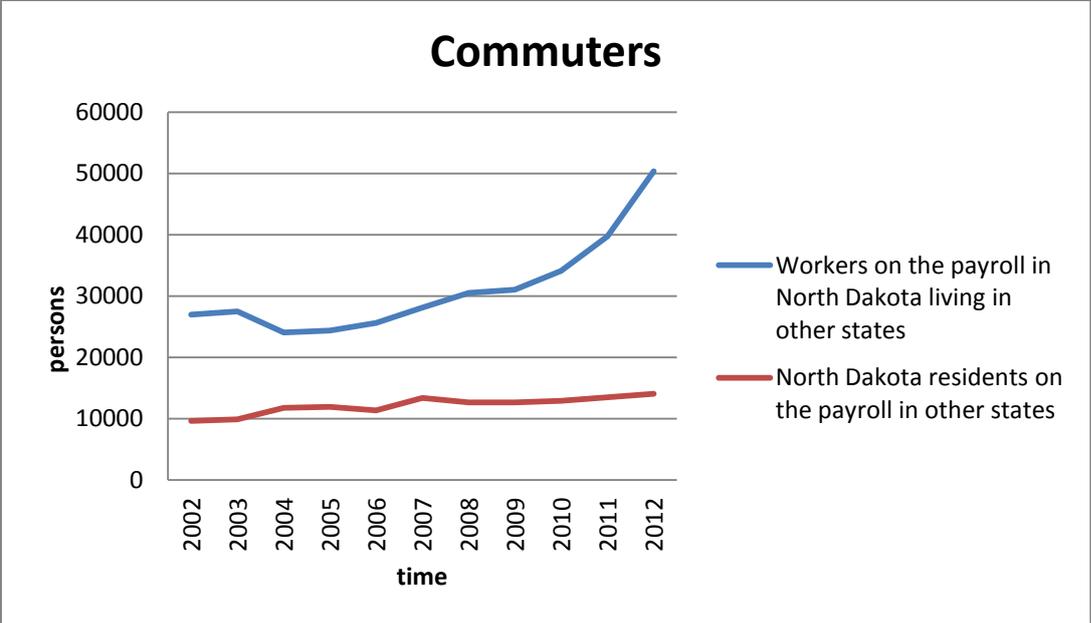
twice. Another important difference in measurement is that the estimation of the employed labor force in the LAUS is a combination of the results of the household survey and an adjustments to the underlying population base, which is revised annually to intercensal estimates, and every 10 years to the decennial census (Bureau of Labor Statistics, 2015). While the QCEW and CE Statistics are based on the current place of work, the LAU statistics are based on the current place of residence. The LAUS estimate of the labor force and the employed labor force thus only reflects the local labor supply, revolving from the residents of North Dakota, new migrant workers included. Commuters living outside North Dakota's borders are thus excluded in LAUS and included in the QCEW and CE Statistics.

The growing gap between LAUS and the QCEW (figure 4) might thus be explained with a growing group of commuters, which are filling North Dakota's jobs. This hypothesis is further tested by correcting the employment in jobs for the multiple job holders. The multiple job holders as a fraction of the total employed labor force (U.S. Bureau of Labor Statistics, Current Population Survey) has decreased from 0.10 in 2000 to 0.079 in 2013. This means that the gap between the employed labor force and the employment in jobs should only have been declined. The growing gap between the employment in jobs and the employment in persons can thus not be explained with a change in multiple job holders.

An analysis of the total employment in persons and jobs on U.S. level gives further support for a growing group of commuters. On U.S. level commuters between states are canceled out. If the data on U.S. level would also reflect a growing gap between employment in jobs and persons, the hypothesis of commuters as being the driver behind the different growth patterns can thus be thrown away. The historical data on the employed labor force and the employment in jobs on U.S. level reveal the same growth patterns (Bureau of Labor Statistics, 2015). The hypothesis of a growing group of commuters can thus not be rejected. It is highly possible that the increasing gap between the employed labor force as estimated by the Local Area Unemployment Statistics and the employment in jobs as counted by the Quarterly Census of Employment and Wages can be explained by an increasing amount of jobs filled by non-resident workers, commuters.

After an analysis of the historical behavior and the methodology, more research has been done on available data on commuters. Data on commuters was hard to acquire. An increase in the representation of commuters active in North Dakota's labor market after the year 2009 is confirmed with the Home-Destination Report, which shows an increasing growth from 31 066

to 50 339 workers from outside North Dakota on the payroll. Meaning that in 2012, 13,5 % of total employment is from outside North Dakota according to the Home-Destination Report. In contradiction to the inflow of workers from other states, the amount of North Dakota residents being employed outside the state is only raised from 9 647 persons in 2002 to 14 099 persons in 2012. This stands for a percentage of only 4,2% of North Dakota's employed residents who are working outside North Dakota. It is, however, important to note is that other sources (not published) make different, higher estimations of the amount of commuters in North Dakota. One of the reasons lies in the fact that the Home-Destination Report already bases its estimation on 296 093 total jobs, and a total amount of primary jobs of 269 671 in 2002. The primary jobs include only the highest paying job for an individual worker and is the same as the count of workers (OnTheMap Help and Documentation, 2015). The total employment in jobs according to the QCEW in 2002 is equal to 311 809, which is 15 716 jobs more than the Home-Destination Report is saying. Therefore, one should be careful in using those estimations of the commuters for validation purposes of model output. Nevertheless, the patterns can be compared and used for validation



	Workers on the payroll in North Dakota living in other states	North Dakota residents on the payroll in other states
2002	27001	9647
2003	27505	9893

2004	24067	11779
2005	24397	11947
2006	25627	11358
2007	28115	13405
2008	30540	12684
2009	31066	12690
2010	34117	12931
2011	39755	13516
2012	50339	14099

Figure 5 - commuters

source: Home-Destination Report, 2015

To sum up, a significant percentage (13,5%) of North Dakota's primary jobs are filled by workers commuting to a job in North Dakota from other states, compared to 4,2% of the jobs outside North Dakota which are filled by North Dakota residents. 4,2% of North Dakota's labor force as measured by the LAUS is thus not part of the supply of labor within North Dakota's borders. While the labor force does not show the part of the supply of labor coming from outside the borders. Most research studies on the labor supply do not include the flow of commuters. Probably because in most countries the net flow of commuters is close to zero, and the flows are relative constant. A booming economy in a small state such as North Dakota is however driving on these commuting flows. The supply of labor can therefore sustain with an evaluation and simulation of the labor force alone. The supply of labor in this research will thus include both North Dakota's labor force and the flows of commuters from and to North Dakota.

3. CONTRIBUTION TO LITERATURE

Booming economies are more frequent studied in literature. From the late 19th century until now most research studies on booming economies concentrate on the production side of the economy. The Dutch Disease is often examined in the context of an oil boom in open economies (Beine and others, 2011; Ismail, 2010) . The Dutch Disease represents de-growth in the production of the manufacturing sector as a result of the boom in the oil sector. The boom in the oil industry affects the other sector negatively through increasing exchange rates which lead to decreasing global competitiveness. Also the re-allocation of labor has a negative impact of other industries. Corden and Neary (1982) study the Dutch Disease with a focus on the medium-run effects of a boom in one of the industries on the allocation of labor and capital over the various industries. Also the income distribution is captured in their research. The main conclusion from research projects on the Dutch Disease in relation to the supply of labor is that the boom in employment in the oil industry would have the side effect of a decreasing level of employment in other industries, driving by re-allocation of labor. The impact of labor in the production of sectors is kept at an highly aggregated, abstract level.

The impacts of oil shocks within the oil sectors and its relation to the level of production in others sectors have gained high attention in scientific research (Gelb, 1988). Understanding is gained of the effects of declining energy prices on the oil sectors. This would have a spillover effect on other sectors. Although the dynamics between sectors during a boom are broadly accepted and studied, the dynamics are mainly limited to re-allocation of resources and its effect on the production level. The resources are assumed to be fixed.

Beine, Coulumbe and Vermeulen (2012) used the basic model of the working of the Dutch Disease (Corden and Neary, 1982), and changed the characteristics of labor from a fixed factor into a variable factor. That paper examines whether the Dutch Disease can be hindered by an immigration effect on the supply of labor, the immigration is driven by labor market conditions. Their focus is on Canada's oil boom. Their empirical analysis differentiates different types of migration, namely temporary international migration, permanent international immigration and interprovincial migration. Temporary migrants are workers who work under the provincial temporary workers programs. From their observations they conclude that the Dutch Disease can be mitigated through immigration. The temporary

employment programs and interprovincial migration are the key drivers of this immigration process.

The common ground between Beine, Coulumbe and Vermeulen (2012) and this research is that both researches assume mobility of workers between the different sectors, as well as an inflow of workers from outside the area. Differences are evolving due to the different geographical area of research. The difference between the case of Canada and North Dakota is that in Canada many workers come from outside the country and need to be selected for work programs to be able to work temporary in Canada. Which is in contradiction to North Dakota, where workers from all over the United States are allowed to work in the state. Many jobs are therefore filled with workers who are not residents of North Dakota. Most other studies of booming economies are concentrated on countries, which do not allow these commuting patterns and the labor supply dynamics of studies are thus limited to migration patterns. Weber's (2012) study on the effect of the oil boom is, however, concentrated on states which allow commuting patterns. The study concentrates on the inflow of workers in Colorado, Texas and Wyoming and the effect on the total employment and wages, but does not specify the inflow of workers. Other research has also been exercised on North Dakota. Hodur and Bangsund (2013) has made population projections for the city of Williston (in the Bakken Area of North Dakota), and differentiated a temporary and permanent employment and population. Commuters are defined as temporary employment. The projections are based on input-output models and do not show the actual dynamics behind the data output. This research will therefore contribute to the understanding of the effect of the commuting patterns on North Dakota's labor market.

Another gap in the research on oil booms is the lack of focus on the level of vacancies. Many research projects only consider the employment levels and do not pay attention the level of vacancies. Beine, Coulumbe and Vermeulen's (2012) model, for example, represents the allocation of workers to different sectors as a result of an increase in production. In North Dakota, the level of vacancies is of great concern to the policy makers, because this would limit further growth. The drivers behind the level of vacancies are studied in job-worker match theories (i.o. Blanchard and Diamond, 1989a; Merz, 1995; Mortensen and Pissarides, 1999) and theories on labor market rigidities (i.o. Helpman and Itskhoki, 2010). According to Mortensen and Pissarides, 'the job-worker match is formed when a qualified unemployed worker and a sufficiently attractive vacancy meet' (1999, p.2574). The labor market rigidities

limit the mobility of workers between sectors and thus the amount of qualified worker to fill the vacancies. While other research studies only concentrate on the effect of production on the employment, Blanchard and Diamond (1989a) also acknowledge the effect of employee quit rates on vacancy creation. These effects are not taken into consideration in the oil boom research studies, but a study of North Dakota's labor supply revealed that many industries suffer from high quit rates.

Also in System Dynamics, a different aggregation level can be noticed between oil boom studies and general labor supply studies. Ford created a holistic model able to simulate the "boom town" impacts that could occur from energy plants which is placed near to a small, isolated community (1976). Ford's model does not take the internal labor supply dynamics into account and does not differentiate between different sectors. Runge's research on the labor market dynamics in return delivered a model of different sectors of the economy. He included 'the causes as well as the consequences of worker movement' (1967, p. 104), which means that the effect of employee quit rates on vacancy creation is included. He, however, did not allow for external growth in the supply of labor. Stevens (2002) created a conceptual model of internal labor market dynamics in relation to the data bases of the Bureau of Labor Statistics, linking the data sources to the stocks and flows. Although this study gives insights in creation and depletion of vacancies, a simulation model is not made. Many simulation models on the labor supply are still based on Stermans model (2000) in Business Dynamics. In those models, only the effect of production on employment is considered. Vacancies are only created as a result of growth in production. There is not yet a System Dynamics model which captures both the dynamics within one sectors, between the sectors and the migration and commuting patterns.

More System Dynamics models on booming economies take a broader view than just the labor market. The earliest System Dynamics model on a booming economy, was Andrew Fords' Boom1 model. The model captured five sectors: 1) housing, 2) public construction and municipal financing, 3) retail and services, 4) power plant and 5) migration. His System Dynamics model shows that the dynamics do not only take place between different industries in a economy, but they also impact other sectors of the economy which can in return impact the industries through the supply of labor. Migration is for example impacted by the labor market, but the population growth also impact the adequacy of facilities and therefore reduces migration and thus impacts the labor supply. Effect of social factors on migration are also

presented in Forrester's model of urban growth in *Urban Dynamics* (1969), where especially the effect of housing on the inflow of population to cities was projected. In this research, we will not be able to present a complete, holistic view on the booming economy. The focus will be on labor supply dynamics, migration and commuting patterns. Since North Dakota has experienced a major housing shortage due to the inflow of workers, the effect of housing on immigration will be included.

To summarize, studies on booming economies do account for labor mobility between sector and growth in labor supply, but do not have the level of disaggregation necessary to explain the levels and trend of labor supply in the different sectors and its relation to the levels and trends of the vacancies. Models and theories on labor supply dynamics, on the other hand, have a better examination of vacancy creation and the filling of those vacancies, but do not reflect the growth in labor supply stemming from changes in migration and commuting patterns as a result of the boom. Since the main concern of the Department of Commerce of North Dakota was to lower the level of vacancies since the beginning of the oil boom, a comprehensive, disaggregated study is necessary to be able to explain the vacancy level. This research will combine both insights from the studies on booming economies and the studies on the labor supply to create a better, comprehensive understanding in the level and trends of the labor supply and the vacancies. This research project tries to capture (1) the internal dynamics of a sector, (2) the external dynamics with the other sectors and (3) the total labor supply dynamics which allows for immigration and commuters. A model with a combination of these different levels of aggregation has by my knowledge never been created before, especially not in relation to oil booms. This research will add to the understanding of all the dynamics within and between the segments of the labor market system. It also shows the effect of these labor supply dynamics on the level of vacancies. System Dynamics is the best tool to deal with complex, dynamics systems. It also allows me to combine the different levels of aggregation.

4. METHODOLOGY

The aim of this research to understand the level and trends in the supply of labor of each sector in North Dakota and its effect on the level of vacancies. Understanding the labor supply dynamics will give more insights in the changes in the level of vacancies in the period 2000-2015. Special attention is being paid to the response of the labor supply to the labor demand. The model created to capture these dynamics can be used to test different policy options and labor demand scenarios. The research takes a holistic approach. The labor supply is studied as a broad concept, including both internal growth rates of the labor force, migration patterns and commuting patterns. Besides that the labor market is differentiated in 8 sectors. All those different segments of the labor market are connected to each other. Only with System Dynamics one is able to create a simulation model which is able to include all the feedback loops.

This research is based on a combined study of qualitative and quantitative secondary data. Online news articles, documentaries on North Dakota booming industry, campaign webpages (i.e. www.findthegoodlifeinnorthdakota.com), governmental reports (i.e. Department of Commerce) and the webpage of the State Government are studied. A study of these data sources works in twofold. First, it reveals the main concerns of North Dakota's population and government. Second, the labor supply is a result of the decision made by the people in North Dakota and other states. The decisions of people are impacted by public information, and thus by the qualitative data sources.

Quantitative data analysis has also formed a big part of the research. Data is retrieved from online sources, mainly the Bureau of Labor Statistics, North Dakota Workforce Intelligence, the Census webpage and the American Fact Finder. Some data is privately received from the Department of Commerce and is unpublished. Several data sources claiming to measure the same variable are showing different data outputs. Analysis of the technical notes of the databases were necessary to understand the methodology behind the estimation or measurement of the variable and the definition of the concept used. In some cases, conversations with the specific data analyst were necessary to get a clear understanding of the behavior presented by the databases. Data analysis are mainly used to set the boundaries of the model, to initialize and to validate the model.

The hypothesis derived from the study of secondary data is tested with formal and informal conversations with managers from the different industries, members of the Department of Commerce, data analysts, and other (former) workers of North Dakota. A literature study is, then, conducted on job-workers match theories, theory on migration patterns and commuting patterns as well as labor supply theories in general. The literature study is mainly used for getting insights in the structure of specific parts of the labor market system, which proved to be important to the behavior of the labor supply as derived from the secondary data analysis.

As Homer (1995) stated, the modeling process is iterative, trial and error are necessary to bring the assumptions behind the model closer to the truth. Trial and error turned out to be the order of the day. More testing of the model, revealed more unknown dynamics which made further qualitative and quantitative analysis necessary. The model started with a simple structure, but disaggregation was rapidly required to be able to explain some patterns found in the news articles. Structure verification took place during the whole process. Forrester and Senge (1980) mention that 'a structure verification test is first conducted on the basis of the model builder's personal knowledge and is then extended to include criticism by others with direct experience from the real system' (p. 416). The model structure has been reviewed by prof. David Wheat, at the University of Bergen, and Scott Johnson, at the University of North Dakota. The structure of the explanatory model has also been presented to members of the Department of Commerce and relations are verified.

Sensitivity tests has been conducted on various variables to test the sensitivity of the system to these variables. Furthermore, extreme validation testing had been done to validate the model. To test the strength of the major loops in the system, loops has been closed and the difference in behavior has been analyzed.

Analysis of the behavior of the simulation model reveals policy leverage points. A combination of secondary qualitative data analysis on governmental policy recommendation documents (i.o. Empower North Dakota) and conversations with policy makers from the state government of North Dakota showed a few, well established policies. Those policies were tested in the simulation model.

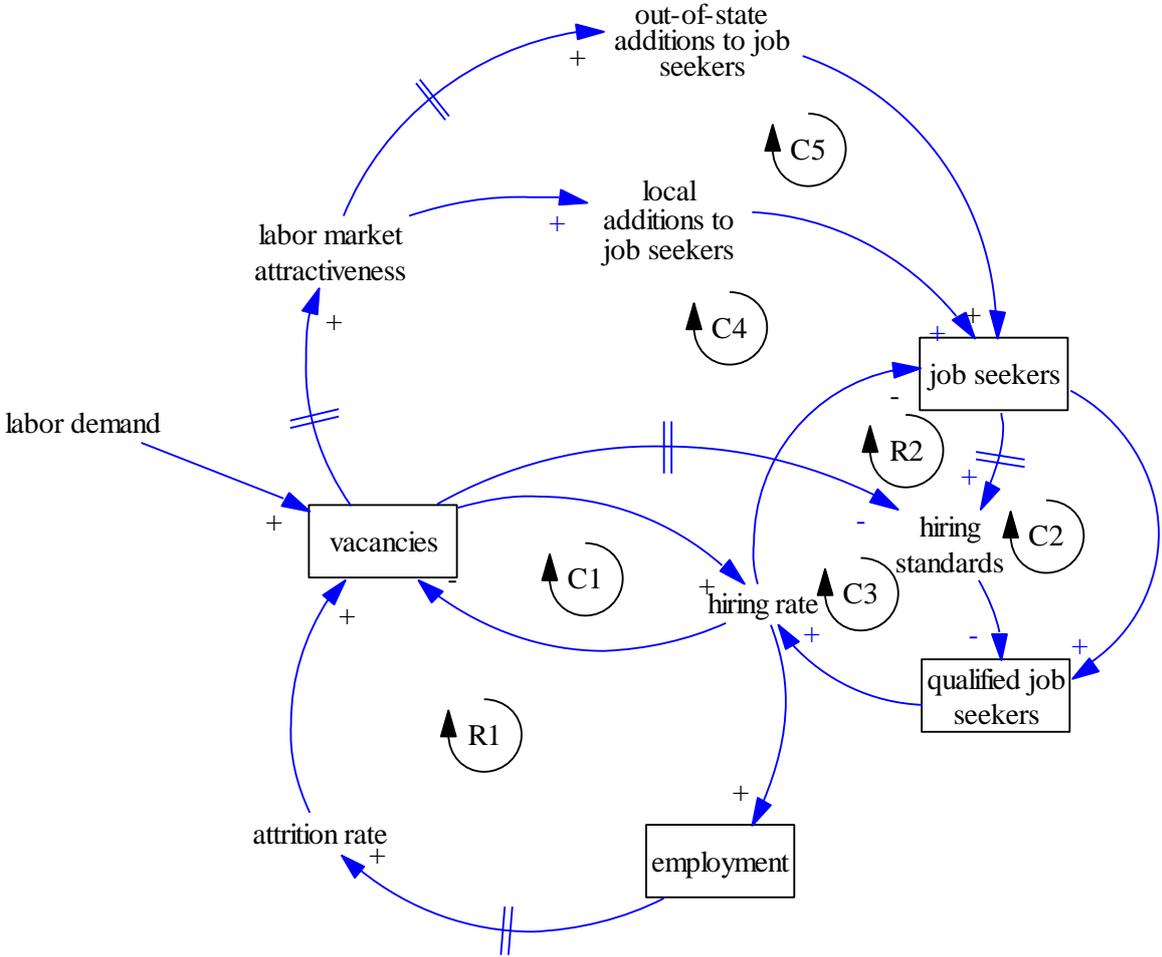
5. CONCEPTUAL MODEL

The level of vacancies in North Dakota has been increased to 27 000 vacancies in 2014, one-third of the vacancies is a result of the oil and gas industry. In the beginning of the 00s the high oil price and the development of new technologies made it possible to start drilling oil in the Bakken Area. The boom in the oil and gas industry has raised the demand for labor. The effect is not only noticeable in the oil and gas industry, but also in other industries throughout the state. The high production in the oil and gas industry stimulates a higher demand for the other industries. To meet the increase in the labor demand, more workers got hired. The unemployment rate in North Dakota becomes the lowest of all states. Most job seekers are able to get a job within a day and wages are rising. Even persons who were not planning to participate in the labor force are now attracted by the high job prospective. The high job prospective also triggers workers employed in lower paid jobs to leave their current job and to find a higher paid job at the oil field. This gush leaves many organizations with the problem of high attrition rates. North Dakota's labor force is trying to keep up with the demand for labor. This is expressed by the vacancies. North Dakota's local labor force is, however, not able to fill all the jobs, even when more residents start to participating in the labor market. Organizations lower their hiring standards to be able to fill more jobs.

Business and state government have started campaigns to attract workers from other areas. The mobile workers who move from oil field to oil field quickly find their way to North Dakota. Many other unemployed workers from the surrounding states are also attracted by the high labor market attractiveness. They quickly find a job at North Dakota's oil field or at other industries. These workers go for the big pay check in a short period of time. Since North Dakota is not prepared for the huge inflow of worker, the housing and other infrastructure is not keeping up with the demand. Living conditions are not satisfying the demand, but this is compensated with higher earnings.

In the end of 2014, the oil price busted, leading to collapsing project profits. The demand for labor declines and employees got fired. The labor market attractiveness worsens, creating new challenges for North Dakota's labor supply.

The main effects of the boom in the labor demand on the labor supply and the level of vacancies are illustrated in model 1. The labor supply exists of both the job seekers and the employed workers, the employment.



Model 1 - conceptual model

Model 1 shows that if the labor demand increases more vacancies will be created and thus the level of vacancies will increase. As a response the hiring rate will be increased. An increase of the hiring rate implies that more vacancies will be filled and this depletes the level of vacancies (see C1). The working of this counteracting loop is however weakened by the effect of job seekers on the hiring rate. The hiring rate reflects the amount of job-worker matches made per year. A job-worker match can only take place if '... a qualified unemployed worker and a sufficiently attractive vacancy meet' (Mortensen and Pissarides, 1999, p.2574). The hiring rate is thus constrained by the number of qualified job seekers. The number of job seekers affects the group 'qualified job seekers'. The more job seekers, the more qualified job seekers. If there are more qualified job seekers, more job seekers are thus qualified enough to

be hired and the hiring rate increases. Due to the hiring of job seekers, these job seekers will become employed and this will deplete the stock of job seekers. A decrease in job seekers thus decreases the hiring rate. The loop C2, will thus have a counteracting effect on the hiring rate, meaning that less vacancies can be filled.

A labor shortage can arise when the amount of job seekers per vacancy decrease either because the supply of labor in the form of the job seekers decreases and/or the level of vacancies increase. However, organizations will still want to fill their vacancies. To be able to hire more workers, the organizations have to adjust their hiring standards. The hiring standards is based on both the characteristics of the job, the experience of the job seekers, the desired motivation and fit to the organization. The hiring standards determine when a job seekers is assumed to be qualified enough to perform the job and thus gets hired. If the desired hiring rate increases and less job seekers will are assumed to be qualified than the desired hiring rate requires, the hiring standards will be lowered. This means that the organization has less to demand of the qualities of the worker and thus more job seekers will fit the demands, so more job seekers are assumed qualified. Loop C3 shows that if the vacancies go up, the hiring standards are lowered, more job seekers are assumed to be qualified and the hiring rate can go up. This will in return depletes the level of vacancies.

Also an increase in the amount of job seekers will lead to more qualified job seekers and thus more potential job-workers matches. So even if the number of vacancies stays equal, the hiring rate could be increased. If the amount of job seekers increase and the organization does not need to hire more workers than before, the organizations are able to adjust their hiring standards. An increase in hiring standards, leads to less qualified job seekers and to a lower hiring rate. A lower hiring rate implies a lower depletion of the job seekers and the level of job seekers will thus be higher, than would have been under lower hiring standards. Feedback loop R2 presents this reinforcing effect.

Not only do the organization respond to the changing labor market conditions, also the labor supply reacts. As a response to an increase in the level of vacancies, the labor market attractiveness will increase. In the first place, an increase in labor market attractiveness will increase the participation of North Dakota's working-age population in the labor force and thus stimulates an inflow of local job seekers. This increase in job seekers, will increase the hiring rate and will deplete the level of vacancies. This will in return lower the labor market

attractiveness (see C4). This counteracting loop through the labor market attractiveness is only strengthened by the effect of the labor market attractiveness on the net flow of out-of-state job seekers. If the labor market in North Dakota is more attractive relative to the labor market attractiveness in the original place of residence, workers from other states in the U.S. and from other countries will come to North Dakota, resulting in the net flow of out-of-state workers increasing. This will increase the number of job seekers in North Dakota and increase the hiring rate (see C5).

The counteracting loops together still have a down pressing effect on the level of vacancies through the hiring rate on the level of vacancies. The important contribution of this research is the reinforcing loop through the attrition rate. An increase in hiring rate, leads to an increase in employment. If the employment is higher, there will be a higher rate of attrition (with reasons of employees finding another job, retirements and emigration). This will in return higher the level of vacancies (see R1). As a result, a boom in the demand for labor, leading to an increase in employment, will lead to a higher equilibrium level of vacancies.

This simplified, small conceptual model is created to summarize the main loops at an highly aggregated level. The combination of all the loops reveals an important reinforcing loop. Namely, a higher level of vacancies, stimulated by an increase in labor demand, improves the labor market attractiveness. This fosters an inflow of job seekers, both from within and outside of North Dakota's borders, which increases the job seekers in North Dakota. The labor supply thus increases as a response to an increase in labor demand. This increases the hiring rate and thus the employment. A higher level of employment, then increases the attrition rate and the level of vacancies increases again as more vacancies are being placed for replacement. This will stimulate a new inflow of job seekers (see the combination of C5 and R2).

5.1 Setting the frame for disaggregation

The conceptual model presented in the previous section will be disaggregated to get a deeper understanding of the dynamics of the labor supply. A differentiation should be made between the different types of job seekers and the different reasons of attrition. For example, out-of-state workers tend to retain their job for a shorter period of time and thus impact the attrition rate more than local workers do. More attention is also paid to the hiring process of the different job seekers and the dynamics between the sectors. The next chapter will present a

deeper, disaggregated examination of the labor supply dynamics, showing two simplified stock-and-flow diagrams. First, some background of different types of job seekers will be given.

Job seekers can be either unemployed or employed. Definition of unemployment and employment are taken from the Bureau of Labor Statistics. Persons are classified as unemployed if they currently do not have a job, are available for work and have actively been looking for work during the last 4 weeks. Persons are classified as employed if they hold a job for pay or profit, or if unpaid they should work at least 15 hours per week for family-operated enterprises. The decision process of becoming a job seeker in North Dakota will thus affect the hiring rate. This hiring rate will impact deplete either the stock of employed or unemployed job seekers. Each step in the hiring process is subject to the conditions of the labor market.

Job seekers can also be differentiated in residents and non-residents (or out-of-state job seekers). Only the job seekers who are having their primary residence in North Dakota and are therefore counted as North Dakota's population following the Current Population Survey are measured as resident. Only this group is reflected in the statistics for North Dakota's labor force (Local Area Unemployment Statistics). Following the Online Job Openings Report, the out-of-state job seekers are responsible for 8% of all online job seekers in June 2008 up to 34% at the peak in January 2012. For construction and transportation this percentage rises even to respectively 51% and 57% in January 2012. This indicates the importance of the out-of-state job seekers for the applicants available for selection in each sector. After having explained the general structure of the labor force, which only includes the residents of North Dakota, the model will be extended with the out-of-state job seekers. The out-of-state job seekers who are being hired are employed within North Dakota. They can make the decision to move to North Dakota or keep their primary residence in their current state or country and commute to North Dakota for work. Commuters, for example, have shifts of two weeks straight, one or two weeks off (Siegler, January 31, 2015). During their shifts they stay in temporary housing, such as hotels, RV camps and man camps. In the last case, the employed are counted within the Current Employment Statistics, but not in the Local Area Employment Statistics. The commuters have different characteristics than workers who are also residents of North Dakota. For example, if the employed and commuting workers are starting to search for another job, they have no reason to limit their job search to North Dakota.

As said, the next chapter will focus on the differentiation between the different job seekers. Two simplified stock-and-flow models will be presented which reflect the labor supply, one for North Dakota residents, the local workers, and one for non-residents, the out-of-state workers. The models are presented at the level of one sector, but show some factors that represent mobility between sectors. After having presented the two simplified stock-and-flow diagrams, some essential, small stock-and-flow structures, which reflect the labor mobility will be further, explained to add the dimension of the eight different sectors. The sectors are:

- Agriculture, foresting, fishery, hunting;
- Construction;
- Manufacturing;
- Mining;
- Other sectors;
- Retail, food and lodging;
- Utilities;
- Wholesale trade and transportation.

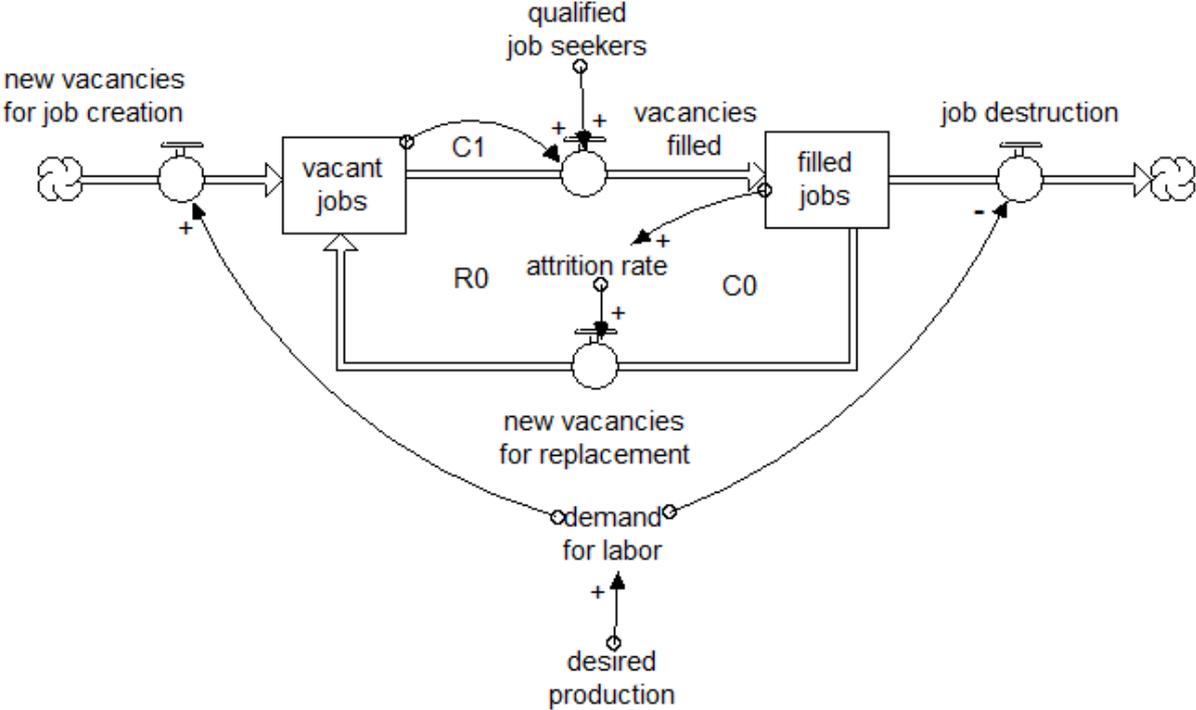
5.2 Extension of the conceptual model

In model 1, the main feedback loop in North Dakota's labor supply system is illustrated. These loops will be further disaggregated to create a better understanding of the drivers of labor supply dynamics.

5.2.1 Recruitment Process

Model 2 presents a simplified model of the vacancies. The oil boom in North Dakota has led to an increase in the desired production which was followed by an increase in the labor demand. In order to increase the labor to necessary level for production, new vacancies are being placed for job creation. In case of a decrease in production, the demand for jobs decreases and jobs will be destructed, which implies that workers get fired. When new vacancies are being placed, either online, in newspapers or through other channels, they become vacant jobs. Selecting an applicant to fill the vacancy, in other words when a job-worker match is established, will fill the vacant jobs. According to Mortensen and Pissarides, 'the job-worker match is formed when a qualified unemployed worker and a sufficiently

attractive vacancy meet' (1999, p.2574). The amount of vacant jobs, which can be filled per period, is thus constraint by the amount of qualified applications per period.



Model 2 - simplified stock-and-flow diagram "local labor supply dynamics" part 1

If the industries in North Dakota would receive a sufficient amount of qualified applications, the industries would be able to fill the desired amount of vacancies and the level of vacancies would go down to the desired level. However, North Dakota labor force is not able to meet the needs of North Dakota labor demand. 'North Dakota's strong economic growth and traditionally low unemployment rate has created an urgent need for additional workforce' (North Dakota's Department of Commerce, 2012, p. 7). In order to understand the behavior of vacancies, it is not only important to understand the demand for labor, but also the supply of labor. It is therefore important to understand what the motivation of someone is to send an application to a business within one of the sectors.

The second reason that the supply of labor is important for the level and trends of the vacancies is the effect of the decision being made by the supply of labor, the workers. Not only does the organization have the power to dismiss a worker from his job, also the worker can decide to quit. When a worker resigns, the filled job becomes vacant and the worker has to be replaced. Assuming that a worker only desires to retain one job for a certain time period (employee tenure), a higher number of workers employed, leads to a higher number of

workers who resign each year. Therefore, more vacancies for job creation will lead to a higher level of vacancies and a higher level of filled jobs. A higher level of filled jobs will lead to a higher 'normal' rate of vacancies posted for replacement and thus a higher 'normal' level of vacancies, see R0. The higher attrition rate will also lower the filled jobs and will therefore lower the attrition rate again, see C0.

The supply of labor thus has a two-fold impact on the level and trends of the vacancies in North Dakota, through the amount of job seekers that are available in each sector and through the attrition rate. The attrition rate will be further disaggregated later in this chapter.

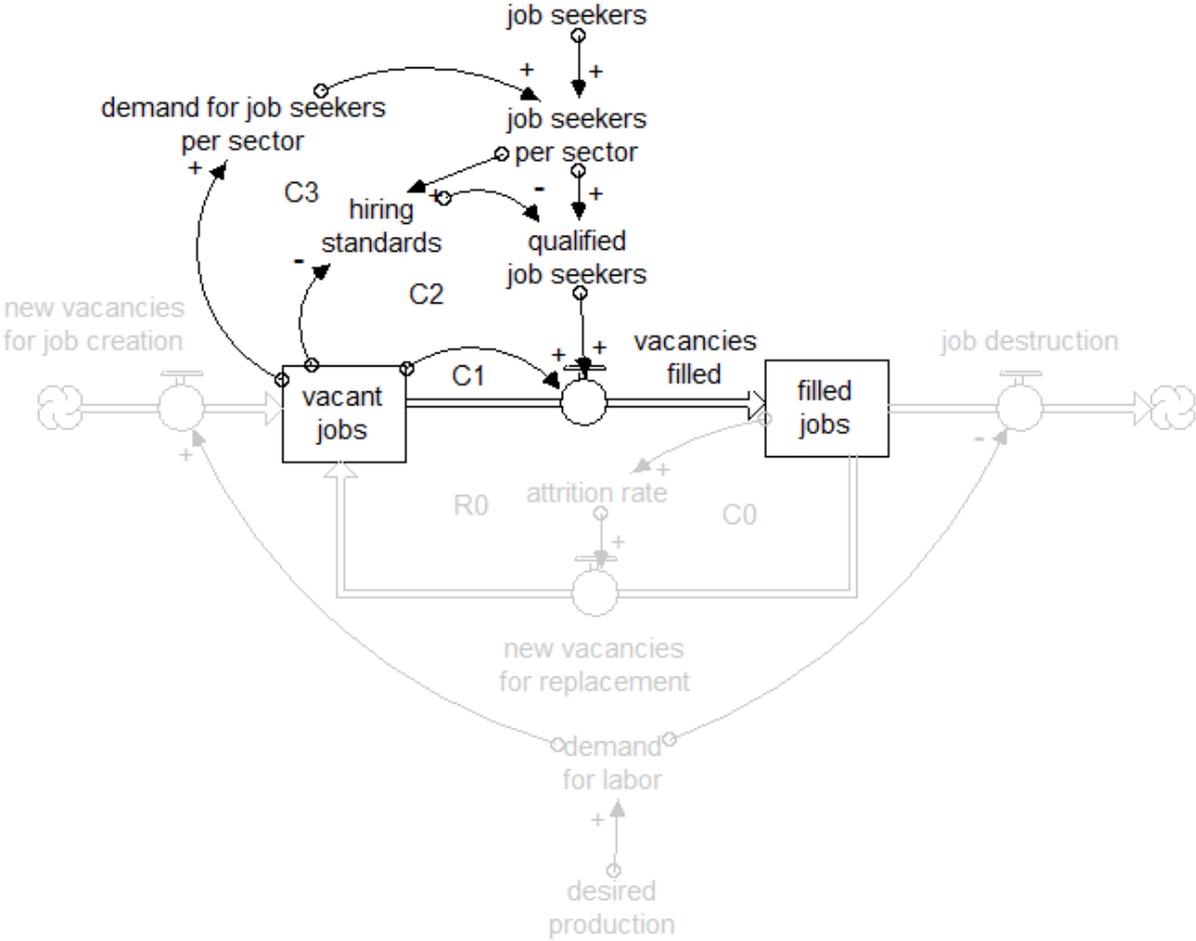
5.2.2 Selection Process

Creation of the vacancy announcement is the first step in the recruitment and selection process of an organization as pictured in the steps in selection procedure of North Dakota Human Research Management Services and the step-by-step recruitment and selection hiring process University of California, Riverside. After that, the selection process determines the amount of job seekers, which are being accepted, and thus the amount of vacancies being filled. From the perspective of the organization, there are several steps in between the vacancy creation and the hiring of a new employee:

- (1) A vacancy announcement is being created;
- (2) Applications for the vacancy are being received;
- (3) Job seekers are selected for interviews and interviews are conducted;
- (4) The best job seekers is selected and hired, the vacancy is filled.

This process is at an industry level conceptually illustrated in model 5. The more vacant jobs, the more vacancies the industry is willing to fill. The amount of vacant jobs being filled depletes the stock of vacant jobs left, meaning that fewer vacancies remain to be filled (see C1). From the pool of job seekers, which are available in each sector, the job seekers who are qualified are being selected for interviews. As discussed in the previous chapter, whether a job seeker is assumed to be qualified is dependent on the hiring standards. The recruiting organization will use the information available for each job seekers and will compare it to its own hiring standards, which is based on both the characteristics of the job, the experience of the applicants, the desired motivation and fit to the organization. The hiring standards will be adjusted to the current labor market conditions. If the amount of job seekers available in each

sector is high compared to the desired hiring rate of the sector, the hiring standards will be high. Higher requirement can be set for the new employee of the organization. However, when the amount of applications decrease, the industry still wants to fill the same level of vacancies and thus the hiring standards need to be lowered as well. C3 shows this counteracting loop, more vacant jobs in a sector, driver the hiring standards down if the same amount of job seekers are available per sector. This leads to more qualified job seekers and more vacancies that will be filled.



Model 3 - simplified stock-and-flow diagram "local labor supply dynamics" part 2

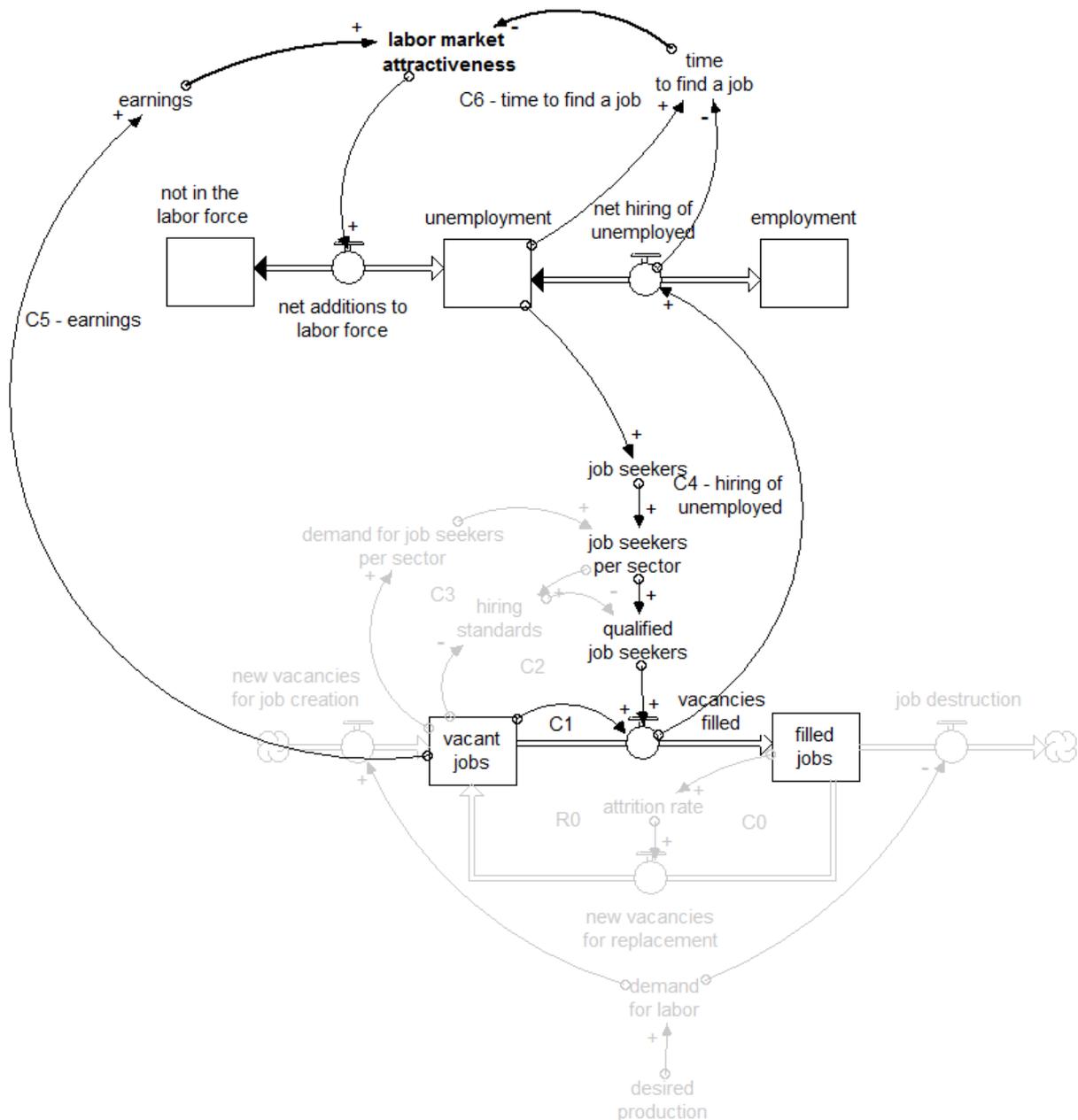
The amount of job seekers who are applying for a job in each sector depends both on the total amount of job seekers in the state and on the fraction of those job seekers who apply for a vacancy for the specific industry. The fraction who apply within each sector is dependent on the demand for the workers in that sector relative to the demand in other sectors. If the demand for job seekers in one sector increases, it will be more attractive to apply for a job in that sector. More job seekers will go to apply in this sector. This process is related to the labor mobility, which is discussed in most research literature on booming economies. The

counteracting loop C3 shows this balancing effect. More vacancies, leads to a higher demand for job seekers, more job seekers apply in that sector and more vacancies are being filled.

Two important conclusions can be derived from this process that are important for the development of North Dakota's industries. First, if the level of vacancies in the oil and gas industry increases, more job seekers will apply for a job at the oil and gas industry instead of applying for jobs in other sectors. Even if the demand for workers will stay constant in the other sectors, the other sectors can still experience a decrease in applications that puts pressure on their hiring process. Second, with the worsening of applications received in relation to the amount of vacancies, the hiring standards have to be lowered. Lower hiring standards, meaning that the requirements for new employees are lower, can imply that those new employees are less productive and therefore push the overall productivity of the industry down.

5.2.3 Job search

Previous conclusions are based on a constant amount of job seekers who will apply for vacancies in one of the eight sectors. The total job seekers within an area (North Dakota) are however impacted by the labor market conditions. Counteracting loop 4 reflect the effect of the hiring of unemployed job seekers. If there are more vacancies, more vacancies will be filled. *Ceteris paribus*, this implies that more unemployed job seekers will become employed and the unemployment will be lowered. A lower unemployment implies that there are less job seekers, meaning less job seekers per sector, and therefore less vacancies can be filled in the next period.



model 4 - simplified stock-and-flow diagram "local labor supply dynamics" part 3

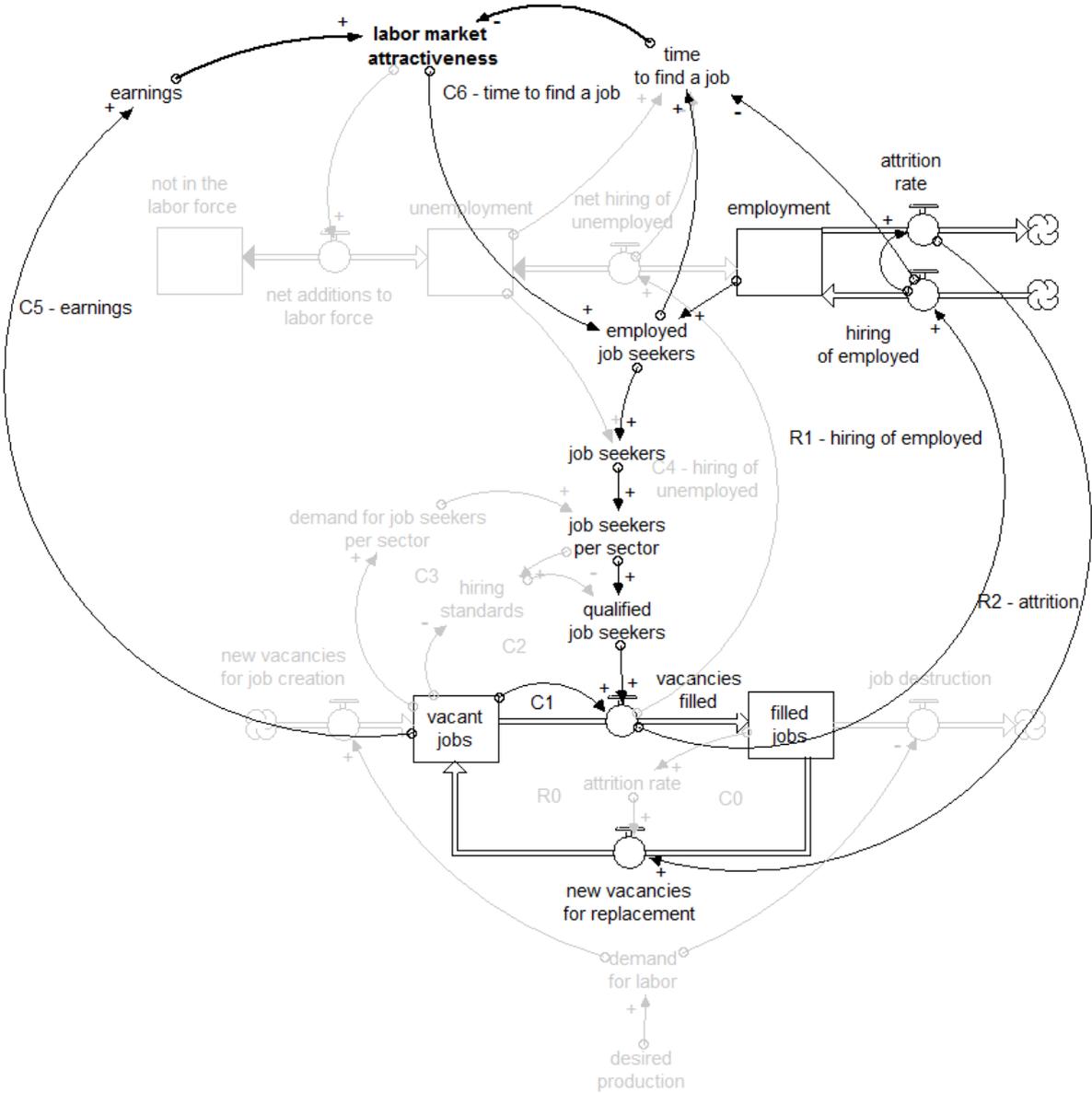
The labor market conditions, however, trigger a higher inflow of job seekers. Earnings increase due to a higher amount of jobs that cannot be filled. If these vacant jobs cannot be filled, there is shortage in total working hours and the current employees have to make more hours. Also the hourly wage will increase because companies want to attract more job seekers. If the average earnings increase, the labor market becomes more attractive, which creates incentives to start looking for a job. Also, when more unemployed job seekers will be hired, the time to find a job will go down. If the time to find a job goes down, this also increases the attractiveness of the labor market. More vacant jobs will thus lead to higher labor market attractiveness and therefore more job seekers. These job seekers will apply for

the vacancies and the vacancies can therefore be lowered again. The labor market attractiveness has a counteracting effect through 2 loops: C5- earnings and C6 - time to find a job.

The job seekers do not only exist of the unemployed job seekers. Previously we have stated that there are unemployed job seekers, employed job seekers and out-of-state job seekers. In model 7 the employed job seekers have been added to the system. A fraction of the employees will be looking for another job and thus will be applying for vacancies, either in its own sector or another. More employment can lead to more employed job seekers, therefore more jobs can be filled, which will lower the amount of vacancies. If more persons get hired, the employment should be increased and in theory would lead to more employed job seekers (see R1 - hiring of employed). However, in contradiction to the hiring of an unemployed job seeker, the hiring of an employed job seekers, forces that persons to quit his/her current job. This will decrease the employment again; the hiring of an employed job seeker will thus not have an impact on the overall level of employment. If per year more workers quits their current job, the attrition rate will increase and more vacancies have to be placed for replacement. These will again higher the level of vacancies (see R2 - attrition). If a vacancy is filled with an employed workers this will thus not have an impact on the total level of vacancies.

Although the effect on the overall level of vacancies and employment will not be noticed when an employed job seekers is hired, there can be an effect on the levels per sector. Sectors do not only hire workers who were previously employed in the same sector, but can also hire workers employed in other sectors. If an employed worker from another sector is hired, the vacancy level in the own sector goes down and the employment goes up. The other sector however has to deal with a higher attrition rate and will see the level of employment go down and the vacancy level go up. Hiring of employed job seekers can thus lead to a shift in the vacancy and employment levels, even when the total stays equal. This effect can be seen in North Dakota, where the oil and gas industry was hiring workers from inter alia the manufacturing and the retail sector. Although the oil and gas industry would prefer to hire workers with experience in the same industry, a shortage of available applications with experience would force the industry to lower hiring standards and accept workers from other sectors.

The shift in vacancies due to a boom in one of the sectors is enforced with the counteracting loops C5 - earnings and C6 - time to find a job. When one sector (the oil and gas sector in North Dakota) experiences a boom, the vacancies in that sector go up. This will decrease the time to find a job in that sector and the vacancies cannot be filled due to a shortage in qualified applications, the wages will be increased. This will increase the labor market attractiveness and as a result more employees will be trying to find another job. For the booming sector this will have a counteracting effect as those job seekers will apply for vacancies in their sector and thus more vacancies can be filled. For the other sectors, this will only lead to an even higher attrition rate, and higher vacancy levels.



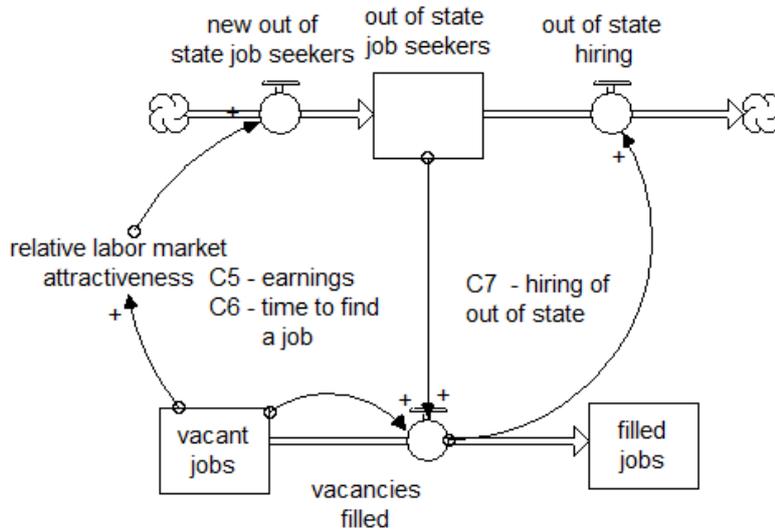
model 5 - simplified stock-and-flow diagram "local labor supply dynamics" part 4

In relation to North Dakota's labor market we can conclude that a boom in the oil and gas industry can lead to higher vacancy levels in other sectors, even when the desired production of those sectors stays equal. To offset the increase in vacancy levels, also the wages in other sectors should be increased. A problem arises since the sector who do not experience such a boom in production, might not have to capital available to boost the wages.

So far we have limited the discussion of the labor supply system to the dynamics within a state. The next step is to broaden the scope and allow for growth in the supply of labor from outside the state. The out-of-state job seekers will be added to the system.

5.2.4 Out-of-state job seekers

An increase in the labor market attractiveness also attracts job seekers from outside the state. In the decision to move to a different place, migrants optimize their earnings according to employment options and possibilities in both the current state of residence and the potential new state of residence. They want to improve their economic, social, and personal situation in every move (Constant and Zimmermann, 2011). The effect of North Dakota's labor market is thus relative to the labor market attractiveness of the current state of residence. In general, a higher level of vacant jobs leads to higher labor market attractiveness and to a higher inflow of out-of-state job seekers. The out-of-state job seekers will apply for vacancies, and therefore more vacancies can be filled, as illustrated by model 8, C5 - earning and C6 - time to find a job. The effect of hiring on job seekers will be the same as the hiring of unemployed job seekers. If out-of-state job seekers get hired, the stock of out-of-state job seekers will be depleted, leading to less remaining job seekers to fill the vacancies. This counteracting feedback loop is presented by C7 - hiring of out-of-state.



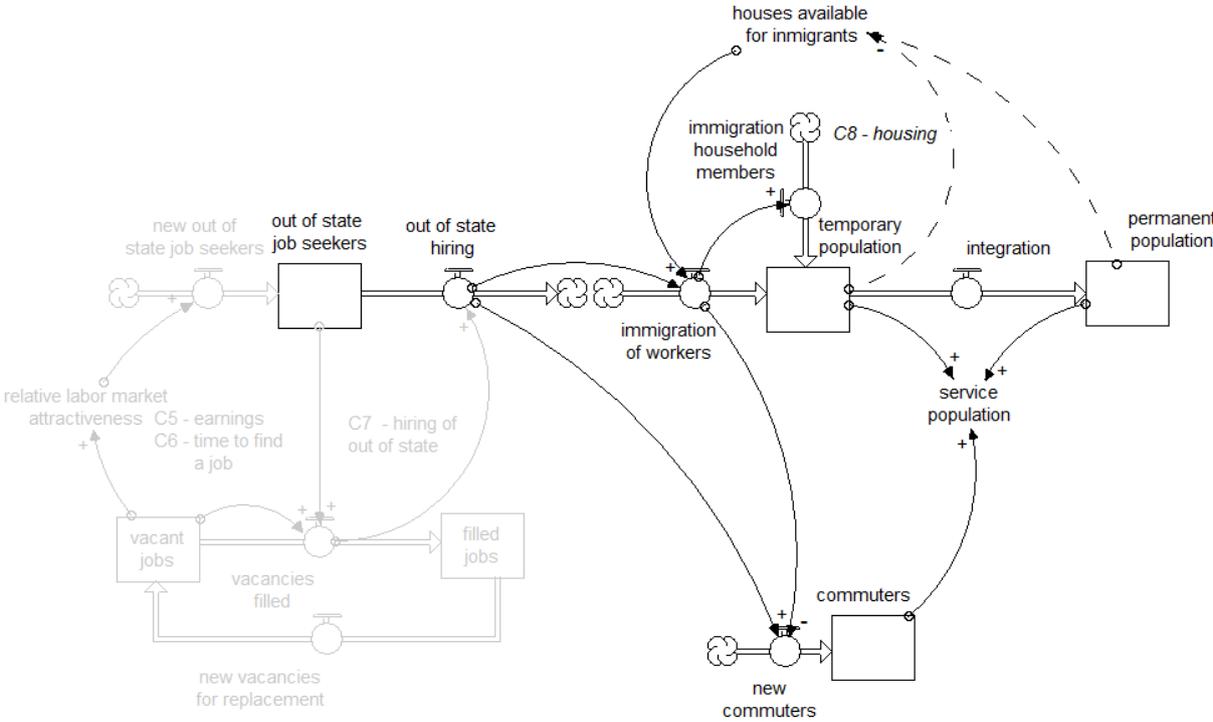
model 6 - simplified stock-and-flow diagram "out-of-state labor supply dynamics" part 1

Assumed is that job seekers from outside North Dakota will first want to have a job before moving to North Dakota. Once they are hired that will make the decision to move to North Dakota or to maintain their current residence and commute to the state. There is always a fraction of the out-of-state job seekers who will commute, since their place of residence might be close to the border of North Dakota. The distance from home to work might thus be short enough for commuting. As we have mentioned before, the oil boom also impacts another flow of commuters, the long-distance commuters. Long-distance commuters are especially important during an oil boom. The reason is that only the drilling of oil wells is labor intensive. The maintenance of a well does not require that much manpower. Many of the workers at the oil field thus follow the drilling patterns all over the United States. During their working days they stay in temporary housing - man camps, R.V. camps, hotels - other days they will spend in their home state. Another part of out-of-state job seekers will be willing to migrate.

Model 9 illustrates the effect of out-of-state hiring on the migration and commuting patterns. If the out-of-state hiring increases also the immigration of workers and the amount of new commuters increases. The immigration of workers is, however, limited to the houses available for immigrants. If there is a housing shortage, as in North Dakota, workers might be hired and willing to move, but are not able to find a house. If they are not able to find a house, they are forced to stay in temporary housing. They will then become long-distance commuters. The

houses available for immigrants are part of a counteracting loop, C8. If more workers will move to North Dakota, North Dakota residents will occupy more housings units and there will be less houses available for immigrants. Although the feedback loop is presented in this conceptual model, it is not within the scope of this research to endogenousize the housing market. The housing units will be taken exogenous.

The difference between affect of hiring out-of-state workers who migrate and who become commuters, is that only the immigrants become North Dakota residents and thus become part of North Dakota's labor force. The commuters are, however, still part of the labor supply within North Dakota. If workers migrate to North Dakota, they will bring their household members with them. This will lead to further population growth.



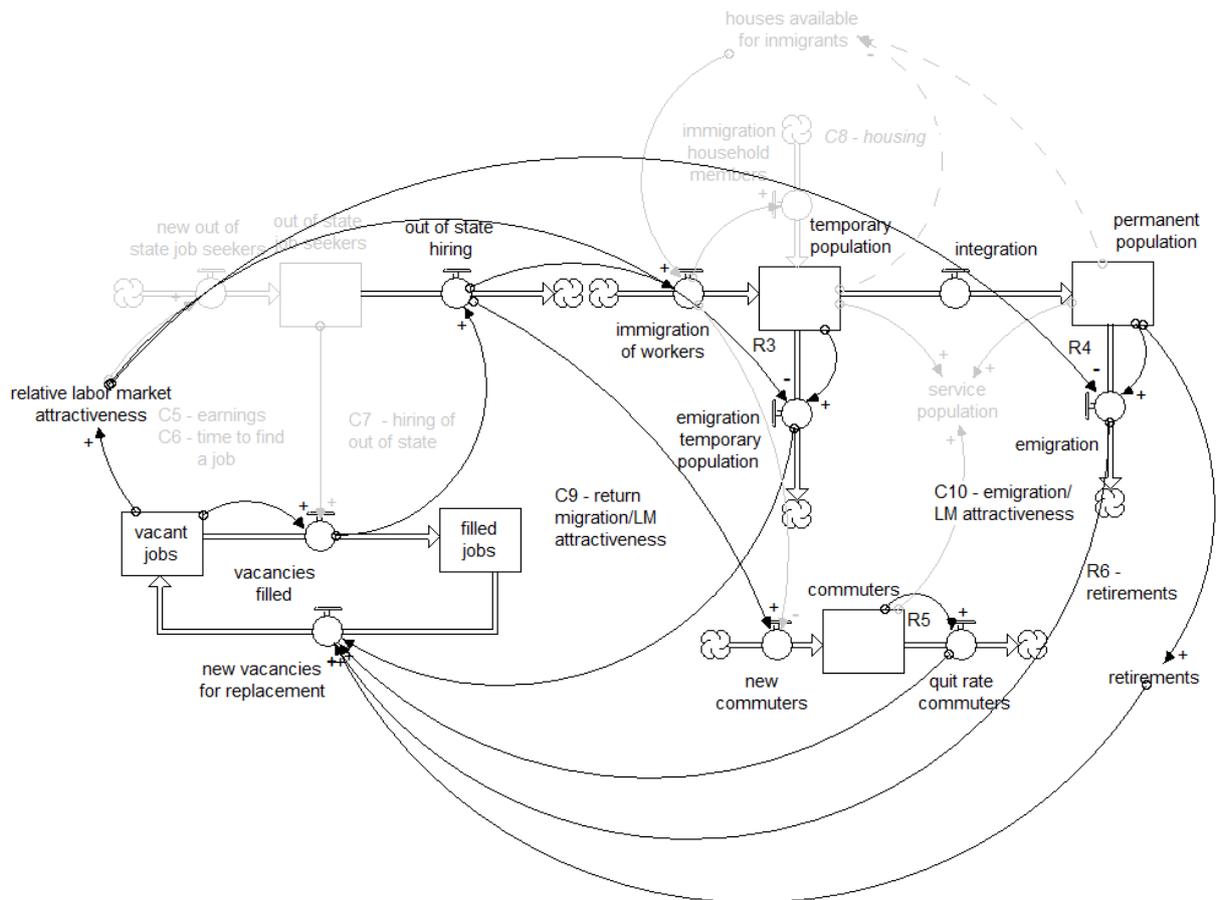
model 7 - simplified stock-and-flow diagram "out-of-state labor supply dynamics" part 2

Immigrants are first defined as temporary population. It takes a while before they are integrated. Family members of immigrant workers are new potential job seekers, who are able to fill jobs within North Dakota. Assumed is that the family members will not directly search for a job themselves. In the first years after immigration, the chance is higher that the household will return to the home state or another state. Migrant families are overall more dependent on one earner. Only after the decision is made to stay for a longer period of time in

the state, the household will integrate in and the other household member(s) will make start participating in the labor force.

Campaigns of the Department of Commerce especially concentrate on attracting families (see the Find the Good Life in North Dakota campaign). The family members are considered to be an additional source of job seekers who are able to fill the high level of vacancies. On the other hand, if those family members are not joining the labor force, the inflow of families will only lead to a higher increase of the service population. The service population is the total of the North Dakota residents and the commuters. Because the commuters work most of the times two weeks on-two weeks off, and do only spend half of the time in North Dakota, the commuters divided by two are included in the service population. Also the commuters who are temporary housed in North Dakota are part of the service population because they make use of the facilities. When the economy is booming, the extreme increase in service population lowers the adequacy of the facilities. Schools are overcrowded, the lines in the supermarket are long and the roads are overloaded with cars. The supply of facilities does not keep up with the demand, and the quality of life goes down. The effect of the service population on the facilities is not modeled within this research. Nevertheless, a negative effect of the tremendous growth in the service population of North Dakota on the adequacy of facilities is publicly accepted. Policy design does therefore needs to take the effect of migrants versus commuters on the service population into account.

In the previous models we have presented the impact of the unemployed job seekers, the employed job seekers and the out-of-state job seekers on the applications an industry receives and its effect on the amount of vacancies which can be filled. We have seen that if employed job seekers get hired, those workers will quit their current job and new vacancies have to be placed for replacement. We have also seen that it is thus more effective for the overall level of vacancies to stimulate hiring of unemployed job seekers. Workers can also have different reasons to quit their jobs, which leads to the need of replacement, which we have not considered so far. Workers can also resign, because they leave the state or because they retire. In this case, they will not be part of the North Dakota labor supply anymore. These effects are illustrated in model 10.



model 8 - simplified stock-and-flow diagram "out-of-state labor supply dynamics" part 3

When employees reach the age of 65, employees can decide to retire. The filled jobs become vacant and another worker has to be hired for replacement. The rate of retirements is dependent on the population and the demographical distribution. If a high level of vacancies leads to an inflow of workers, the growth in population will eventually lead to a higher rate of retirements and will further increase the level of vacancies (see R6 - retirements). Important to note is that the reinforcing loop (R6) will most of the times not be immediately visible. The age of immigrants are mainly centered between 18 and 35. The high immigration as a result of an oil boom will thus lead to a shift in the demographical distribution of the population, increasing the population between in the age group 18-35, relative to the population above 35. In the short term, only a small effect on the number of retirements might be noticed. The biggest effect will be visible when the group of immigrants reaches the age of retirement, assuming they will stay in North Dakota.

A more direct impact of hiring out-of-state workers is the effect on the emigration. Previously we have discussed the integration of the temporary population, the immigrants who just

settled in North Dakota. In general, a big part of the immigrants tend to leave the state again within the first years after arrival. The more out-of-state job seekers are hired to fill the vacancies, the higher the temporary population in a state and the higher the emigration of the temporary population, which is mostly referred to as return migration when they migrants return to the previous state of residence. This return migration will then require the creations of new vacancies. When the local labor supply is not sufficient, this will drive a new inflow of out-of-state workers. R3 illustrates this reinforcing effect. A higher level of vacancies, leads to a higher hiring rate of out-of-state workers, leading to more immigration. If there are more immigrants, the return migration will rise, which will again increase the level of vacancies. R5 reflects the same feedback loop, but then for the commuters. The difference between commuters and migrants is that the commuters will always leave the state when they quit their job. When they quit their job in North Dakota there is no reason to limit their job search to the same state. Only a fraction of the migrants will leave the state when resigning their current job. This implies that if out-of-state workers get hired who will commute, it will have a stronger reinforcing effect on the level of vacancies through the quit rate than when workers get hired who will immigrate.

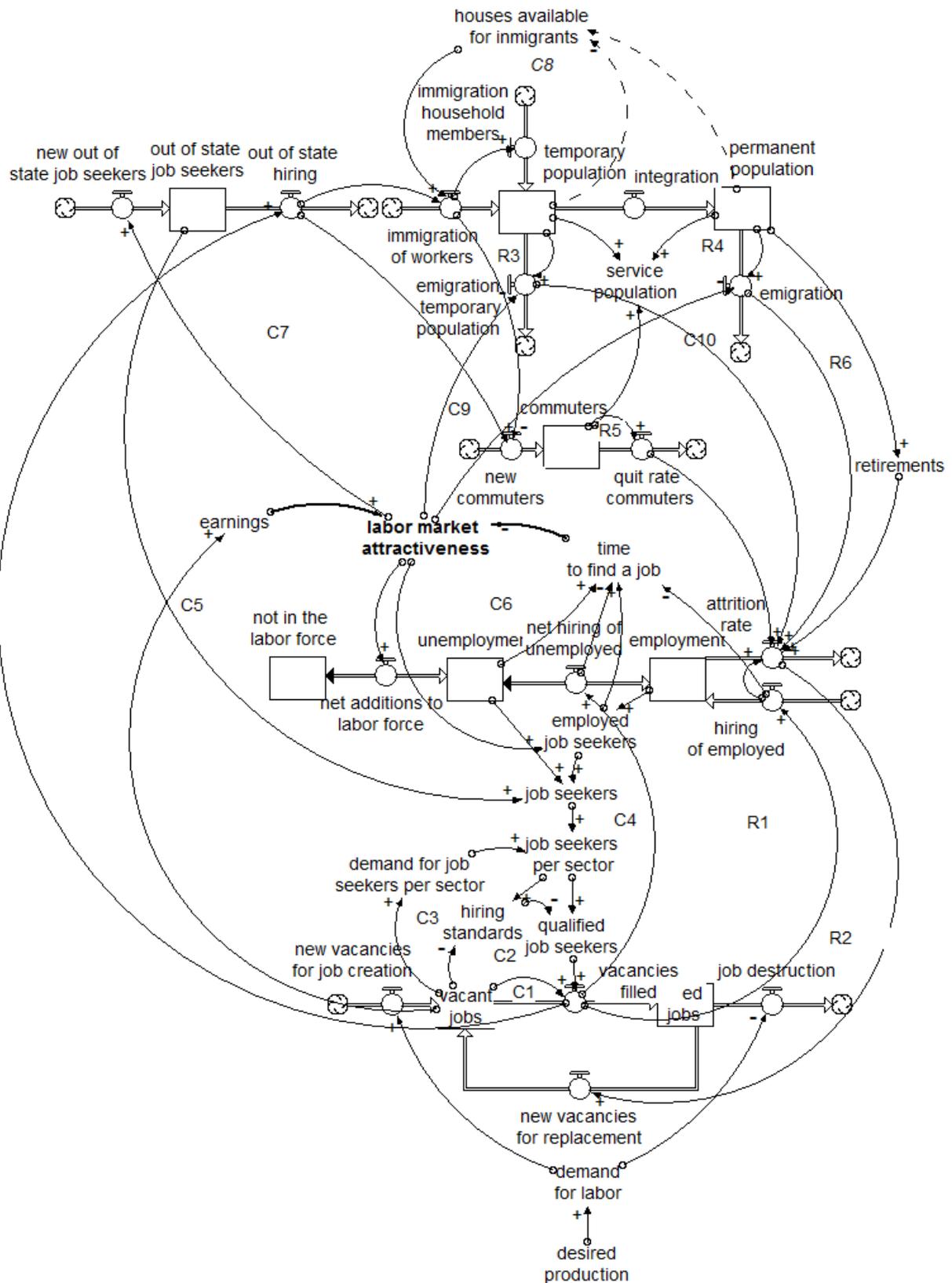
Also permanent residents of North Dakota can decide to emigrate. If the population grows as a result of positive net migration or through local net growth (births per year exceed deaths per year), the emigration rate is expected to grow as well. Again, there is a reinforcing effect through the immigration to emigration of permanent population and new vacancies which can trigger a new inflow of out-of-state job seekers.

The emigration is also impacted by the labor market conditions. As an increase in labor market attractiveness triggers out-of-state job seekers to apply for a job in North Dakota, a decrease in labor market attractiveness triggers North Dakota workers to apply for a job outside the state. This will thus push the emigration. A higher emigration leads to more vacancies for replacement, which can then increase the labor market attractiveness again. C9 and C10 illustrate those counteracting feedback loops.

From model 10 we can conclude that an increase in hiring from out-of-state will deplete the level of vacancies in the short run, but will in the longer run lead to an increase in the attrition rate because of workers leaving the state. This will then again push the level of vacancies up. A decrease in relative labor market attractiveness will strengthen the working of this loop. To

make the link to the recent decline in oil price: as a result of declining oil prices in North Dakota, the demand for labor in the oil and gas industry declines and many workers are getting laid off. Less new workers are getting hired. Earnings are pushed down, also because the profits on the wells decline with the decrease in oil price. Less money is thus available for bonuses and other extras. These factors worsen North Dakota's labor market attractiveness. When the high relative attractiveness declines, the incentives for immigrant workers to stay in North Dakota disappear and the outflow of workers increases.

Model 11 presents the two conceptual models in one. The model shows the relations between different types of job seekers and its effect on the vacancies and the employment. It also shows the different impacts of hiring different types of job seekers on the attrition rate and therefore on the level of vacancies. This model captures many relations, which can increase the understanding of the comprehensiveness of the labor supply dynamics. It gives a more disaggregated view on the North Dakota labor supply. It therefore serves as a better tool to investigate the sources of certain labor supply dynamics than the simplified conceptual model does.



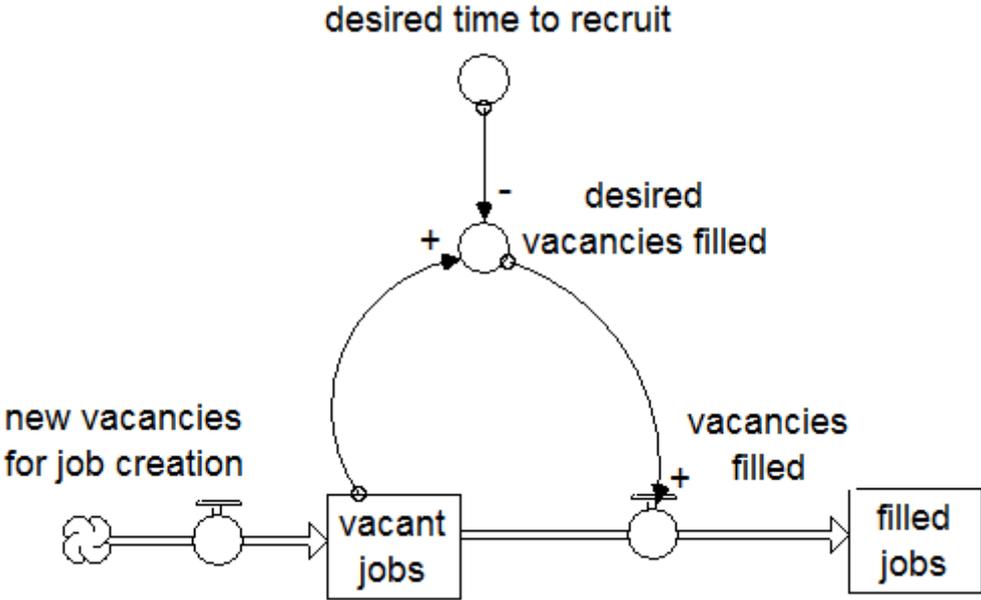
model 9 - simplified stock-and-flow diagram " labor supply dynamics"

6. ESSENTIAL STOCK-AND-FLOW STRUCTURES

So far, we explained the labor supply dynamics in a two-dimensional conceptual model. The models showed the effect of different kind of job seekers and the impact on the employment and the level of vacancies. Less attention is being paid to the dynamics between the sectors and the impact of delays within the labor supply system. In this chapter a closer look will be taken at a few important pieces of the stock-and-flow model. These pieces of stock-and-flow will either strengthen or weaken feedback loops in the models discussed before.

6.1 Time to recruit

If vacant jobs could be instantaneous filled, the applicants hired would be equal to the number of vacant jobs. However, the process of recruitment and selection of an applicant takes time. Before the vacant job is being posted the recruiting organization determines when it wants the vacancy to be filled. The vacancy can be open for applications during a predetermined posting period, can be open until a suitable candidate is found to fill the vacancy or an organization can have a continuous recruitment of the same position (see job opening announcements at ND Workforce Connection or Indeed). Assumed is that the vacancies are being placed either when the need for a new position is recognized or when a workers in an existing position needs to be replaced. Therefore, we do not include the continuous recruitment.



Model 10 - desired time to recruit

Under the assumption that the recruiting organization has a timeframe in mind for the collection of the application (desired time to recruit), the desired vacancies to fill in the selection process each time period would equal the number of vacant jobs divided by the desired time to recruit, see model 10. During the time to recruit, the team of recruiters will collect the applications and select an applicant for the vacancy. The desired time to recruit will be different in each sector, because each sector requires a different kind of selection process to test the applicant on the characteristics necessary for the job. The longer the desired time to recruit, the lower the desired hiring rate, and this will thus result in a higher level of vacancies than would have been if the time to recruit would be shorter (see the effect on the feedback loop C1 in model 2).

In the situation of a boom in the economy, more vacancies will be placed for job creation. Even when the labor supply in North Dakota would have been high enough to serve the demand for labor, the level of vacancies would still increase, because it takes time to fill the additional vacancies. The length of the desired time to recruit will thus have a big impact on the effect of a boom on the increase in the level of vacancies.

6.2 Adjusting the hiring standards

During the time frame set for recruitment, the selection process will take place. Information is gathered about the applicant, this information is used to decide which application will be accepted and which application will be rejected. The type of information can be separated in low bandwidth data and high bandwidth data. Low bandwidth data typically refers to information which is objectively verifiable, such as education, credentials and experience. This information can be usually be received by the submission of a resume together with the application. The high bandwidth data refers to quality, motivation, and the fit to the organizations culture, those attributes are typically hard to verify. Interviews are used to gather this kind of information (Autor, 2001). Most of the selection processes also entail a background investigation to validate if the information provided was correct, as well as to check the criminal record, for example. The recruiting organization will then use the information available for each applicant and will compare it to its own hiring standards, based on both characteristics of the job and desired motivation and fit to the organization. The best applicant will be picked to fill the vacancy. In general, the 'best' applicant has the highest expected productivity compared to the other applicants.

Under the assumption that the labor market is homogeneous, all applicants would meet the low bandwidth hiring criteria - suitable education, experience, etc - as well as the high bandwidth hiring criteria - right motivation and good fit - of the recruiting organization. Every person would have the same productivity of the anyone else. However, the labor market is heterogeneous. Not all workers and vacancy can form a match. Petrongolo and Pissarides (2001) refer to this concept as mismatch, this concept 'measures the degree of heterogeneity in the labor market across a number of dimensions, usually restricted to skills, industrial sector and location.' (p.7). Assumed is that a job seeker will already select a vacancy to apply on based on location and industrial sector. But according to this concept, still more applicants needs to be in the pool to be able to select an applicant which meets the hiring standards. The hiring standards are in line with the minimum productivity requirement most organizations have for the potential worker (Autor, 2011). Since these hiring standards are soft attributes and hard to capture in a model, the general concept is represented as a standard for a qualified fraction of the job seekers. Assumed is that when the hiring standards are higher, a lower fraction of the job seekers will be assumed to be qualified. A different standard is assumed for employed, unemployed and job seekers from out-of-state. The reason is that they have in general a different level of experience and organization would prefer more experience.

Once the applications you receive during the time to recruit is not sufficient to meet the amount of applications you need to keep up your hiring standards, the organization has two options. The organization can wait for more applicants to apply or lower its hiring standards and therefore raise the fraction of job seekers which is assumed to be qualified (standard qualified fraction). Organization are however reluctant to lower the hiring standards since this impacts their company's performance through a lower level of productivity of the new workers. Nevertheless, the hiring standards will be adjust to the current condition of the market, because the a less productive workers is better than no worker at all. So stated LM WindPower in a personal conversation that now, they have to accept less qualified workers due to the labor shortage within North Dakota. The feedback loop C3 and C2 in the conceptual model in model 1, and feedback loop C2 in simplified stock-and-flow diagram in model 3 shows this effect in the overall system. A closer look at the actual process is illustrated in model 11. The model refers to unemployed job seekers, but the same structure is working for other job seekers.

unemployed job seekers and would thus have a positive effect of the maximum qualified fraction. In chapter 8 more attention will be paid to this policy.

The time the industries take to adjust their hiring standards will have an impact on the fraction of applications which are assumed to be qualified enough to be hired. If the industries are faster in adjusting their hiring standards to the labor market condition, more job seekers will be hired and the vacant jobs will be pushed down to a normal level in a shorter period of time.

6.3 The application decision

The conceptual model showed the effect of the application decision on the amount of applications a sector receives. This concept is linked to the mobility of labor between sectors which is often used in studies on oil boom in relation to the Dutch Disease. The job seekers decision process to chose a sector to apply in, will be further clarified. Each period new workers start their job search, as explained earlier. Those job seekers can be employed, unemployed, resident or non-residents, thus coming from out-of-state. When these job seekers start their job search they will decide to apply for a vacancy within one the sectors. Feedback loop C3 in model 3 showed that the application decision of job seekers is based on the demand of the different sectors. Assumed is that all the job seekers base their application decisions on the same grounds, they all want to maximize the value of the job search (Rogerson, Shimer and Wright, 2004). The value of the job search, however, is different for each type of job seekers and we therefore differentiate between types of job seekers in the distribution over applications over the sectors.

Within the groups of job seekers we assume that everyone will be distributed in the same manner over the sectors, irrespectively of their current employment or experience. The reason that this is possible is that the sectors are based on industries, not on occupations. For many occupations it is possible to find the same or a related occupation in a different sector. For example, North Dakota's oil and gas industry has been hiring mechanical engineers, who were previously employed in manufacturing (personal conversation).

Model 14 illustrates that the new job seekers are distributed over the different sectors based on a distribution factor. The distribution factor per sector is a fraction between 0 and 1. The sum of all distribution factors is equal to 1, since all new job seekers have to enter one of the sectors. The distribution factor is affected by the demand for job seekers. The demand for job

6.3.1 Internal labor supply dynamics in literature

In literature, the system for matching vacancies and workers is studied within Search Theory. Diamond, Mortensen and Pissarides (1999) have developed the two-sided search theory to create a matching function which not only takes the amount of vacancies and job seekers into account, but also the effort both sides of the labor market put into the job search. The effort is relying on the market tightness and wages and affects the intensity of which job seekers are applying for a job. The market tightness is the relative numbers of traders on both sides of the labor market, the job seekers and the organizations. The same factors are affecting Moen's (1997) model for competitive search equilibrium. Based on this model workers enter the submarket with the highest expected income. The highest expected income is a function of both the wages offered in this sector and the market tightness. Following Rogerson, Shimer and Wright (2004) and Burdett (1978), unemployed job seekers chose their policy whether to accept a job on the wage offered compared to the job seeker's reservation wage. Employed job seekers will accept any offer which is higher than their current wage. Besides search theory, most labor market supply studies assume that the supply of labor is a function of the current and the future discounted wage rates (i.a. MaCurdy, 1981). The theory is based on Friedman's Permanent Income Theory, which compares income to leisure.

Also, news articles are overwhelmed by statement of business raising their wages, trying to attract more workers (see Briody, for *The Fiscal Times*, November 5, 2013; Lindholm for *NPR*, December 18, 2012; Little for *CNBC*, June 20, 2014) . Most theories base their models on assumptions related to market tightness and wages and wages seem also important to business owners. In this research we do not include the effect on the market tightness and the wages on the distribution of applications over sectors. The reason is that the distribution factors are hard to endogenize based on wages and market tightness since this research works with eight different sectors. Although a positive effect of wages and market tightness on the inflow of applications could be modeled for one sector, modeling eight sectors demand a cohesion of inflows. Another reason to use the distribution of the demand for applications as an input for the distribution of applications over sectors, is that it is assumed to represent the same trends as the relative wages and market tightness would do. The wages and market tightness, defined as the time to find a job, do however impact the applications a sector received through the effect on the new job seekers.

An other difference with literature is that this model does not include varying search intensities. A job seekers can only apply for one job at the time. The reason lies within the terminology. In search theory, a given number of unemployed job seekers is taken, and only the search intensity can differ. However, we cover under unemployed only that part of the civilian non-institutionalized population, who do not hold a job and have been actively searching for a job within the last 4 weeks. A person is counted as civilian non-institutionalized if that persons is not an inmate of an institutions, e.g., penal and mental facilities, homes for the aged, and is not on active duty in the Armed Forces (Bureau of Labor Statistics). Within this group of actively searching unemployed, the search intensity will not differ. Therefore, the applications per job seeker will stay the same. However, we do acknowledge the principle of a variable search intensity within the context of the labor force participation rate. The labor force participation rate is that percentage of the civilian non-institutionalized population which is part of the labor force. The market tightness and the wages will influence the behavior of the discouraged workers. The discouraged workers are the workers who are currently not actively searching for a job, but are in fact willing and able to have a job (Bureau of Labor Statistics). Relatively to the market tightness and the wage, they can determine to leave or return to the labor market and search for a job.

This research also has a different definition of job seekers than most other literature does. We do not only include the job seekers who are unemployed, but also those who are employed, but looking for another job. Most literature is based on only unemployed job seekers. Mortensen and Pissarides (1994) for example separate the supply of labor into workers being unemployed and searching or employed and producing. Burdett (1978) was the first differentiating the on-the-job search. He assumes that employed job seekers will only chose to quit a job, when they can become employed at another firm for a better wage. Workers will not quit a job to become unemployed. This also implies that if a worker finds a job at a different firm, he will quit his old job, and thus replacement is necessary. The need for replacement leads to the creation of a new vacancy. Burdett distinguishes two causes for workers quitting their current job: wages or age. Dependent on these factors the tenure of a worker differs. The higher the age, the higher the tenure. Also Blanchard and Diamond (1990) recognize the effect of the quit rate on the vacancies. The quit rate would be subject to the labor market conditions and would work pro-cyclical.

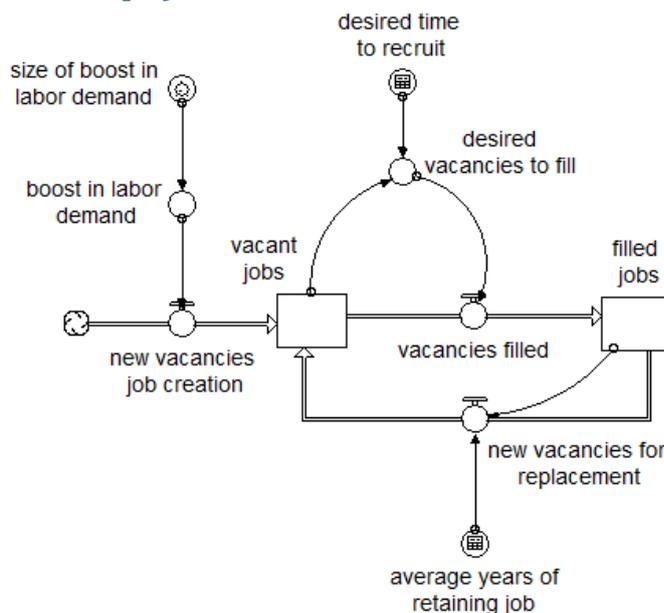
The problem of retaining employees is also addressed at the Chamber of Grand Forks and East Grand Forks: "We need to find a way to motivate some of those people who have been job-hopping to stay in their positions longer." (Barry Wilfahrt in Grand Forks Herald, June 16, 2015). Many business do not only struggle with attracting workers, but especially with retaining their current workforce. Workers run off to better paid jobs at the oil field. This suggests that (1) it was easy for those workers to get a job at the oil field and (2) the wages offered at the oil field are higher than the current wage.

7. ANALYSIS OF THE BEHAVIOR

The system as has been described conceptually in the previous chapters is now being quantified. Each relation presented in the conceptual model or simplified stock-and-flow model has been translated in one or in a sequence of equations. This chapter will describe and analyze the behavioral output of the System Dynamics model created to explain the supply of labor. The supply of labor has been differentiated in the labor force, both employed and unemployed, and the commuters. Special attention will be paid to the dynamics between labor supply by sector, the attrition rate and the migration and commuting patterns.

Before the behavior of the output of the model will be described, a simple model is presented to isolate the effect of employee retention on the level of vacancies. In this simple representation the dynamics will be easier to understand.

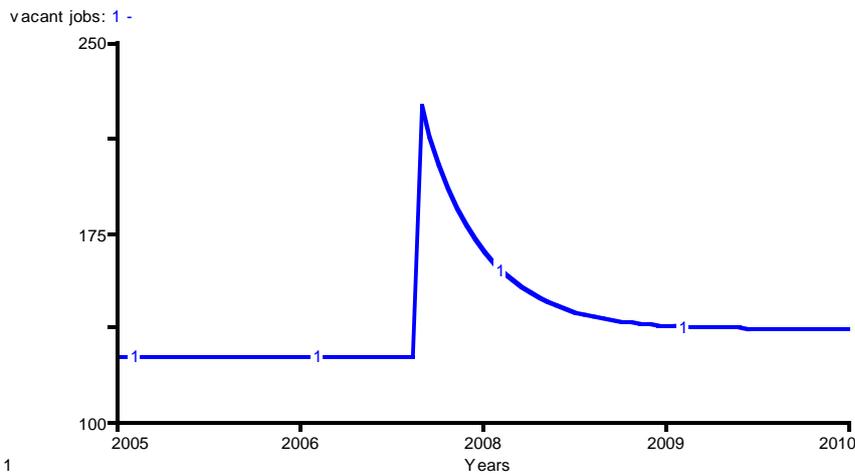
7.1 Simplified structure



model 13- simplified simulation structure

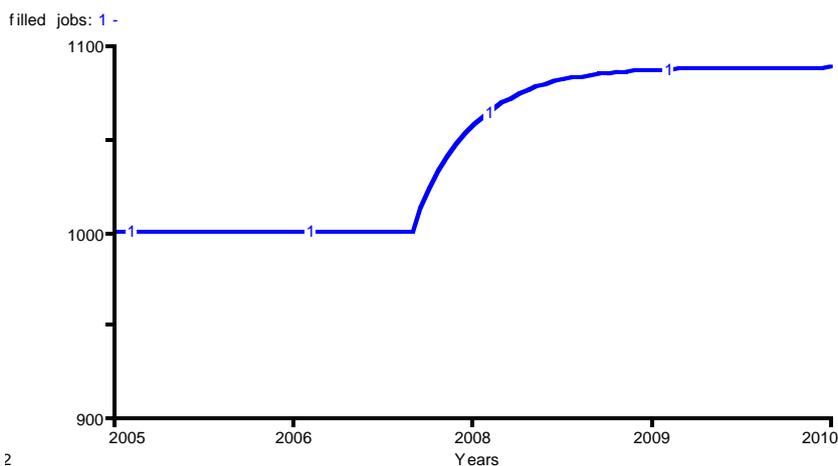
In the previous chapters we have seen that the level of vacancies is not only determined by the labor demand, but also by the labor supply. Model 1 suggested that an increase in the employment (filled jobs) caused by a boom will lead to a higher attrition rate. Therefore the equilibrium level of vacancies will be increased. To support this feedback loop a small simulation model is created, which can be found in model 13. Each year vacancies have to be created for replacement. This rate is equal to the filled jobs divided by the average years of

retaining a job (or employee tenure), which is set at 4 years. The vacancies will be filled under the assumption that the labor supply will be enough to be able to fill the vacancies within the desired time to recruit.



graph 1 -simplified simulation model: vacant jobs

Graph 1 presents the behavior of this simple structure. In the hypothetical illustration, the system starts in equilibrium. Only vacancies will be posted for replacement of employees resigning their job. The level of vacancies remains at the level of 125 jobs. In 2007 there is a boost in the labor demand of 100 jobs. 100 vacancies for job creation will be placed and the level of vacancies increases to 225 jobs. Because it takes time to recruit, it takes a while before the level of vacancies stabilizes again at an equilibrium level. This equilibrium level increases with 11 jobs to a level of 136 jobs.



graph 2 - simplified simulation model: filled jobs

The filled jobs starts in equilibrium at 1000 jobs, after the boom in labor demand they increase to 1089 jobs. The filled jobs increase with 89 jobs instead of 100 jobs (the increase in

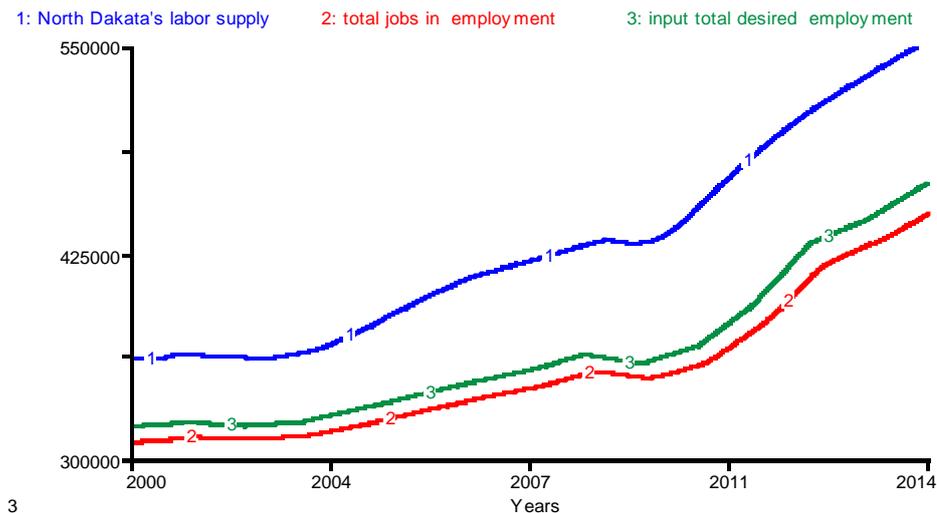
desired jobs), because replacement of workers causes the vacant jobs to increase with the 11 jobs. Part of the desired jobs will thus remain vacant due to attrition. Both the average years of retaining a job and the desired time to recruit affect the level of vacancies and the level of employment. The simulation model for North Dakota's supply of labor will the years of retaining a job endogenousized as well as the actual time to recruit.

From this behavior we can conclude that the increase in the level of vacancies of North Dakota is not only caused by a shortage of workers. For a big part the increase in the level of vacancies can be explained by an increase in normal attrition of a higher number of employees.

7.2 Analysis of North Dakota's labor supply dynamics

This chapter will discuss the simulation outcomes of the System Dynamics model created for the purpose of modeling North Dakota's labor supply dynamics as a response to the labor demand. North Dakota's labor supply includes both the local and the out-of-state labor supply, those who are employed or actively looking for a job. Graph 3 shows the behavior of the labor supply in comparison to the labor demand. The labor supply responds to the labor demand. The labor supply is always a larger number than the labor demand, because the labor supply includes besides the workers also the job seekers. The labor demand is called the input of total desired employment. The gap between the total employment (in jobs) and the desired employment is the level of vacancies.

Both the labor supply and the labor demand stay constant until 2003. The labor demand increases from 319 156 jobs in 2000 to 322 364 jobs in 2003. The labor supply increases during the same period from 360 718 persons to 364 217 persons. After 2003 both the labor demand and the supply increases at a low rate until 2008. In 2008, the labor demand decreases due the crisis, reaching the 358 221 jobs in 2009. The supply of labor also decreases as a response to a decline in the labor demand to a level of 431 745 persons in 2009. After 2009, the labor demand really begins to rise at a higher growth rate due to the oil boom and the labor demand increases to 467 460 jobs in 2014. The supply of labor increases to 554 392 persons in 2014.



Graph 3 - North Dakota's labor supply

Graph 3 shows that the increase in the labor supply is higher than the increase in the labor demand, an increase of 122 647 persons compared to 109 239 jobs from 2009 to 2014.

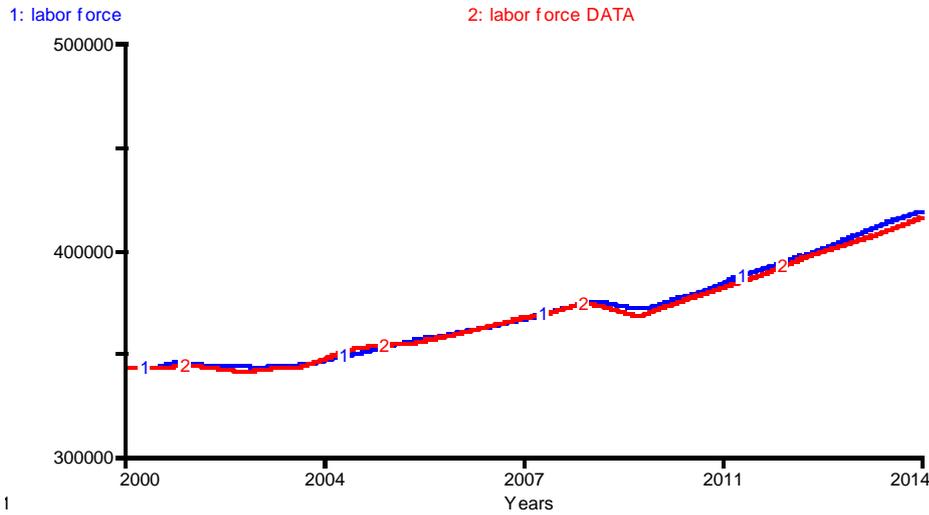
Although the level of labor supply increases more than the labor demand, the level of vacancies still increase. The level of vacancies can be derived by subtracting the total job in employment from the total desired employment. This can be explained by the reasoning that not all additional job seekers are able to fill a job, because not everyone is qualified. Therefore, the increase in labor supply has to be bigger than the increase in labor demand.

This chapter will further examine the labor supply by analyzing the different components of the labor supply: the labor force, both unemployed and employed, and the commuters. Conceptual model 1 showed the major feedback loops which ought to explain the labor supply dynamics. Whether this conceptual model can explain the labor supply dynamics is tested by cutting major loops in the simulation model and analyzing its effect on the labor supply components.

7.2.1 Different labor supply components

The most common measurement of the supply of labor is the labor force. Graph 4 presents the behavior of the labor force. The simulation output follows the historical pattern. The simulation output of the labor force starts in 2000 with 342 211 persons, which is equal to the historical data. First, the labor force stays constant and after 2004, the labor force starts to increase. There is a small decline in labor force in the year 2008. At 2009, the lowest point of this labor force during the recession has been reached with a labor force of 367 286 persons.

After 2009, the labor force starts to increase again with the same growth rate as before 2009. In 2014, the simulation output reaches the 418 863 persons, compared to an actual labor force of 415 484 persons (LAUS). This implies a gap of 3371 persons or a 0.8% error from the actual historical data.



graph 4 - labor force (source: Local Area Unemployment Statistics)

To be able to explain the behavior pattern of the labor force, we will first differentiate the labor force into the employed and the unemployed labor force. Graph 5 shows the employed labor force. In the Local Area and Unemployment Statistics someone is assumed to be employed, if that persons did any work for pay or profit during the survey reference week; did at least 15 hours of unpaid work in a family-operated enterprise; or was temporarily absent from their regular jobs because of illness, vacation, bad weather, industrial dispute, or various personal reasons. If a person holds two jobs, that persons is only counted once. Graph 5 shows that the employed labor force is behaving in a similar patterns as the historical trend. In 2000, both the simulation output and the historical 331939 First, the employed labor force declines, however, not as much as the historical patterns shows. In 2003, the simulated employed labor force is 334 283 persons compared to historical data of 329 121 persons. A gap of 5 162 persons. After 2004, the employed labor force increases in the same pattern until 2008. In 2008, the employed labor force declines, but not as much as the historical data shows. In 2009, the simulation output is 362 140 persons, compared to a historical data of 352 515 persons. This is a gap of 9 625 persons and an error of 2.7% from the historical data. After 2009, the simulated employed labor force increases at the same growth rate as the historical

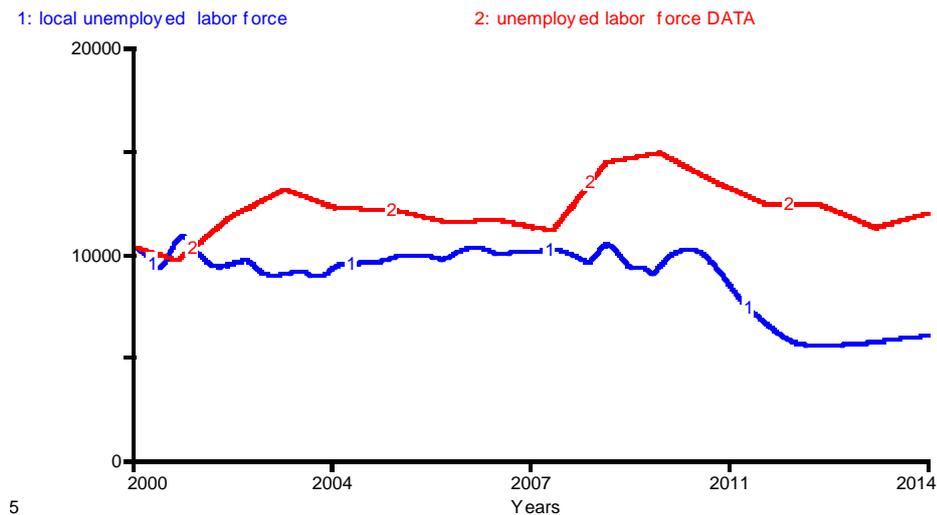
data. In 2014, the simulation output is 412 859 persons compared to the historical data of 403 539 persons. A gap of 9 320 persons and an of 2.3% error.



Graph 5 - employed labor force

The differences in behavioral patterns between the historical data and the simulation output of the employed labor force might be explained by a decline in the employed labor force in the period 2001-2003 and 2008-2009, which turns out too small in the simulation model. The amount of North Dakota workers being fired should be higher than the firing rate produced by the simulation model. Since the firing rate is a direct result of a decrease in labor demand, the input used for the labor demand might deviate from the actual labor demand. Also a decline in labor demand in other states could be part of the reason. Recall that the employed labor force does also include the North Dakota workers employed in other states. A decrease in labor demand in states other than North Dakota also lead to a decline of North Dakota workers employed in these states. This research, however, does not includes all changes in labor demand in other states. Only the total time to find a job in the U.S. influences the time it takes for a North Dakota resident to find a job outside the state of North Dakota.

In the same period that the simulation model produces a level employed labor force which starts deviating from the historical, a deviating from historical data can also be found in the unemployed labor force. This increase the possibility that the decline of labor demand during the period 2001-2003 and 2008-2009 is not good represented in the simulation model. Graph 6 shows the output of the simulation model for the unemployed labor force next to the historical behavior.

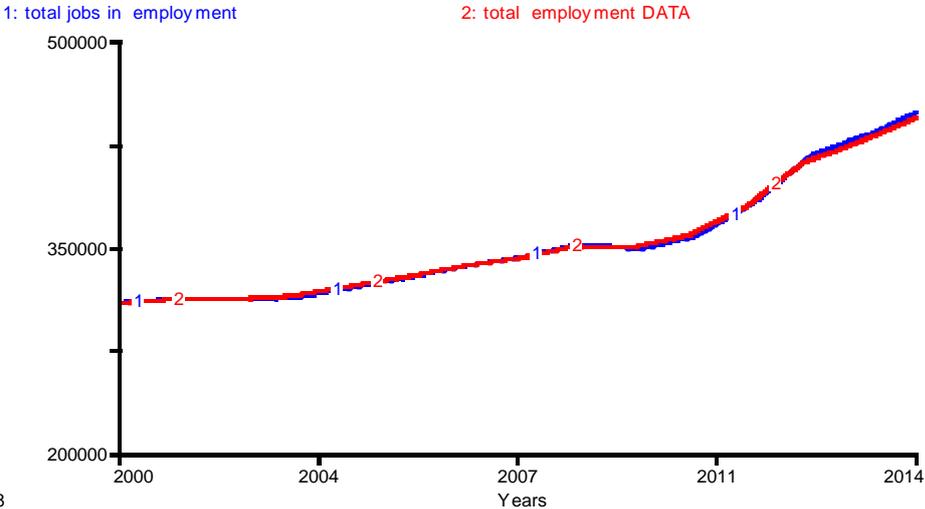


Graph 6 - unemployed labor force

The unemployed labor force starts in 2000 with 10 272 persons. The behavior of the unemployed labor force is significant different from the historical behavioral pattern. The historical data shows an increase from 2001 to 2003, up to a level of 13 098 unemployed persons in 2003. The simulation output show only an unemployment level of 9 004 persons. A gap of 4 094 persons, which is almost equal to the gap in the employed labor force at the same point in time. Also in 2008, the simulated unemployed labor force does not increase as much as the historical behavioral data indicates. In 2009, the simulated unemployed labor force is 9 153 persons compared to historical data of 14 869 persons. A gap of 5 716, an error of 38.4% from the historical data. This makes it more plausible that the discrepancy in the employed labor force can be explained by an underestimation of decline in labor demand and thus the firing rate.

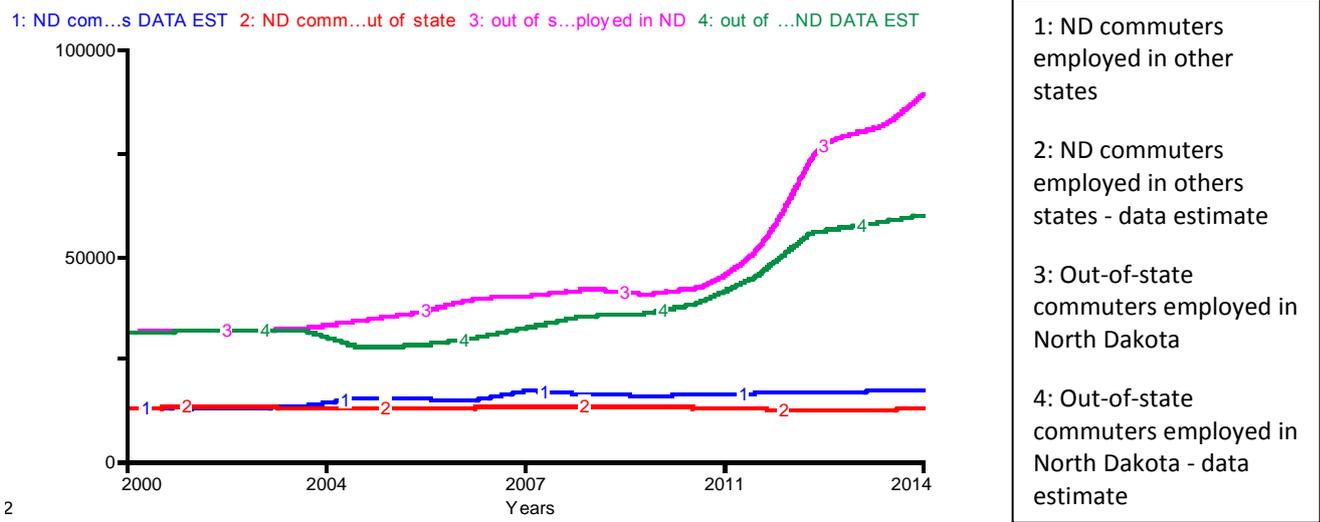
The primary driver of the employed labor force is the demand for labor. The desired employment (in jobs) reflects this labor demand in graph 3. In graph 7 the actual employment in jobs as simulated by the model is presented. The employment in 2000 is 309 224 jobs. The growth rate in employment in jobs stays around zero until 2004. A growth rate below zero implies that people have been fired, which will both deplete the employment in jobs and the employed labor force. From 2004 to 2008, there is a small growth rate in jobs leading to increase the employment from in 2004 from 319 760 jobs to 351 442 jobs in 2008. During this period the simulation models shows a total growth in jobs of 31 682 and a growth in employed workers of 24304. During 2008-2009, the growth rate is around zero. The employed labor force does also show an increase. As already discussed in the problematic

behavior (chapter 2), the biggest difference is the growth in jobs and persons since 2009. The employment increases from 348 548 jobs in 2009 to 448 802 jobs in 2014. A total growth of 100 254 jobs compared to a growth of 50 719 employed workers who are resident in North Dakota.



Graph 7 - employment in jobs

To create the complete picture of the labor supply, graph 8 presents the commuters, both those coming from out-of-state and are employed in North Dakota and those who are resident in North Dakota but are employed out-of-state. The data estimates are based on the Home-Destination Report. It is an estimation because the Home-Destination Report uses employment data different than ours. Therefore, the fraction of North Dakota primary jobs which is filled with out-of-state workers as measured by the Home-Destination Report is taken and multiplied by the employment measurement we use.



graph 8 - commuters

Looking at the commuters who are resident in North Dakota we see that behavior resulting from the simulation model stays relative stable. In 2000, there are 12 614 North Dakota commuters, in 2014 there are 12 320 commuters. The estimation indicates that there are 16 949 commuters from North Dakota in 2014. The reason behind the discrepancy is that the job search of North Dakota commuters in other states is based on the relative market attractiveness. Due to the good relative labor market attractiveness in North Dakota, there are not as much North Dakota residents applying for jobs in other states.

Nevertheless, the simulation model does show an increase in North Dakota job seekers in other states. This is because North Dakota labor force has been increasing and therefore there are more people who can apply for a job somewhere else. This increase in job seekers is not reflected in the commuters from North Dakota in other states, because it is offset against a high time to get a job for these job seekers. The time to find a job has been increasing to 35 weeks according to data from the U.S. Bureau of Labor Statistics. Therefore, the North Dakota job seekers that are out searching for a job in other states are hardly getting a job and less people can thus become a commuter outside North Dakota.

In reality, however, the chances for a job might be better than as reflected in the U.S. time to find a job. Also other factors might be playing a role in the increase in North Dakota commuters in other states. For example, a general increase in labor mobility. Also for workers in border regions, the location of the job opportunities in other states might be closer to their home than the job opportunities in the Bakken Area. Other factors which fall outside the

boundaries of this model might also impact the trend of commuters from North Dakota to other states. In this research, the commuters from out-of-state to North Dakota will have a bigger impact on the supply of labor. Therefore, more attention is being paid to the commuters from out-of-state employed in North Dakota.

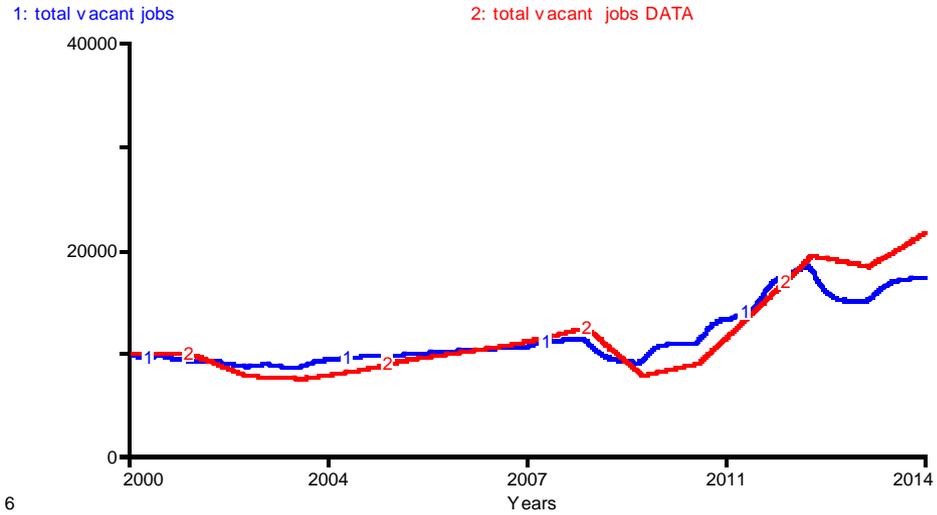
The out-of-state commuters employed in North Dakota start in 2000 at a level of 30 961 persons. This number stays relative stable until 2003. The data reflects a decrease in out-of-state commuters after 2004 while the simulation output shows an increase. Until now, the reason of this decrease in out-of-state commuters after 2003 remains unclear, since North Dakota's economy has just been catching up. Compared to the U.S. average also North Dakota's labor market attractiveness increases. Since the commuting patterns as modeled in this research is based on the solely the labor market attractiveness the amount of commuters employed in North Dakota shows an increase. Related to the reference data estimates presented in this graph, one should note that it is just an estimation. Therefore, also the real historical trend might differ from what is presented as the data estimates here. Further, the remark should be made that the commuters estimate is only based on a yearly data from 2002-2012. To find out what the actual trend have been in 2003 is problematic since the information available on commuters is really scarce.

What is more relevant is the increase in out-of-state commuters employed in North Dakota when the oil boom has started. It has begun in 2007, but the biggest growth rate in commuters has been after 2009. From 2009 to 2014, simulation model shows an increase in the out-of-state commuters from 40 336 persons to 89 325 persons. This is an increase of 48 989 commuters. The data estimates are only available until 2012 and therefore it does not reveal the estimation after 2012. However, based on other estimations by the Department of Commerce and the high need for temporary housing, the estimate of an increase of 48 989 commuters is plausible.

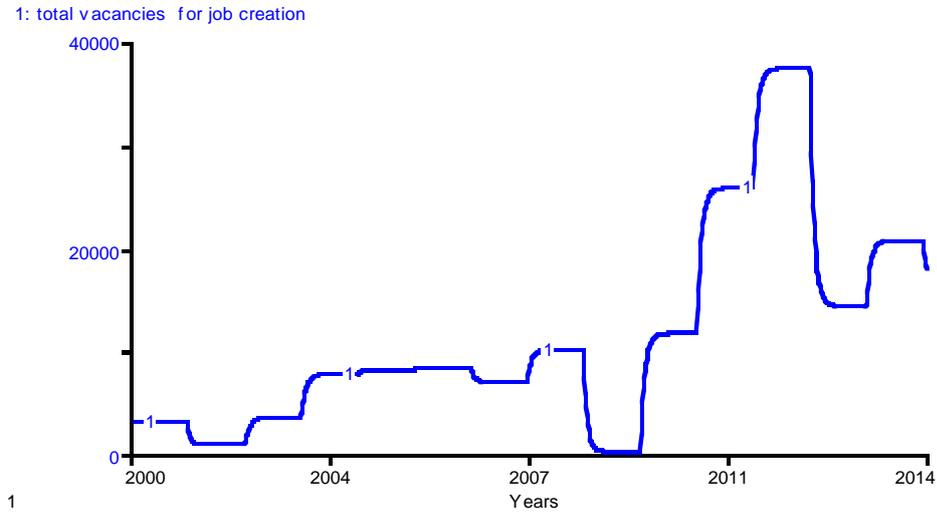
The last important behavioral graph which should be explained is the vacancies, see graph 9. The vacancies start at a level of 9 733 vacancies, it stay relative equal until 2008. In 2008, the vacancies go down and after 2009, when the whole economy starts growing, the vacant jobs increase. The simulation model researches the highest point in 2012 with 18 334 vacant jobs. After 2012, the vacancies start to decline. The reason lies within a slowdown in the demand for labor, which results in a drop in the vacancies being placed for job creation of 23 282 jobs,

compared to the year 2012, see graph 10. The vacant jobs drop till 14 888 jobs, a decrease of 3 446 jobs. In 2014, the vacant jobs increases again up to 17 190 jobs (+ 2 302 vacant job).

What is remarkable is that the vacancies created for job creation only increases just a bit in the period 2013-2014. This therefore indicates that the increase in vacancies in 2013 is thus more a result of vacancy creation for replacement than for job creation.



graph 9- vacant jobs



graph 10 - vacancies for job creation

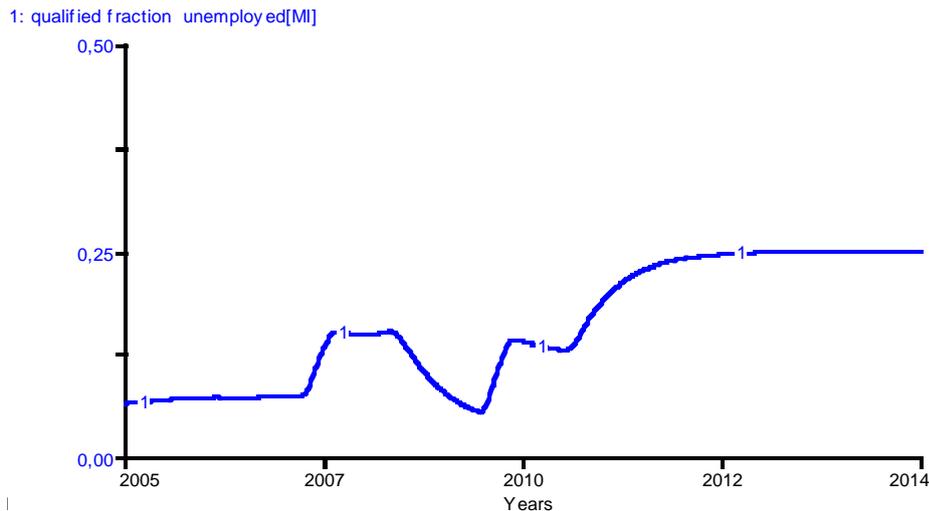
The simulation output of the level of vacancies differs from the historical data. This can either be because (1) the vacancy creation for job creation is higher than modeled based on the input for desired employment, (2) vacancy creation for replacement is higher than what is produced by the simulation model based on the attrition rate or (3) too many vacancies are being filled because of a qualified labor supply which is too high (see model 2). A combination is also

possible. Unfortunately there is no data available on attrition rates. Also, the input for the desired employment which is used can be different according to different databases (see the discussion in the chapter 2 of the problematic behavior). A disadvantage is that annual data is used for the input of the desired employment. Therefore, the vacancy creation for job creation takes place in steps. This behavior is also reflected in the vacancy trend. Monthly data would have been better. Data on labor supply including the job seekers both in North Dakota and out-of-state is only limited available in the Online Job Openings Report. Different input used might result in a different vacancy level. However, overall the behavior pattern produced by the simulation model is compared to the behavioral pattern of the available data a good representation of the reality.

So far, the different components of the labor supply are outlined and the behavior patterns are analyzed compared to the historical behavioral trends. The next step is to analyze the role of different feedback loops as illustrated in the conceptual model (model 1) on the dynamics of the labor supply. Recall that the main feedback loops represent the (1) the effect of the hiring standards on the qualified job seekers, (2) the effect of labor market attractiveness on the additions to the labor force, (3) the effect of labor market attractiveness on the inflow of out-of-state job seekers and (4) the effect of the attrition rate. To analyze the effects of each loop, model output will be generated with and without the loop being active. The focus will be on the period 2005-2014, because this is most relevant for the oil boom. It will also delete the noise in the first year, which exists because of an imbalance in the model due to the input of incoherent data input.

7.2.2 The effect of the hiring standards

The feedback loops C3 and R2 in the conceptual model (model 1) suggests that the organizations adjust their hiring standards to the labor market conditions. As presented in model 11, the hiring standard is modeled with qualified fraction. A decrease in the hiring standard is an increase in the qualified fraction of job seekers. In the previous chapters we have suggested that if the labor market becomes more tight, organizations will lower their hiring standards. As an example, the qualified fraction for mining is presented.



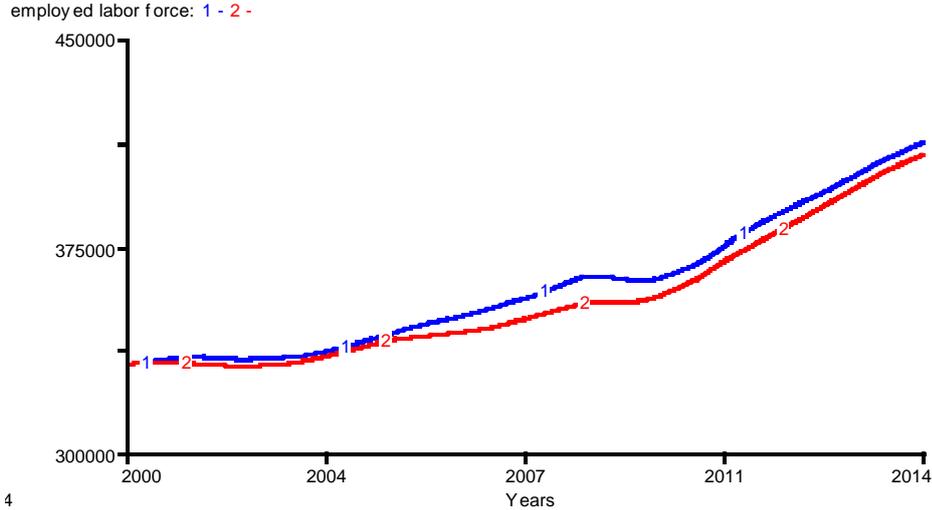
Graph 11 - hiring standards unemployed job seekers in the mining sector

From 2005 till 2006 the qualified fraction stays equal. When the boom in the oil and gas industry starts around 2007, the qualified fraction of unemployed workers in the mining sector goes up, the hiring standards are thus going down. In 2008, the crisis leads to a decrease in demand for labor in the mining sector and an increase in the job seekers. The hiring standards can thus be raised again, the qualified fraction goes up. After 2009, the demand for labor in the mining sector increases again and the qualified fraction goes up. The demand for labor in this sector keeps growing at a higher rate. Around 2010, an inflow of job seekers makes it possible to keep the hiring standards at the same level as the year before. However, the shortage in labor grows after 2011, which makes it necessary to lower the hiring standards again and thus increase the qualified fraction. Around the year 2011, the maximum qualified fraction has been reached. In this model a maximum is set to the qualified fraction, because even though hiring standards can be adjusted, not everyone is able to do the job.

Also other sectors have a similar reaction to their change in labor demand and the available job seekers per sector. With the same pool of job seekers, the hiring standards determines the amount of qualified job seekers and thus the hiring rate. Since the job seekers are split up in employed job seekers, unemployed job seekers and out-of-state job seekers, the hiring standards determines the hiring rate of each type of job seeker. From graph 11 we can conclude that the qualified fraction has reached its maximum in the year 2011. From 2011 on, the availability of qualified unemployed job seekers in the mining sector is not sufficient and therefore the mining sector is not able to hire as many unemployed job seekers as they desire. They have to hire more workers from out-of-state.

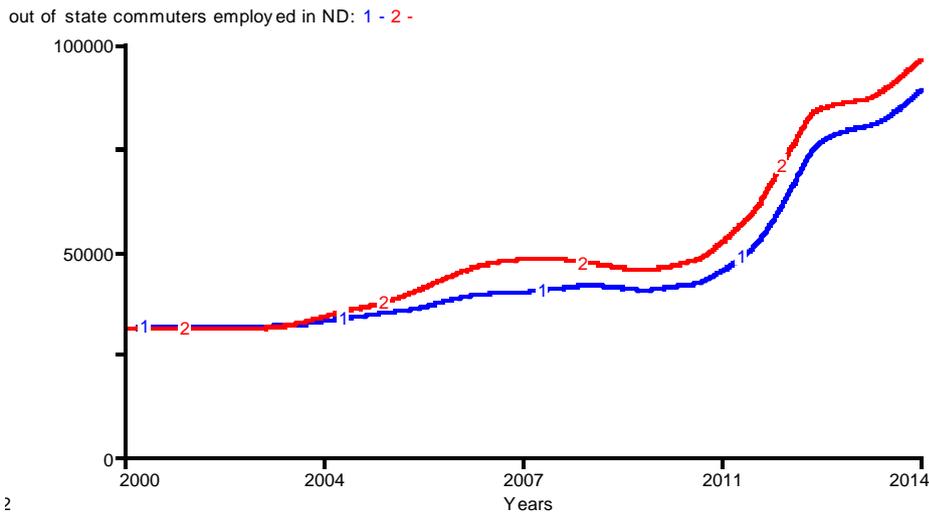
Since all sectors experience the same problem during the oil boom, all sectors have to hire more workers from out-of-state. Those workers can either migrate and become part of the labor force or commute.

In graph 12, the effect of the adjustment of the hiring standards is shown. Scenario 1 - the blue line - represents an adjustment of the hiring standards. In scenario 2 - the red line - the hiring standards are not adjusted. Loop C3 in the conceptual model (model 1) is thus cut between the vacancies and the hiring standards, R2 is cut between the job seekers and the hiring standards. Due to fixed hiring standards, the hiring standards remain higher during the oil boom compared to a situation with a variable hiring standard. The qualified fraction of job seekers is thus lower than if the hiring standard is variable. Graph 12 shows that higher hiring standards result in a lower level of employed labor force.



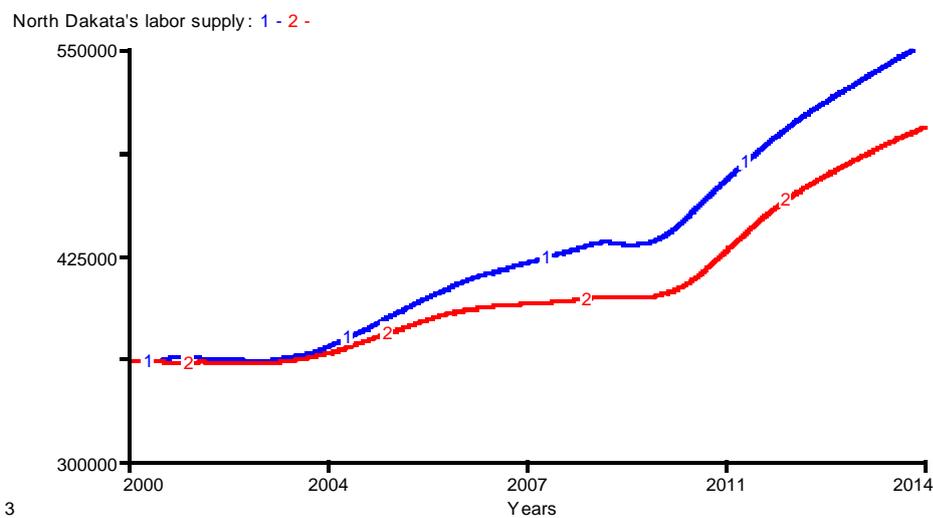
Graph 12 - Effect of adjustment of hiring standards on employed labor force

If the hiring standards will not be adjusted, less persons from within North Dakota are assumed to be qualified enough to be hired. More people have to be higher from outside the state. Therefore, the employed labor force will end up at a lower rate. The employed labor force will still increase, because the increase in labor market attractiveness still attracts more job seekers from within North Dakota and from outside North Dakota. It is especially the immigration of out-of-state workers which fosters the growth in employed labor force. Graph 13 amplifies that the fixed hiring standards lead to a higher hiring rate of out-of-state job seekers and a higher level of commuters in North Dakota.



Graph 13 - Effect of adjustment of hiring standards on commuters

Graph 14 presents the labor supply. The higher hiring standards in scenario 2 lead to a lower supply of labor. Due to higher hiring standards, the chances on a job are lower. Meaning that the time to find a job is higher and the labor market is thus less attractive. Therefore, less job seekers will search for a job in North Dakota and the supply of labor will be lower.

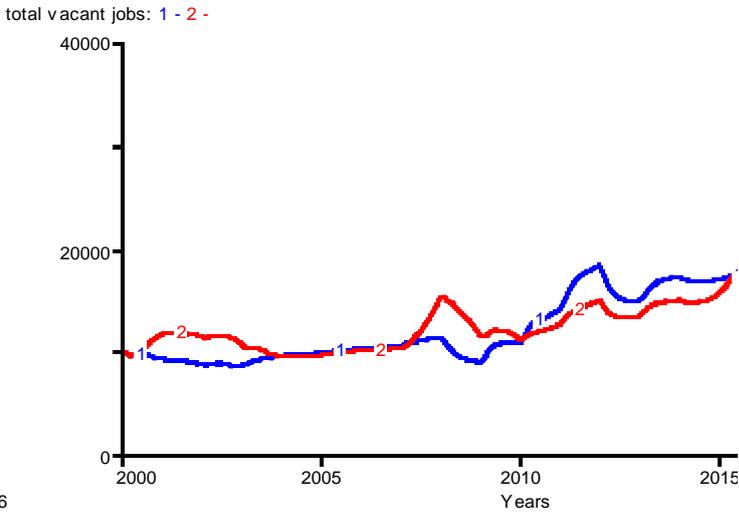


Graph 14 - Effect of adjustment of hiring standards on North Dakota labor supply

Interesting to see is the effect of fixed hiring standards on the level of vacancies. In 2007, the demand for labor increases already and with a fixed hiring standards the amount of qualified job seekers are not sufficient to fill the vacancies. Less job seekers from North Dakota can and will be hired. This effect can also be found in graph 12, which shows a lower increase in the employed labor force after 2007. Also, higher hiring standards, leads to a lower labor market attractiveness and less supply of labor, which we have seen in graph 14. Because the

increase in hiring rate is limited by the fixed hiring standards, the level of vacancies increases in 2007.

What is especially interesting to see is that the level of vacancies after 2010 is not increasing as much with a fixed hiring standard as with a variable hiring standard. The reason is that fixed hiring standards forces the organization to hire out-of-state job seekers instead of employed job seekers. Surprisingly after 2009, the level of vacancies does not increase as much. This is because the U.S. labor market has become less attractive during the crisis. The relative increase in attractiveness of North Dakota's labor market thus lead to an inflow of out-of-state job seekers. The out-of-state job seekers will only fill the vacancies and add to the labor force, while if an employed job seekers is hired the workers need to be replaced. Fixed hiring standards thus lead to more out-of-state workers who fill the jobs in North Dakota. And because less workers who are employed get hired, less workers switch from job, the vacancy creation for replacement is lower and the level of vacant jobs is lower. However, because more jobs are filled with out-of-state job seekers, the service population increase tremendously.



Graph 15 - Effect of adjustment of hiring standards on vacancies

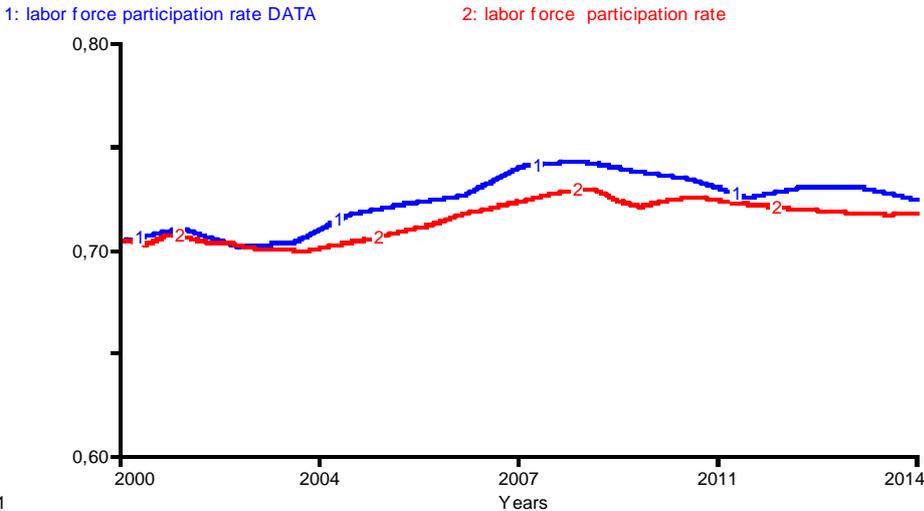
We can thus conclude from the analysis that the loops which adjust the hiring standards (loop C3 R2 in model 1) have a significant impact on the dynamics of the supply of labor. The hiring standards affect the qualified job seekers and therefore impact the completion of jobs with either local or out-of-state workers. The employment of these different type of workers

also has a different affect on the attrition rate, the hiring standards do also affect indirectly the level of vacancies.

7.2.3 The effect of labor market attractiveness on the additions to the labor force

Another important driver of the number of job seekers available in each sector is the labor market attractiveness. The conceptual model, feedback loop C4, shows that if the labor market attractiveness increases, the additions to the labor force will be higher. Model 4, shows that the additions to the labor force add up in the unemployed labor force. An increase in the attractiveness will thus increase the labor force and the amount of job seekers (C5 and C6). As a result, more job seekers can be hired, the hiring rate goes up and the level of vacancies goes down.

A measurement of the effect of an increase in the labor market attractiveness on the additions to the labor force is the labor force participation rate, which is presented in graph 16. The labor force participation rate is the percentage of the civilian non-institutionalized population 16 years or older who are employed or actively looking for a job. The historical data shows that the general trend in the labor force participation rate in North Dakota increases from 70% in 2000 to 74% according to the historical data, after 2007, the labor force participation rate declines to 72%. The model behavior shows less fluctuations than the historical behavioral pattern. The labor force only increase to 73% in 2007. In the years 2001-2003 and 2008-2009, when North Dakota unemployment shows an increase, the labor force participation rate declines.



Graph 16- labor force participation rate

This decline in the labor force participation rate is consistent with the feedback loops C5 and C6 in model 4. When the unemployment increases, the time to find a job for unemployed job seekers will be higher. This will lower the labor market attractiveness. More job seekers think they will not be able to find a job, they become discouraged and leave the labor force. This process adds to the understanding of why the simulated unemployment in graph 6 does not increase when the labor demand goes down. The layoffs which should lead to an increase in unemployment, are compensated with persons leaving the labor force due to worse labor market conditions.

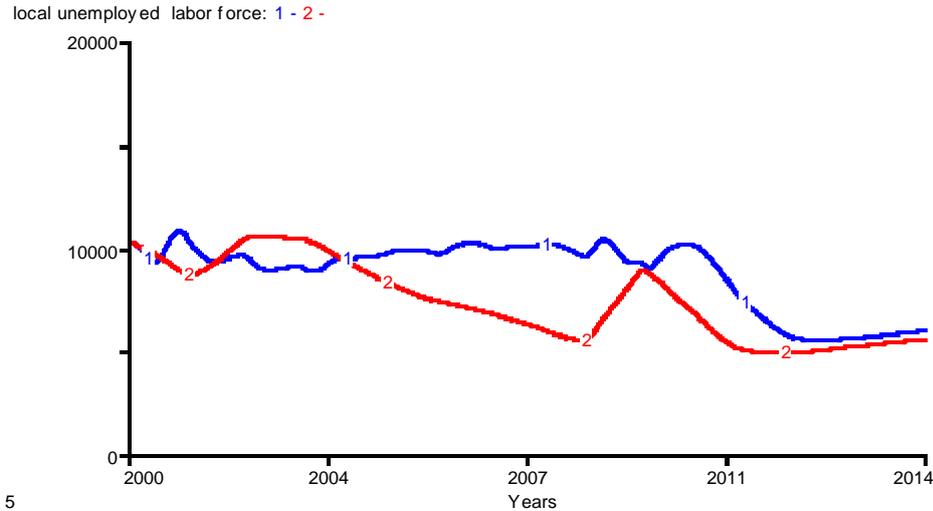
Against most expectations, the labor force participation rate still declines after 2009. It would make sense that the labor force participation rate will increase due to a higher labor market attractiveness as a result of the oil boom. In fact, more North Dakota residents will indeed join the labor force. However, this increase in the labor force participation rate is offset by the inflow of migrant workers and their household members. The household members will not immediately integrate in the labor market, because it is plausible that they will stay only temporary in North Dakota. Immigrant families are also attracted by the high wages for the primary earner in the family, the partner does not necessarily have to work. Unfortunately, research has not yet been conducted on the integration of the partner of migrant workers for interstate migration. The only research available on integration of partners of migrant workers is devoted to country-to-country migration flows. The huge inflow of migrant families after 2009 is therefore pushing the average labor force participation rate down.

In this simulation model, the labor force participation rate responds with a delay on the labor market conditions. It takes some time for the labor supply to perceive the time to find a job and the relative earnings, and then again, it takes time before the labor supply will act on the new knowledge gained on the labor market conditions. This delay causes small oscillations in the simulation output of the unemployment in graph 6.

To analyze the impact on the labor supply dynamics of loop C4 in the conceptual model (the effect of the labor market attractiveness on the additions to the labor force), two scenarios will be compared. Scenario 1 includes the effect of the labor market attractiveness on the additions to the labor force, the labor force participation rate will thus be variable. Scenario 2 shows a scenario in which there is no impact of the labor market attractiveness on the additions to the labor force, the labor force participation rate is fixed. Loop C4 is thus cut between the labor

market attractiveness and the additions to the labor force. Graph 17 shows the outcome on the unemployment. The blue line represents scenario 1, the red line scenario 2. Note, that even with a constant labor force participation rate the additions to the labor force can increase, because the population increases.

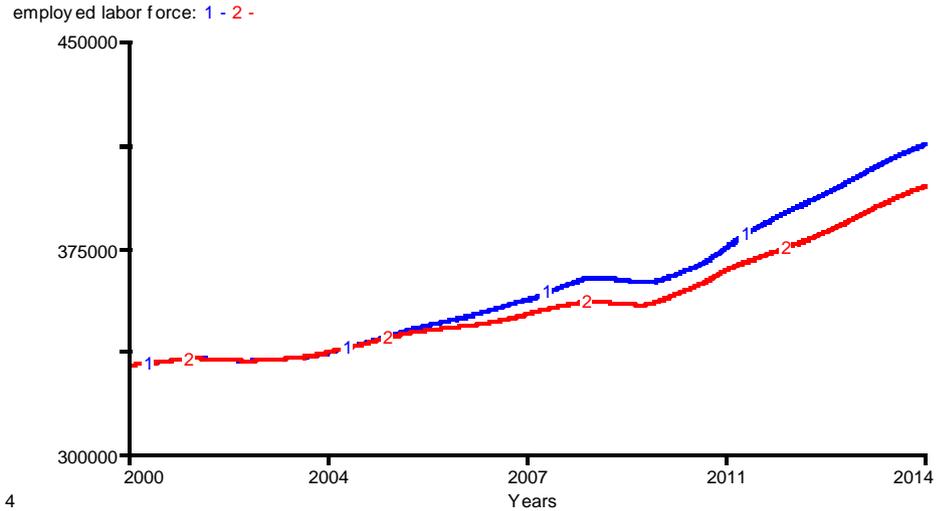
Assuming a fixed labor force participation rate, the labor supply will not respond to a worsening of the labor market attractiveness. Workers who were fired will keep looking for a job. Therefore, in contradiction to a variable labor force participation rate, a constant labor force participation rate is able to show the increase in unemployment in the period 2001-2003 and 2008-2009. From 2001 to 2003, the unemployment increases from 8 726 persons to 10 422 persons, an increase in unemployment of 1 696 persons, which is closer to the actual increase in unemployment of 2 465 persons as reflected in the historical data, than the simulation output with a variable labor force participation rate. In the period 2008-2009, a constant labor force shows an increase in the unemployment of 3 573 persons, compared to an increase in historical data of 3 784 persons.



Graph 17 - unemployed labor force with constant labor force participation rate

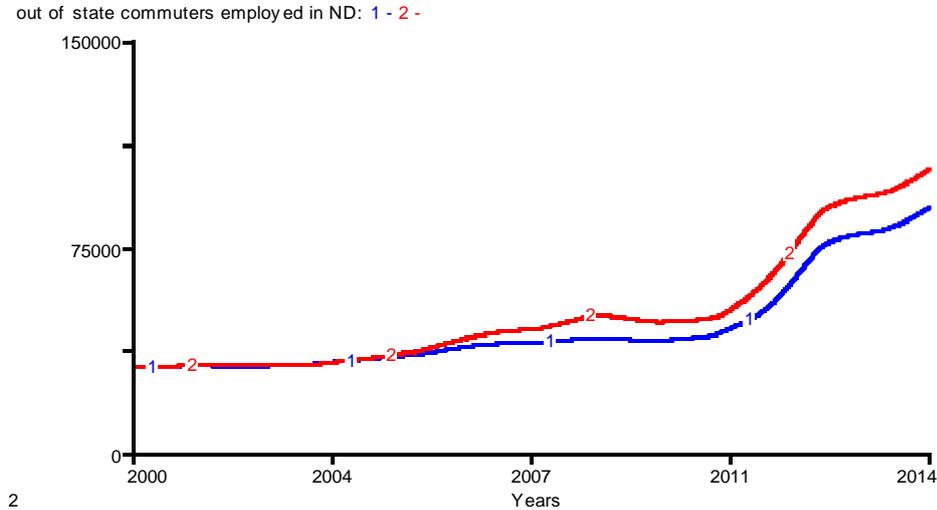
A fixed labor force participation rate is better able to explain the level of unemployment than a variable labor force participation rate. However, a constant labor force participation rate is not realistic. Historical data displayed in graph 16 (Local Area Unemployment Statistics) shows that the labor force participation rate does change. A constant labor force participation rate will also limit an increase in the employed labor force from local residents.

Graph 18 shows that the employed labor force will increase at a lower rate if the labor force participation rate is fixed. The employed labor force in 2014 is 412 859 persons with a variable labor force participation rate and 397 461 persons with a constant labor force participation rate, a difference of 15 408 persons. The reason is that if the labor force participation rate will not grow, the amount of local job seekers are not able to grow as much. Therefore, less vacancies can be filled from within North Dakota borders.



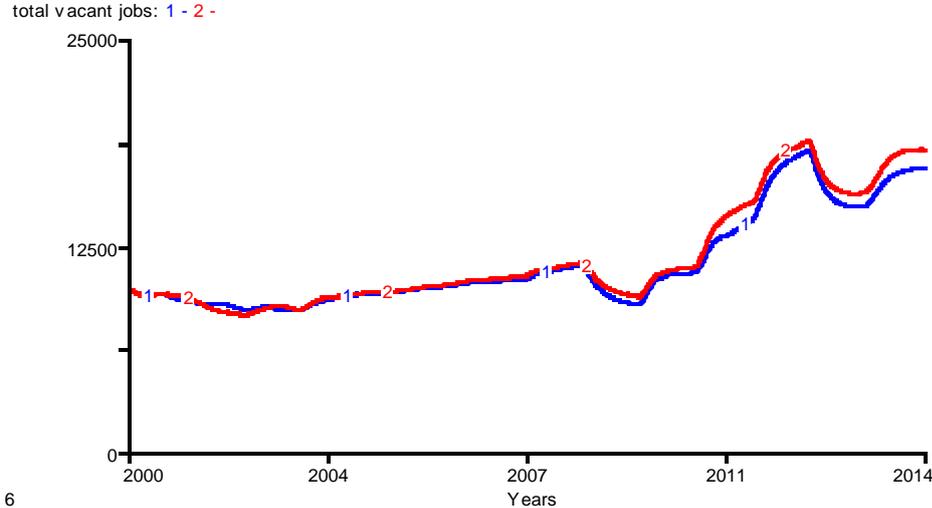
Graph 18 - employed labor force with constant-variable labor force participation rate

With a lower labor force participation rate, more jobs will be filled with out-of-state workers. The out-of-state hires who migrate are included in the employed labor force. The out-of-state hires who commute are not. As we have clarified in this research, commuters form an important source for filling up the vacancies. In the scenario of a constant labor force participation rate, there are thus more out-of-state commuters in North Dakota (+ 14 076 persons).



Comparative graph 19 - commuters with constant-variable labor force participation rate

Although the workers from out-of-state will be able to fill the vacancies, more commuters and immigrant workers will also lead to a higher quit rate of workers. In conceptual model 1, we have seen that workers, the labor supply, can make the decision to quit working. The attrition rate in return impact the vacancy level. Model 9 shows that out-of-state workers are more likely to quit their job. Because they are less tied to the state, they can decide to return to their home country or to find a job with better opportunities in another state. The employee tenure of these out-of-state workers is thus assumed to be lower than that of the local workers. Having more out-of-state workers employed, will thus lead to the need to place more vacancies for replacement and thus leads to a higher level of vacancies. This can be seen in graph 20. The difference between vacant jobs in 2014 with a variable or constant labor force participation rate is 1 084 jobs (filled with 1 084 persons). Note that there is still a discrepancy between the sum of the increase in vacancies and commuters and the increase in employed labor force, because more North Dakota residents, commuters, are employed in other states (an increase of 248 persons in 2014).



Graph 20 - vacant jobs with (1) variable or (2) constant labor force participation rate

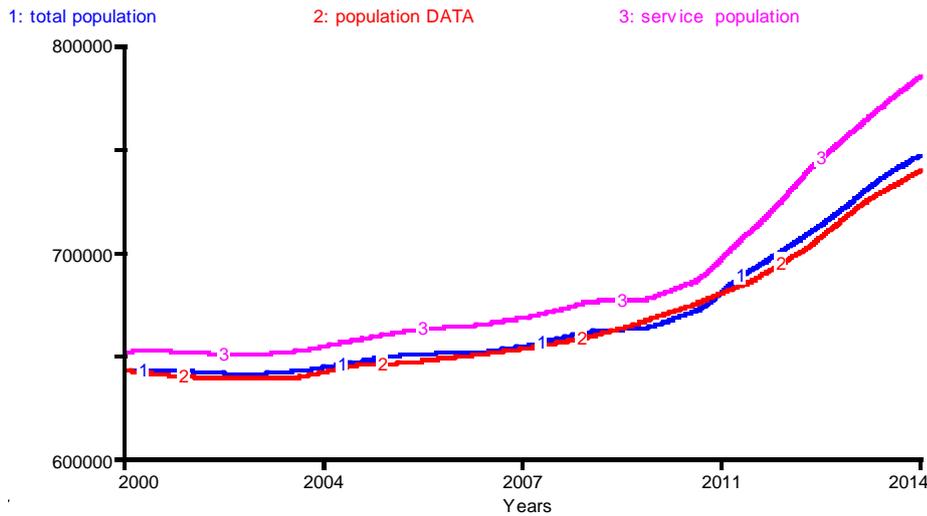
The analysis of the two scenarios show that loop C4 in the conceptual model, the feedback loop that suggests the impact of the labor market attractiveness on the additions to the labor force, does have a significant impact. The labor market attractiveness impacts the local job seekers, those who are resident in North Dakota and who are thus part of the local labor

supply. A higher labor force participation rate, leads to more local supply of labor and therefore, less jobs have to be filled with workers from outside North Dakota. If a smaller portion of the jobs is filled with out-of-state workers, the attrition rate will be lower. This is because out-of-state workers tend to have a lower average employee tenure than local workers, because they are likely to leave the state again. As a result, less vacancies have to be placed for replacement, leading to a lower level of vacancies.

7.2.4 The effect of the inflow of out-of-state job seekers

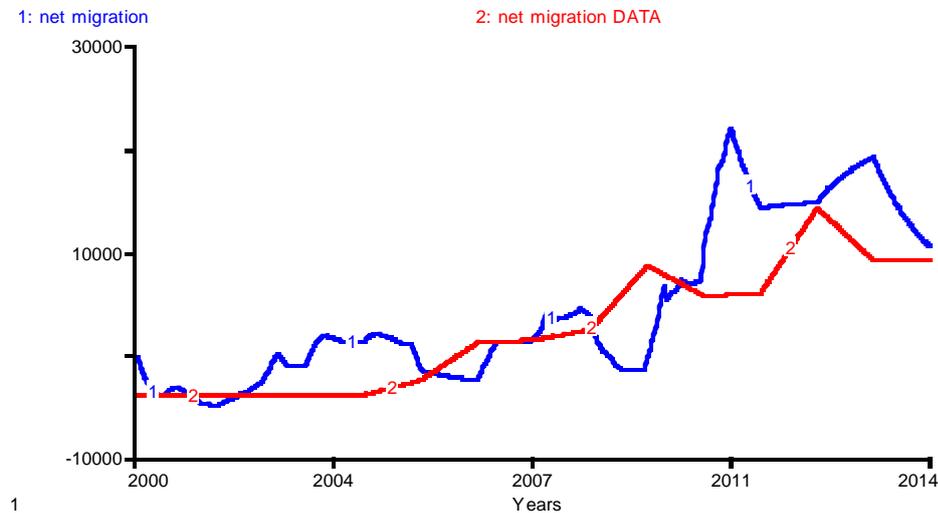
In this previous sections of the behavioral analysis the effect of an inflow of out-of-state workers has already been part of the discussion. The output which has not been discussed yet is the impact on the population. Due to the inflow of migrants the population increases. The increase in commuters being employed in North Dakota increases the service population. The behavioral pattern of the population as produced by the simulation model is similar to the historical data trend. The population increases from 642 200 person in 2000 to 662 628 persons in 2009. From 2000-2003 the population was declining due to emigration, see graph 22. After 2003 the population increases at a steady rate until 2009. Since 2009, the inflow of migrant workers to fill the vacancies leads to an increase in the population. The population simulated in this model increases from 662 628 persons in 2009 to 746 687 persons in 2014, which is an increase of 84 059 persons.

Even as important is the service population. The service population includes also the commuters, who might not live in North Dakota, but because they work two weeks off-two weeks on, they spend half of their time in North Dakota. The behavior of the service population produced by the simulation model shows that the service population increases in the same pattern as the population from 651 374 persons in 2000 to 676 356 persons in 2009. After 2009 the service population increases at a higher rate than the population, because also the amount of commuters in North Dakota. In 2014, the service population was 785 378. From 2009 to 2014, the model thus shows an increase in the service population of 109 022 persons. Although there is no historic data on the service population available, an increase in the service population is also founded by Hodur and Bangsund (2013).



Graph 21 - population

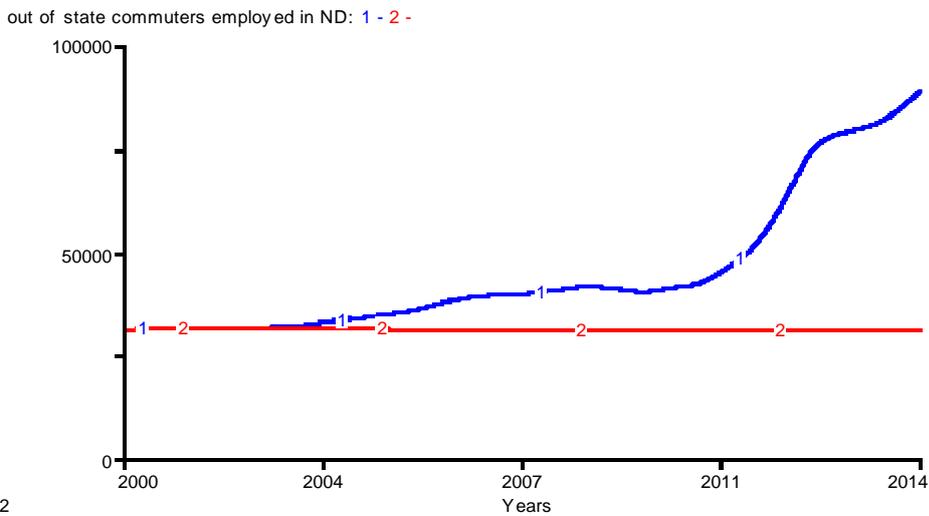
The net migration in graph 22 is set against the historical data which is available since 2005. Before 2005 an estimation is being made based on the total net migration in the year 2000-2004. However, the data on migration has a large measure of error and can thus only serve as a general pattern check. The migration simulated by the model shows some deviations from the historical data, but the trend in net migration since 2009 is both increasing.



Graph 22- net migration

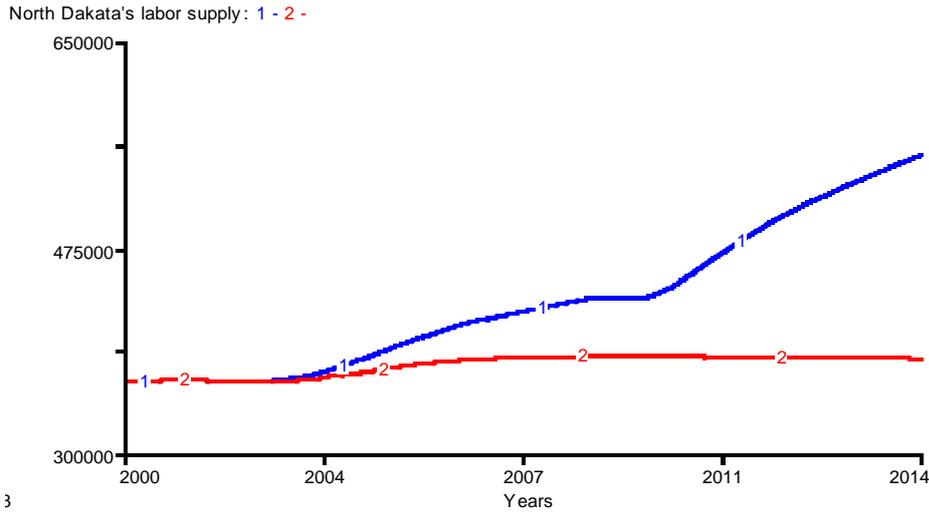
These outputs show the strength of the loop of the labor market attractiveness through the inflow of out-of-state job seekers (loop C5 in model 1). To further confirm the strength of this loop, the effect of the labor market attractiveness on the additions to out-of-state job seekers will be taken away. Loop C5 will be cut between the labor market attractiveness and the out-

of-state additions to job seekers. Graph 23 shows the effect of fixed additions to out-of-state job seekers. Scenario 1- the blue line - represent the behavioral pattern of the out-of-state commuters employed in North Dakota when additions to job seekers are variable. Line 2 - the red line - shows the effect of fixed additions to job seekers. When the labor market attractiveness would not impact the additions to the labor force, the amount of out-of-state job seekers in North Dakota will stay the same. This puts a limit to the hiring rate of out-of-state job seekers, therefore the level of commuters in North Dakota stays almost the same. The same effect holds for the immigration.

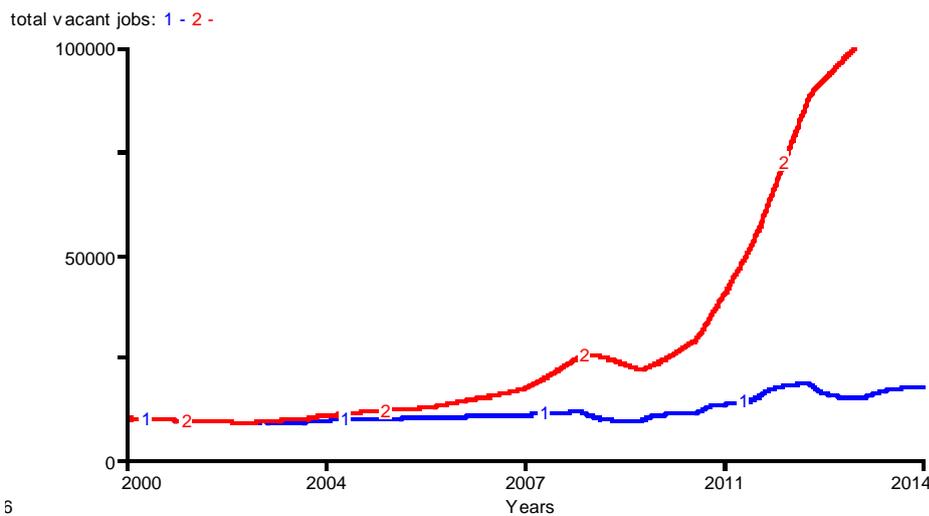


Graph 23 - the effect of labor market attractiveness on out-of-state job seekers and the commuters

If there is no increase of out-of-state job seekers, the supply of labor is only able to increase with local workers, see graph 24. This supply of labor is not sufficient, so the vacant job cannot be filled. As a result, the vacant jobs increase after a boom in the labor demand, see graph 25.



Graph 24 - the effect of labor market attractiveness on out-of-state job seekers and the labor supply

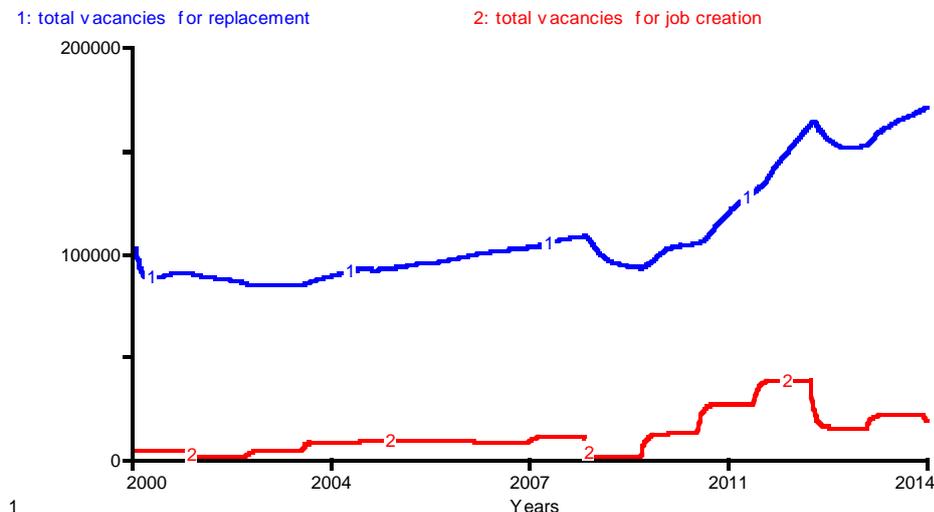


Graph 25- the effect of labor market attractiveness on out-of-state job seekers and the vacancies

One can thus conclude that loop C4 in model 1, the effect of the labor market attractiveness on the out-of-state job seekers, is very important in explaining the labor supply dynamics. Without this growth in out-of-state job seekers, only a small part of the vacant jobs will be filled.

7.2.5 the effect of the attrition rate

The last loop which will be test is the effect of the attrition rate in loop R1 in model 1. Figure 26 showed the vacancy creation for replacement and for job creation. In 2000 the vacancies created for job creation were 2 949 jobs per year, the vacancies created for replacement was 101 802. The vacancies for replacement represents thus 97.2% of the total vacancies. The vacancy creation for job creation increases slowly after 2003. In 2008, the vacancy creation for job creation declines to 154 jobs per year. In 2008, the vacancies for replacement also decrease to a rate of 92 487 jobs per year. From 2009 on, the behavior simulated by the model shows an increase in both the vacancies for job creation and the vacancies for replacement. The vacancy creation for job creation increases to 19 646 jobs per year, which is an increase of 19 492 jobs per years compared to the crisis in 2008. The vacancy creation for replacement increases to 162 999 in 2012, which is an increase of 70 512 jobs per year compared to 2008. After 2012, both the vacancy creation for job creation and for replacement decline. In the 2014, the vacancy creation for job creation is 20 674 compared to 169 934 jobs year for replacement. In 2014, the vacancies placed for replacement capture thus a share of 89.1% of the total vacancies created per year.



Graph 26- vacancy creation

The behavioral output in graph 26 thus shows that the vacancies for replacement are the main source of vacancy creation. The vacancies for replacement are being placed when attrition occurs. Model 9 offers insights in the sources of attrition. In this model, attrition can occur because of retirement, job-hopping, emigration or quit rates of the commuters. Conceptual model 1, already showed that the attrition rate increases when the employment increases.

When there are more workers employed, more workers will also resign, under the assumption that the average years of retaining a job stays equal. This effect has been shown in the small simulation model which is analyzed in the beginning of this chapter.

The increase in the rate of vacancies placed for replacement cannot solely be explained by an increase in employment. Also the years of retaining a job has changed. An important factor for the years of retaining a job is the desire of the worker to look for another job. This is shown in model 5, a more attractive labor market increases the on-the-job search. More employed job seekers lead to more employed job seekers being hired, which increases the attrition rate. The average employee tenure thus goes down.

Figure 27 presents the behavior of the average employee tenure in the manufacturing sector. In 2000, the average employee tenure was 5.12 years. The employee tenure fluctuates a bit in line with the vacancies. In 2008-2009 the employee tenure increases to 5.86 years because of the worsening of the labor market due to the crisis. After 2009, the oil boom improves the labor market attractiveness which leads to a decline in employee tenure to 4.27 years in 2012. This implies a drop in the employee tenure of almost one year.

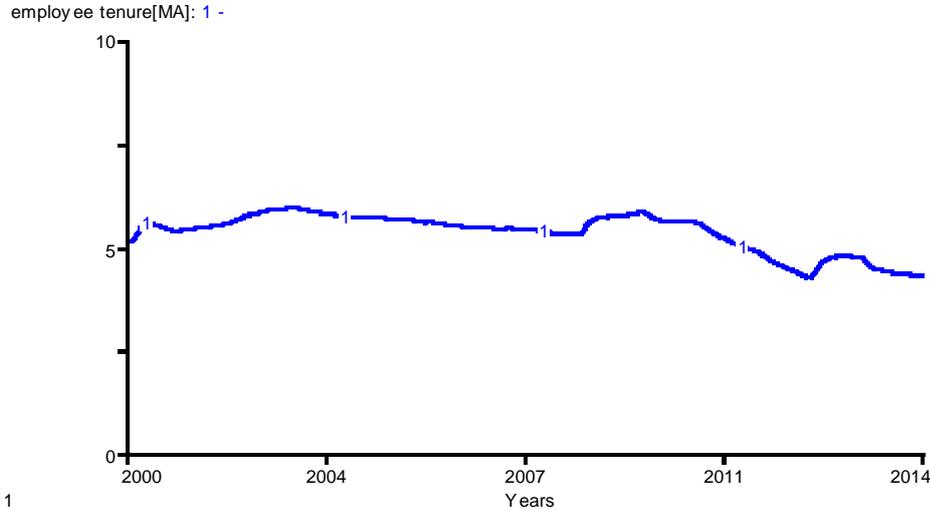


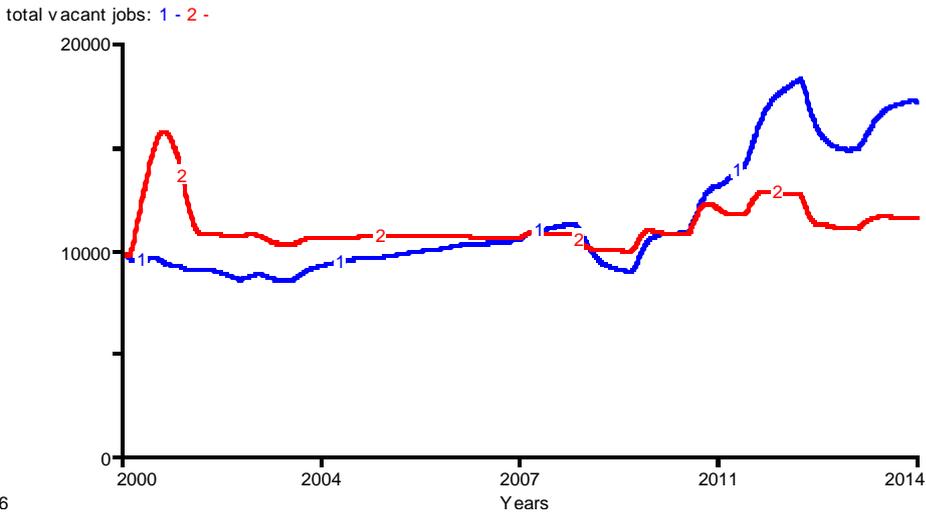
Figure 27 - employee tenure Manufacturing

Also the out-of-state workers play a big role in this development. Both the commuters and the migrant workers tend to have less commitment to the job and are willing to retain a job for less years than the local workers. The reason is that these out-of-state workers are willing to move to another place. The simulation model shows that a larger fraction of the North Dakota jobs is filled with out-of-state workers, this will thus also push the average employee tenure

down. Both a shorter period to retain a job and the increase in the employed workers thus lead to an increase in the attrition rate. This increase in the attrition rate will raise the vacancies for replacement and thus the vacant jobs to a higher level.

Graph 28 shows what would have happened if vacancies for replacement would stay at the rate of the year 2000. Note that this simulation does only include fixed vacancies for replacement, the labor supply system will still respond to the actual attrition rate. Loop R1 in the conceptual model (model 1) is thus cut between the attrition rate and the vacancies. In scenario 1 the attrition rate still impacts the vacancies for replacement, in scenario 2 the vacancies for replacement are kept constant.

In scenario 2, the vacant jobs first increase, while the vacant jobs in scenario 1 decline. The reason is that in scenario 2 the vacancies for replacement do not respond to the decline in the labor demand. The most contributing part of this graph is the period after 2008. With fixed vacancies for replacement, the level of vacancies will only respond to changes in the vacancies for job creation. This graph reveals that only about 1/3th of the increase in the level of vacant jobs can be assigned to an increase in the demand for labor, the other 2/3th is thus caused by an increase in the vacancies for replacement. Loop R1 in the conceptual model, which presents the effect of the attrition rate on the vacancies for replacement, thus turns out to be an important driver for the level of vacancies.



Graph 28 - effect of attrition rate on vacant jobs

This finding is in contradiction to most views, which assume that the vacancy level is a result of an inability to fill the vacancies for job creation. The increase of the level of vacant jobs in

North Dakota is most of the times explained as a result of a supply of labor which is not sufficient to meet the demand for labor. The analysis show that this is not entirely true. Because it takes time to recruit the workers for the position of the vacancy, the vacancies will always increase, even if the supply of labor is sufficient. Also, the increase in the attrition rate due to a higher level of employment and a lower employee tenure creates the need for the creation of more vacancies for replacement. So even if the supply of labor would able to meet the demand, the level of vacant jobs would still increase due to the effect of the attrition rate on the supply of labor.

8. POLICY TESTING

The oil boom and the shortage in workers raised not only the interest of the business, but also of the state. A shortage in labor was considered to be a big threat for the growth of North Dakota's economy, especially in the oil and gas industry. Table 1 shows the policy recommendations which should foster an adjustment of the labor supply to the labor demand. The policy recommendations are written by the Department of Commerce in Empower North Dakota. The policies are mostly concentrated on (1) attracting workers from outside North Dakota and (2) offering more training programs. These policies were already effective during the period 2007-2014. The effects of these three policies on the labor supply system will therefore be discussed in relation to the conceptual models previously presented. The impact of these policies will be evaluated by means of different simulation runs. An examination of the policy scenarios during an oil boom will increase the understanding of the impact of the policies on North Dakota's labor supply and vacancy level. The knowledge gained can also be used for future booming economies. This chapter will end with a discussion of some suggestions for policies based on the analysis of the model behavior in the previous chapter.

8.1 Recruiting workers from outside North Dakota

Most policies are concentrated on attracting workers from outside North Dakota. Already in the beginning of the oil boom, in 2007, the Department of Commerce started campaigns to recruit workers from other states (Davey, 2008, January 1). Subsequent policies to attract workers from other states were still not considered to be successful enough to create a sufficient large workforce within North Dakota's borders. Many businesses had employed commuters, but as we have discussed before, they would prefer hiring North Dakota residents. North Dakota business were looking for ways to reduce the number of these commuters, the employees, who work, but do not live in North Dakota. The North Dakota Economic Development Foundation was addressed '...to recruit and retain a permanent workforce' (Department of Commerce, 2014, p. 1), which should meet the demand of labor from the business sectors. The North Dakota private sector business and education leaders started together with the state government a joint marketing campaign targeting potential workers, named the Find The Good Life in North Dakota campaign. This campaign was launched in 2014 and was primary aimed to serve the labor shortage in the high-demand industries: healthcare, transportation, energy, engineering, skilled trades and information technology.

Table 1 - Policy Updates and Recommendations: Empower North Dakota

Year publication	Goals	Policy recommendations
2009	' Attract a sufficient number of workers to fill energy related jobs due to retirements, attrition and growth within the energy industries.'	'Expand the state’s workforce recruitment and marketing strategy to include other states and international talent pools...'
		' Attract and train more students into energy industry and energy research jobs by building stronger connections between industry and education and improving awareness of energy career opportunities among teachers and career counselors'
2012	'North Dakota must grow workforce within its borders, and also seek out-of-state workers and students to fill high-demand careers'	'Increase efforts to educate North Dakota’s youth...'
		'Encourage and enable the energy industry to collaborate with the North Dakota University System, Governor’s Workforce Development Council, Job Service North Dakota and other agencies...'
		'Support legislation which recognizes the role distance learning will play in the future of education and improve access to technology for students using distance learning programs.'
2014	'Securing skilled workforce to meet the needs of the state’s business community'	'Continue support of the Housing Incentive Fund'
		'Increase efforts to educate North Dakota’s youth about the state’s natural resources'
		'Encourage and enable the energy industry to collaborate with the North Dakota University System, Governor’s Workforce Development Council, Job Service North Dakota and other agencies'
		'Support increased funding for workplace safety and training.'
		'Support legislation which recognizes the role distance learning will play in the future of education and improve access to technology for students using distance learning programs.'

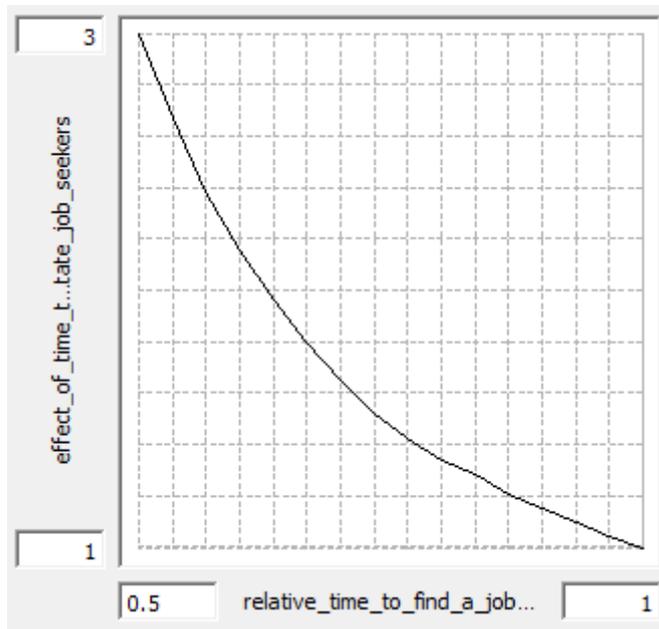
Source: Empower North Dakota (2009; 2012; 2014)

This campaign targets job seekers and students in states with high unemployment, mainly in the states Minnesota, Wisconsin, Illinois, Indiana, Ohio, Michigan and Pennsylvania. Special focus is on the potential workers with a background in S.T.E.M. (science, technology, engineering, mathematics). North Dakota lacks a shortage of highly skilled workers especially in those specific field. North Dakota residents will also be simulated to recruit their friends and family for North Dakota. The campaign is noticed along the interstate roads, where billboards show up with the message of bringing family and friends to North Dakota. A webpage is launched providing the potential workforce with all the necessary information they need to know to make the decision to move to North Dakota. A last point of attention of the agenda of the Find the Good Life in North Dakota is to retain the existing North Dakota workers and residents (Department of Commerce, 2014).

Counteracting loop C5 in conceptual model 1 illustrates the effect of the recruitment of out-of-state workers. Model 8 shows a more disaggregated view on the effect of immigrating families. The campaign to recruit families to move to North Dakota is focused on the inflow of out-of-state job seekers who are willing to move. Businesses and the state government have been advertising with the high number of job opportunities. By presenting North Dakota's labor market attractiveness to potential job seekers, they have been increasing the effect of the labor market attractiveness on the additions to out-of-state job seekers. The current model uses the graphical function as illustrated in graphical function 1. The additions to out-of-state job seekers is normalized to the situation of 2000, so also the relative labor market attractiveness is compared to the year 2000. If the relative time to find a job in North Dakota compared to the time to find a job in the U.S. is equal to the situation of 2000 (the ratio is 1), also the effect of the labor market attractiveness on the additions to the out-of-state job seekers is equal to 1.

The more attractive the labor market, meaning that the relative time to find a job ratio is lower, the bigger is your marginal effect on the out-of-state job seekers. This increasing marginal effect has to do with high reservation wages for potential out-of-state job seekers. They will only be convinced to commute or migrate if the offers are good enough to compensate the traveling expenditures and time away from home. Therefore, the labor market attractiveness has to be a lot better than the labor market in the home state. Assumed is that if the relative labor market attractiveness ratio is 0.5, all potential out-of-state job seekers are reached. An additional improvement of the labor market attractiveness will thus not add to an

increase in the additions of out-of-state job seekers anymore. Therefore there is an increasing marginal effect of the relative time to find a job ratio measured from 1-0.5.



Graphical function 1 - effect of time to find a job on additions to out-of-state job seekers

In this graphical function, the effect on the additions to out-of-state job seekers is now ranging from 1 - 3. Note, that when the relative time to find a job is higher than 1, the emigration will be impacted. It is hard to examine what the effect would have been of the labor market attractiveness on the out-of-state job seekers if there would have been no campaigns.

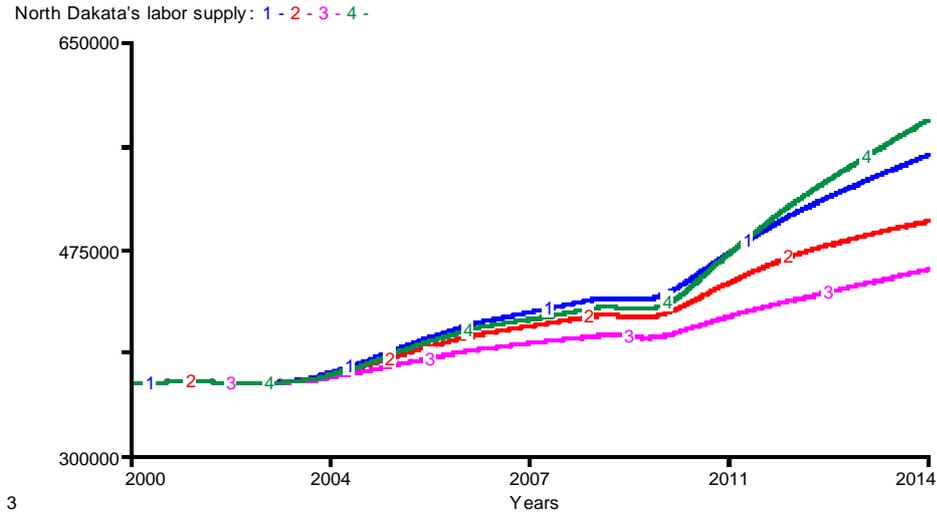
However, it is highly plausible that the campaigns have strengthened the effect of the labor market attractiveness on the additions to out-of-state job seekers. This could thus imply that without intervening the effect of the relative time to find a job on out-of-state job seekers would have been lower. Therefore three scenarios other than the current graphical function are modeled:

- 1) effect ranging from 1-3 (the current graphical function)
- 2) effect ranging from 1-2.5
- 3) effect ranging from 1- 2
- 4) effect ranging from 1-3.5

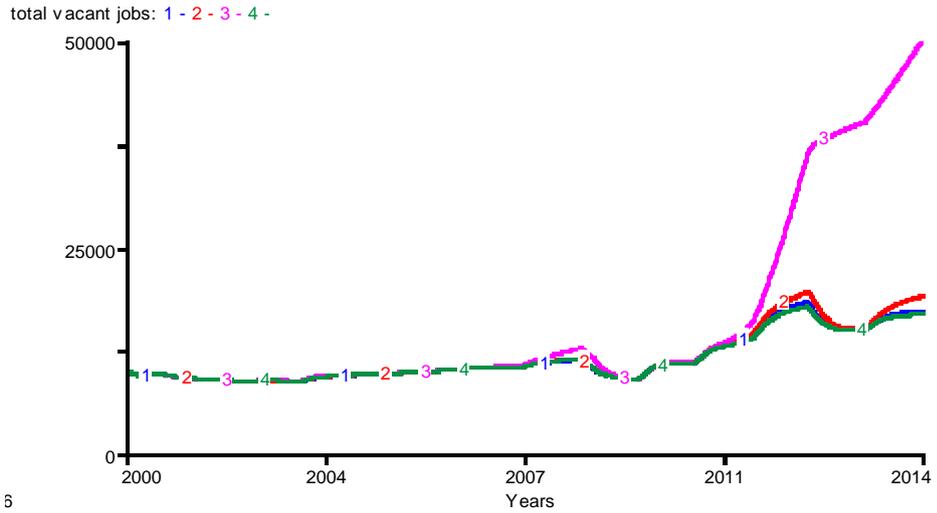
The outcome on both the supply of labor and the level of vacancies can be found in graphs 29-30. Graph 29 shows that the stronger the effect, the bigger the impact on North Dakota labor supply. This can be explained because it leads to a bigger inflow of out-of-state job

seekers who will become part of the supply of labor. A change in the strength of the effect of the labor market attractiveness on the level of vacancies is only noticeable between scenario 2) and 3).

The remark should be made that the graphical function used in this model is only based on an estimation. It is such a soft concept that it could only be validated by comparing the simulation outcomes. There is also no data available on inflows of out-of-state job seekers. This implies that either scenario 2) and 4) can also be assumed to be a plausible effect.



Graph 29 - Policy recruitment of out-of-state workers on North Dakota's labor supply



Graph 30 - Policy recruitment of out-of-state workers on vacancies

Although we cannot know what the effect would have been without the campaign to strengthen the effect of the labor market attractiveness on the out-of-state job seekers, it is

highly plausible that the effect would have been in between scenario 2) and 3). Some effects will always be noticeable because of spreading the word of the job opportunities, so the maximum effect would probably be ranged above 2. If this is the case, the campaigns of recruiting out-of-state job seekers organized by the state and the businesses would have stimulated the inflow of out-of-state job seekers, which helped filling the vacancies. If the effect of labor market attractiveness without policy intervention would have been at the level of scenario 2 or stronger, the policies would not have an impact. The output of scenario 4 also shows that more efforts to recruit out-of-state workers would not have a significant impact on the level of vacancies. The reason is that we have seen in the previous chapter, that the level of vacancies is not mainly a result of a shortage in labor supply, but especially also a result of vacancy creation for the replacement of workers.

To conclude, it is highly possible that the aim of the policy to recruit the workers from out-of-state did indeed reduce the level of vacancies in North Dakota. However, since the normal effect of the relative labor market attractiveness on out-of-state job seekers is uncertain, the real contribution of the recruitment campaigns on the level of vacancies is unknown.

8.2 Training programs

The second policy is concentrated on training the job seekers, especially the youth, so that the skills level should better meet the demand of the industries. TrainND has been established to offer customized training programs, such as commercial driver license (CDL) in order to support the transportation industry and safety training. The training programs are mainly designed to support the industries with a labor shortage. The idea behind the policy to improve training programs is to help support long-term workforce growth in North Dakota which meets the demand of the business sectors (Department of Commerce, 2012). With a better skilled work force, less workers have to be brought from outside the state.

Although the education is not directly included in the model, an effect can be assumed on the qualified fraction of job seekers. The effect within the system is illustrated in model 4, a more extensive view is given in model 7. The qualified fraction in this model is dependent on the required qualified fraction (see model 7). The required qualified fraction will not be changed as a result of the training programs, since business still need to pick just one job seekers per vacancy. The qualified fraction is constrained by the maximum qualified fraction, which represents the minimum hiring standards related to the capabilities required for the job. If the

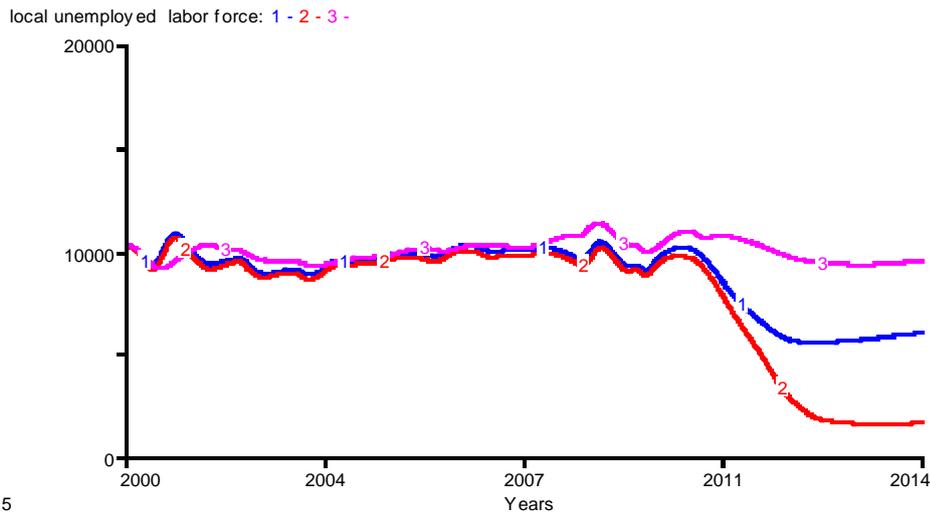
job seekers will be better trained, more job seekers will have the capabilities which are required for the job. With the same hiring standards, the fraction of the applications which will meet those standards will thus be higher. If in general, the qualified fraction is higher, the maximum qualified fraction can be raised. Both unemployed and employed workers within North Dakota will be able to get involved in a trainings program. So if more people will participate in training programs to match their skills to the demand of the industry, the maximum qualified fraction of both the unemployed and the employed job seekers can be raised.

As with the previous policy, the actual impact of the training programs remain unclear. For this research we assume that training programs are successful in increasing the skills level of the job seekers. Three scenarios are presented in order to evaluate the impact of policies to improve skills of the job seekers. There will differentiate between a policy influencing the unemployed job seekers and the employed job seekers.

The first policy simulation is concentrated on the unemployed job seekers:

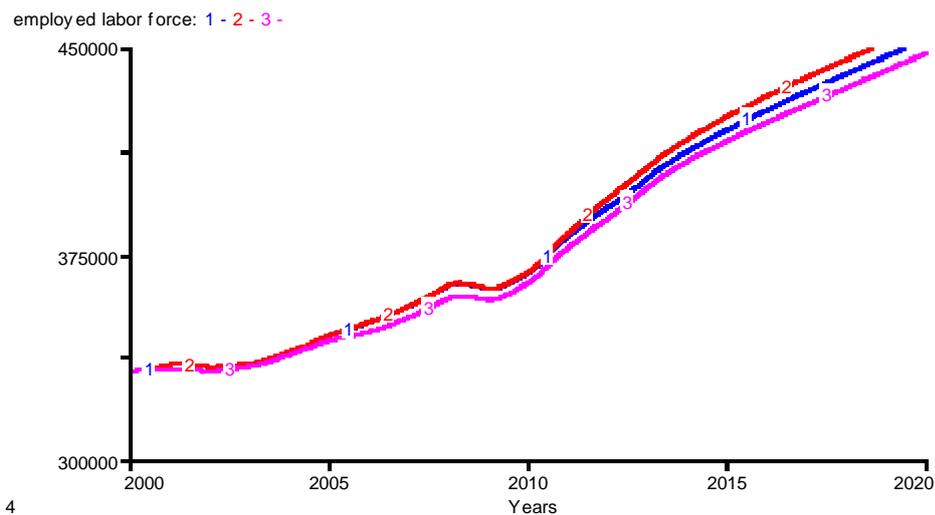
- 1) current skills level of unemployed job seekers (qualified fraction of unemployed: 0.25)
- 2) higher skills level of unemployed job seekers (qualified fraction of unemployed: 1)
- 3) lower skills level of unemployed job seekers (qualified fraction of unemployed: 0.15)

Graph 31 shows that an increase in the skills level of the unemployed job seekers due to retraining will lead to lower unemployment and a higher employed labor force. The reason is that an increase in the qualities of the unemployed job seekers will increase the number of qualified unemployed job seekers and will thus increase the hiring rate of the unemployed job seekers. The increase in hiring rate of unemployed job seekers will lower the unemployment.



Graph 31 - policy of retraining unemployed job seekers on unemployed labor force

The goal of this policy is to grow a skilled workforce within North Dakota's borders (Empower North Dakota, 2012). Graph 32 shows that the policy indeed raises the employed labor force and graph 33 shows that this policy decreases the commuters in North Dakota. As mentioned earlier, effective training programs increase the skills level of the workers, which leads to more qualified job seekers and an increase in the hiring rate of unemployed job seekers. If more unemployed job seekers get hired, less job seekers from out-of-state need to be hired. Therefore, more jobs are filled with North Dakota residents instead of out-of-state job seekers.

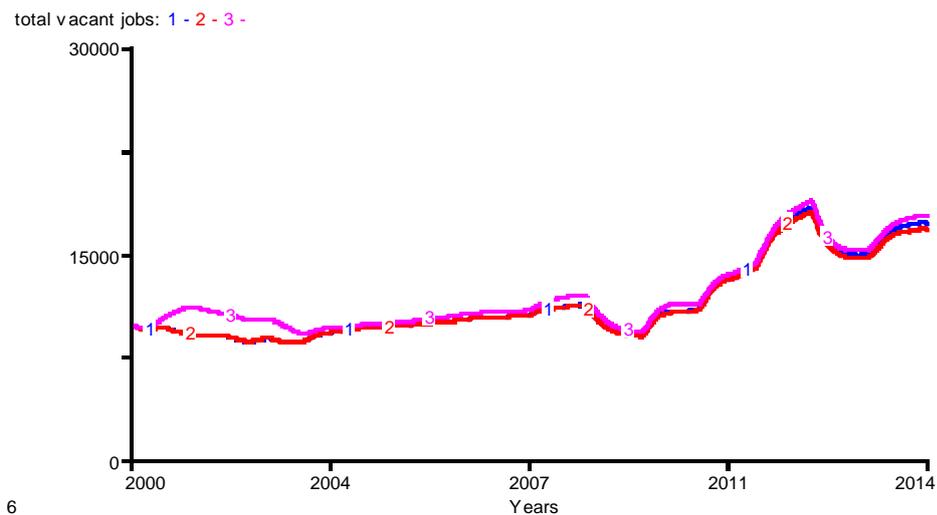


Graph 32- policy of retraining unemployed job seekers on employed labor force



Graph 33- policy of retraining unemployed job seekers on commuters

The overall effect on the level of vacancies is only modest, see graph 34, since this model assumes that if the vacancies will not be filled with local job seekers, out-of-state job seekers will fill the vacancy. However, the rate of vacancies created for replacement of workers will be lower if more local workers fill the jobs. Remember that out-of-state workers tend to retain one job for a shorter period of time than local workers do. Therefore, a higher rate of hiring from unemployed job seekers will decrease the vacancies created for replacement and will result in a lower the level of vacancies.



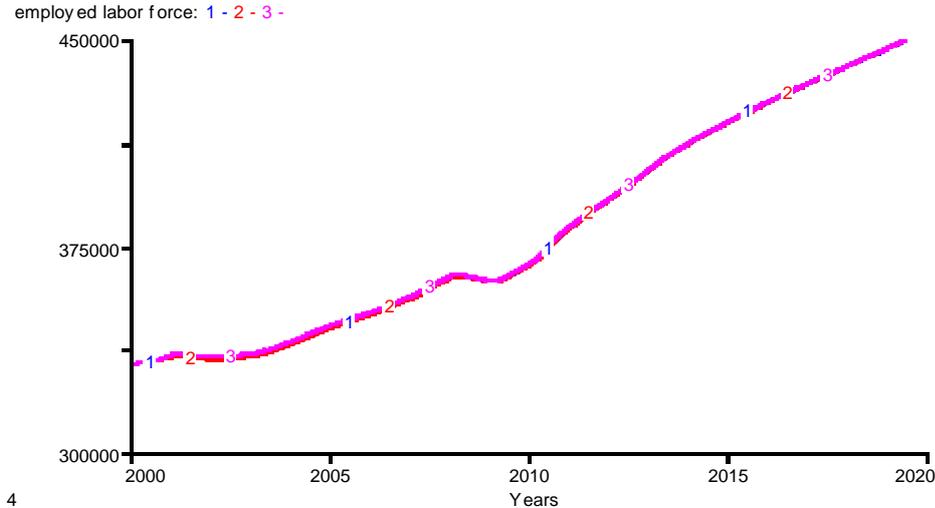
Graph 34- policy of retraining unemployed job seekers on vacancies

To conclude, if the policy to offer more training program has been successful in increasing the average skills level of the unemployed job seekers, this policy has indeed fostered the growth of the workforce within North Dakota's borders.

If the training programs are targeting the employed job seekers the effect will be differently. The following scenarios are simulated in the model:

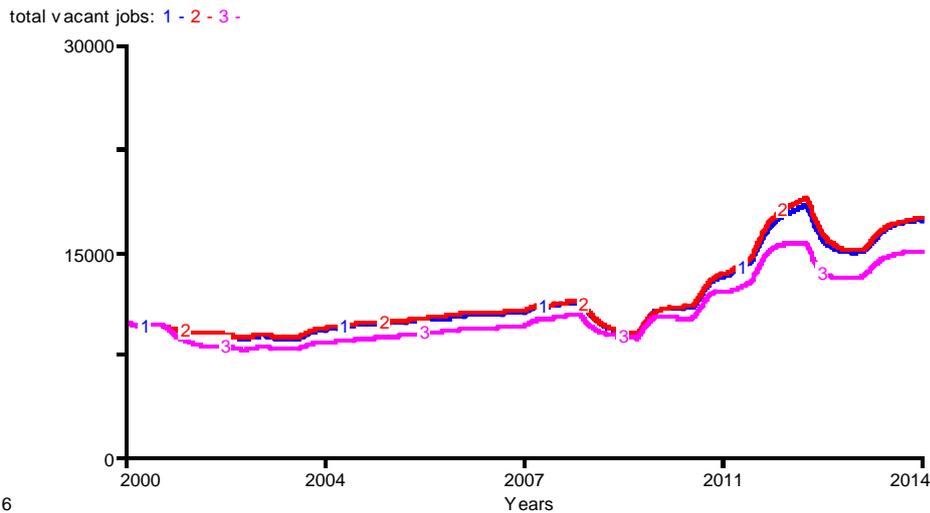
- 1) current skills level of employed job seekers (qualified fraction of unemployed: 0.75)
- 2) higher skills level of employed job seekers (qualified fraction of unemployed: 1)
- 3) lower skills level of employed job seekers (qualified fraction of unemployed: 0.5)

An increase in the skills level of the employed job seekers will increase the number of qualified job seekers and therefore increase the hiring of employed job seekers. However, in contradiction to the unemployed job seekers, the employed job seekers are already part of the employed labor force. Therefore, an increase in hiring of employed job seekers will not have an impact on the employed labor force (see graph 35).



Graph 35- policy of retraining employed job seekers on employed labor force

The increase in the skills level of employed job seekers will, however, have a negative side effect. An increase in the hiring of employed job seekers will namely increase the attrition rate and thus increases the vacancies that needs to be created for replacement of those workers. As a result a small increase in the level of vacancies can be notified in graph 36, as a result of the retraining programs targeting employed job seekers.



Graph 36- policy of retraining employed job seekers on vacancies

The outcome of the training programs targeting employed job seekers is thus conflicting with the goal of the state to lower the vacancies. To summarize, training programs are a good policy to grow a skilled workforce within North Dakota border, but the program should only target the unemployed job seekers and not the employed.

8.3 Potential policies

The policies discussed before are targeting the number of qualified job seekers. The recruitments campaigns try to attract job seekers from other states and countries, thereby increasing the number of job seekers and thus the number of qualified job seekers. The training programs try to increase the number of qualified job seekers when the total amount of job seekers stays constant. Both the conceptual model (model 1) and the combined simplified stock-and-flow model (model 9), however, revealed that the attrition rate also has a major impact on the level of vacancies. The analysis of the behavior produced by the simulation model confirmed that in fact the attrition rate has a bigger impact on the level of vacancies, than the increase in the demand for labor itself. Policies aimed to reduce the level of vacancies will thus be more effective when focusing on the reinforcing loop of the attrition rate (R1).

To be able to reduce the attrition rate the primary goal should be to retain the current workforce. The attrition rate is impacted by the size of the employment and by the employee tenure, which is a result of job-hopping, the desire to stop commuting between place of residence and place of work, emigration and retirement. Policies can therefore focus on creating incentives for the local workforce to reduce the frequency of job-hopping. The local

workers should be willing to retain a current position for a longer period of time. In Grand Forks, the business leaders already work on such a policy. The business leaders there want to reduce the job-hopping by launching a "Fresh Start" program aimed at "energizing the work ethic in individuals having difficulty maintaining employment." (Wilfhart in Grand Forks Herald, 2015, June 16). Details on the design of this policy are, however, not available.

Another policy can focus on retention of the out-of-state workers. If more out-of-state workers are willing to stay permanent in North Dakota, the emigration and the quit rate of commuters will go down. Less vacancies have to be created for replacement and the level of vacancies will be lower. Retaining the current workforce is also part of the goals of the Find the Good Life in North Dakota campaign and is mentioned in the policy recommendations of the Department of Commerce.

If the level of vacancies go down, less new workers have to be recruited from other states to fill those vacancies. This policy will thus enhance the stability of the work force. Businesses would benefit from a higher retention rate, since less workers have to be introduced to the new work ethics and methods. Not only is the work force more stable, a reduction workers leaving the state will also lead to a more stable population. Although this research does not include the effect on the society, one could imagine that a more stability of population of a city will increase the quality of life within the city. If residents will stay for a longer period of time within a place, they will be more likely to integrate with the local residents. If the immigrants would stay only for a short period of time, there is no need for them to invest in the society. If they will stay permanent, it is more likely that they are willing to contribute to the societies wellness.

In several ways, North Dakota would benefit from a policy targeting retaining the current workforce. In reality, the design of a policy to retain the workforce remains difficult. The high geographical mobility of the population of the United States has a positive impact on the inflow of workers from other states, but also implies a high outflow of workers. It is thus a disadvantage when it comes to the stability of the workforce. More research should be necessary to examine why people leave the state. Potential reasons which appear in news articles are the cold climate and the shortage of facilities. The climate is of course outside the boundaries of the policies. The insecure prospective of the labor market due to the current bust in the oil price form another reason for workers to leave the state and find their luck somewhere else. Incentives could be created to make it more beneficial to stay in North

Dakota. An example could be a better social benefit climate which create more security for families. However, as said before, further research would be necessary to examine the real causes of those families leaving the state. Only when these causes are clear, a policy can be designed to either target these causes or create incentives to compensate them. More research is also necessary to figure out how local workers can be stimulated to hold on their job.

9. CONCLUSION

North Dakota's oil boom has stimulated a growing demand for labor, not only in the oil and gas industry but also in other sectors. The boom led to an increase in the level of vacancies, which has gained high attention at the level of state government and businesses. The general thought was that the high level of vacancies could be explained by a labor shortage. North Dakota's labor supply was not capable of meeting the labor demand of the sectors, both in size and in skills. In contradiction to this view, this thesis revealed that the increase in the level of vacancies is not only a result of the incapability of filling the vacancies posted for job creation. More important is that the increase in the level of employment and vacancies stimulates an increase in the creation of vacancies for replacement of workers. If the employment is higher, more workers will resign from their jobs. Primary reasons to resign are job-hopping, the desire to stop commuting between place of residence and place of work, emigration and retirement. A higher attrition rate leads to a higher number of vacancies created for replacement of these workers. The increase in the level of vacancies caused by the increase in the labor demand, also increases the labor market attractiveness. More workers will therefore search for another job, the job-hopping will thus increase. This implies a lower employee tenure and a higher attrition rate.

The attrition rate is a result of the labor supply dynamics. As a reaction to the growth in the labor demand also the labor supply has grown. In North Dakota the labor supply is a combination of the labor force, capturing both permanent and temporary workers from within North Dakota's borders, and the commuters, workers from outside North Dakota's border. This research reveals that there is a different impact of hiring unemployed, employed or out-of-state job seekers on the vacancy creation for replacement and the employed labor force. Hiring employed job seekers will only create the need for another organization to replace the worker and to create another vacancy. Hiring employed job seeker will thus not deplete the level of vacancies or increase the level of employment. Hiring of unemployed job seekers will deplete the vacancies and increase the level of employment. Out-of-state workers hired can either immigrate to North Dakota or keep their current residence and commute. If they immigrate, North Dakota's employed labor force will be increased. If they commute they will not show up in the employed labor force. In North Dakota, the commuters fill a large part of the jobs. In both cases, hiring out-of-state workers will deplete the vacancies.

This research has also shown that the decision to hire either employed, unemployed or out-of-state workers is dependent on the number of qualified job seekers. This is affected by the hiring standards and the average skills level of the job seekers. Policies aimed to increase the qualities of the unemployed job seekers by offering training programs will benefit the local labor supply. It will lead to lower unemployment and a higher local employment. If the training programs target workers, more job-hopping will take place, which will only increase the level of vacancies. Policies aimed to recruit more workers from other states will increase the hiring rate, but will at the same time increase the vacancy being placed for replacement. The reason is that out-of-state workers tend to retain a job for a shorter period of time than local workers do. Out-of-state workers hired will thus contribute to a higher rate of vacancies created for replacement of out-of-state workers. This will create the need for another inflow of out-of-state workers.

This research shows that the most effective way to create stability in the labor supply and thereby impact the level of vacancy is to lower the attrition rate. The most effective policy would thus focus on retaining the current workforce. The policy can aim to decrease job-hopping or retain the out-of-state workers within North Dakota's borders. More research is necessary on these topics to be able to design an effective policy.

10. LIMITATIONS AND FURTHER RESEARCH

In this research we have seen that the labor demand gives an impulse to the labor supply system. The structure of the labor supply responds on the change in labor demand and the combination of both the labor supply and labor demand creates the level of vacancies. The labor demand is expressed by the total of the vacant and filled jobs, which is a combination of the historical data on employment (Quarterly Census of Employment and Wages) and the historical data on the vacancies (Online Job Openings Report). It is highly probable that this method results in a underestimation of the actual labor demand. In the first place, the QCEW does only include a fraction of the agriculture sector. Therefore, the employment in agriculture is in reality higher. This is probably the reason why the data on vacancies in agriculture compared to the data on employment in agriculture is so much higher than in other sectors. The Online Job Openings Report might cover a larger part of the employment than the Quarterly Census of Employment and Wages does. Another underestimation can stem from the use of annual averages. The time interval of the data sets used for input in the model is in years instead of months. This model will does not reveal the fluctuations per month. Per month the level of vacancies can thus be much higher than the historical data and the output of the model show.

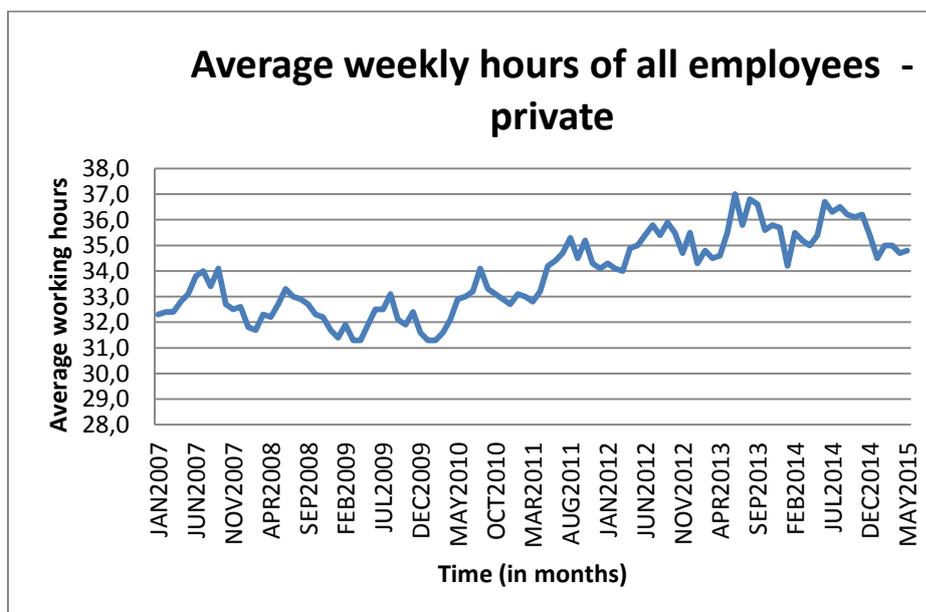


Figure 6 - average weekly hours - all private (Current Employment Statistics)

Another limitation of this method is that the desired jobs only cover the vacant and filled jobs. Andolfatto (1996) and Blanchard and Diamond (1989a) also made a third distinction, the dormant or idle jobs. This type of jobs refers to jobs which are not yet filled by employees, but are not open for applications either. Because of the labor shortage in North Dakota, organization might decide not to post a new vacancy, because the chances that they get filled are low. This would imply that there are an increasing amount of dormant jobs within North Dakota. The hypothesis is supported by the data on working hours.

Figure 6 present the average weekly hours per employee of all private sectors. The graphs shows an increase in average working hours from 32,2 hours per week in January 2007, till 34,8 in May 2015. If we compare the month November in 2014 to same month in 2007, we see a total increase of 3,7 hours, which reflects a total growth rate of 11,4%. The working hours and the online job openings are increasing in the same trend, as we would expect. Because job openings cannot be filled, the existing work force has to work more hours to get the desired amount of work done. The increase in working hours indicates however on a higher number of vacant jobs (based on constant normal working hours) than the data on vacancies in the Online Job Openings Report reveals. The difference in vacant jobs might be a result of the increase in dormant jobs. Because the labor demand in this research, which is expressed by the vacancies plus the employment, does not account for the dormant jobs, the demand for labor is likely to be underestimated. Further research should be necessary to reveal whether this is actually the case.

The earnings in this model are endogenous based on the working hours and degree of which industries are able to fill the desired level of vacancies. Since the working hours based on the level of vacancies does underestimate the actual working hours, also the total earnings are underestimated in this model. In reality, also the impact of the profit and the productivity of a workers should affect the earnings. These factors are part of the production side of the economy and are thus not included within the boundaries of this research. The earnings in this research do thus not reflect the actual development of the earnings in North Dakota.

The most important limitation which falls within the boundaries of the labor supply system is the gross versus the net growth of the labor demand. The total employment by industry is based on the total net growth between of the businesses in this industry. Job destruction in this model does only happen when the total employment of an industry declines. Layoffs in some businesses get cancelled out with creation of jobs by other businesses in the same sector.

Both the job destruction and the job creation (new vacancies for job creation) are thus underestimated. As we could have seen in the behavioral analysis of the simplified model presenting the effect of the vacancies for replacement on the level of vacancies, a higher rate of vacancies for replacement, leads to a higher equilibrium rate for the level of vacancies. Including a higher rate of vacancies for job creation would thus also result in a higher equilibrium level of vacancies. More job creation and destruction would higher the in- and outflow of unemployed job seekers and would therefore also have a down pressing impact on the time to find a job. Although data on job creation and destruction is available in terms of gross job gains and gross job losses (source: Business Employment Dynamics), the data is not consistent with the data on employment. Therefore there is chosen not to include the gross job creation and destruction and only focus on the net growth in employment. However, it might be interesting to include those flows in further research.

More data sets used in this research for validation and initialization purposes have limitations. The data on labor supply indicators are often based on a survey and thus estimated. The margin of error is high and therefore the values used for initialization might differ from the actual values. That the data sets used do not reflect the real historical data implies that the different data sets are not consistent with each other. Besides that, data is most of the times not available on industry level. As we have seen in the description of the problematic behavior, the vacancies were only available per occupation. An estimation has to be made to rearrange the data in sectors. Since the actual number of vacancies per sector is not available, a good validation on industry level cannot be done. In other cases, the data is not available for North Dakota and data for the United States or the Mid-West area is used. All parts in the labor market system are interrelated, so a wrong initialization of one of the variables leads to an extreme imbalance in the system which does not match the historical behavioral patterns.

Data on the desired time to recruit (average duration of vacancies) is, for example, only available for the United States. An adjustment of this time had to be made to correct the system. Another reason why the desired time to recruit on U.S. level had to be corrected is because of the underestimation of the inflow of vacancies. Another limitation related to the desired time to recruit is that this variable is assumed to stay constant over the years. However, since 2000, the internet has decreased the cost of recruiting (Autor, 2011) and improved the chances to reach potential employees. There are different opinions of experts on the effect of the bigger role of internet in the recruitment process on the time to recruit. It might also lead to excess applications, which would increase the time to recruit (Autor, 2011).

A change in the desired time to recruit, would impact the desired vacancies to fill and therefore impact the whole labor supply system.

Besides limitations concerning the data availability, also the scope of the project creates some limitations. The effect of the adequacy of facilities are not included within the boundaries of this model. With the facilities we mean inter alia the schools, supermarkets, shops, restaurants and roads. The facilities were unable to keep up with the growth in population. The inadequacy of facilities lowers the quality of life. This means that less people would be willing to immigrate and more people would be willing to emigrate. Also the effect of fast growing population on the crime level is not considered. With the inflow of thousands of oil worker, the level of crime activity has increases (MacPherson, 2015, June 3). Commuters are reluctant to bring over their family since parents do not like the idea of raising children in an area with that much crime. 'With all the crime and other social problems that have come with this latest oil rush, she says, she doesn't like the idea of raising their son there now' (Siegler, 2014, Jan 31). A more aggregated study on the labor supply dynamics would make it possible to set the scope broader and include the effect of facilities and crime on the various labor supply factors. For example, by keeping the level of vacancies and employment at the state level, and using an artificial way to include the mobility between sectors. This by extending the simplified simulation model 1 and adding an effect on the time to retain a job.

Further work could also use the knowledge gained in this research to build a simple simulation model with artificial input, which would include the feedback loops shown in conceptual model 11. Such a model could be used in learning environments, because it would be easier to grasp. A small model would allow a more user friendly interface, which allows playing with the model. It would also be easier for the user to understand where the dynamics come from.

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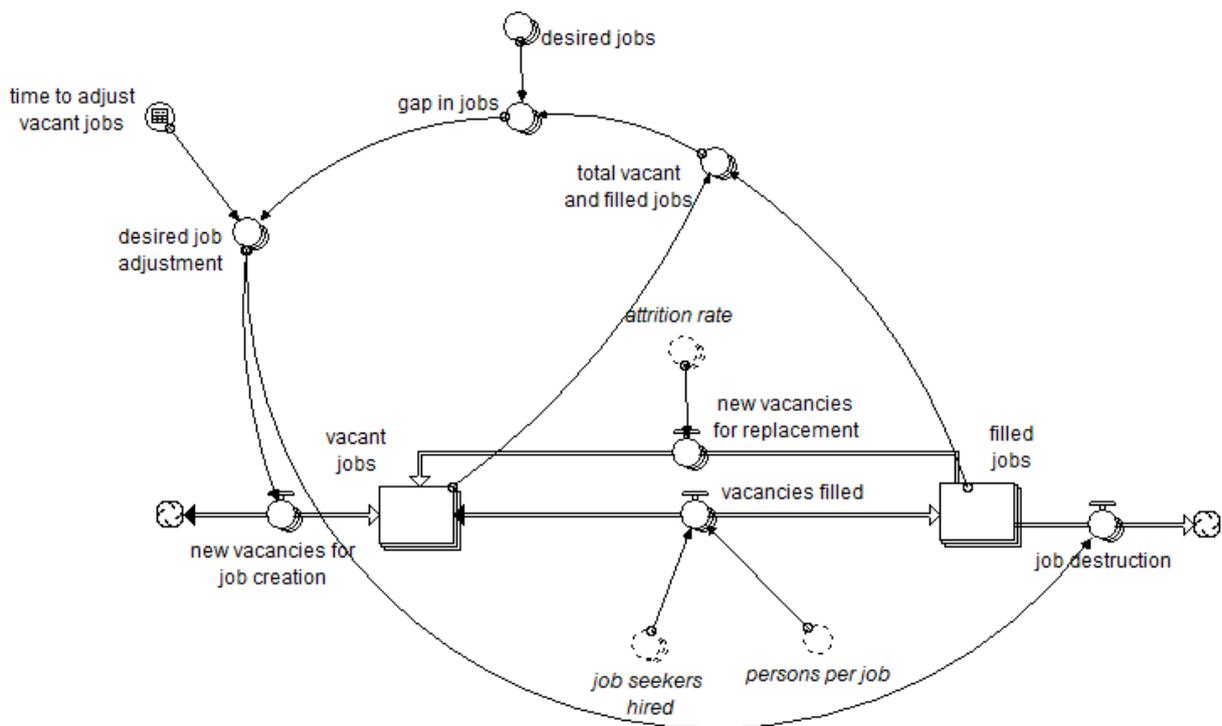
12. APPENDICES

Appendix 1 - Description of the model

This section will explain the structure of the simulation model. Estimation of the initialization and the normal and desired values are explained in appendix 2 and 3.

(1) Creation of the vacancy announcement

This research differentiates two types of jobs, vacant jobs and filled jobs. Andolfatto (1996) and Blanchard and Diamond (1989a) also made a third distinction, the dormant or idle jobs. This type of jobs refers to jobs which are not yet filled by employees, but are not open for applications either. They can become vacant dependent on the expense of recruitment and the cost of posting a vacancy (Felbermayr, Prat Schmerer, 2011). Over the last centuries, the cost of posting a vacancy has decreased due to the internet (Autor, 2001). Job Service North Dakota offers, for example, a free online job opening board. For the purpose of this research, we will therefore assume that there are no costs assigned to the creation of a vacant job, and therefore ignore the dormant jobs.



Simulation model 1 - creation of the vacancy announcement

Vacancies are being created after the need is recognized to create a new vacancy. This can either be because a worker needs to be replaced or for the creation of a new position. A vacancy is being placed for replacement when attrition occurs (see flow of vacancies for replacement). New vacancies add up to the existing vacancies. When the desired employment goes down, the current amount of jobs exceeds the desired amount of jobs, job destruction takes place. Job destruction will deplete the filled jobs. This implies that persons will get fired.

The creation of vacancies for job creation is based on the exogenous input of the labor demand, which is measured as the desired jobs. The desired jobs is equal to desired amount of filled jobs - or desired employment (Quarterly Census Employment and Wages) - plus the desired vacant jobs (Online Job Openings Report). The vacant jobs are necessary to keep the filled jobs at a sustainable level. The desired employment is dependent on the demand for labor, which is inter alia dependent on the production. This research takes the desired employment exogenous. A complementary research on the demand side of the labor market in North Dakota can be added to this labor supply focused research to study the interacting effects of supply and demand on the labor market.

The structure used for creation of the vacancy announcement is quite similar to Sterman's labor hiring structure in *Business Dynamics* (2000). Sterman creates a desired hiring rate by comparing the desired jobs to the current jobs and making an adjustment for the difference between desired and current vacancies. This research compares the sum of desired jobs to the current filled jobs and vacancies. A comparison is taken between both the vacant jobs and the filled jobs and not just the filled jobs. If the vacancy creation would be equal to the gap between the desired jobs and the filled jobs, the model would continue to add vacancies if the vacancies will not be filled. However, in reality vacancies for job creation will only be placed once.

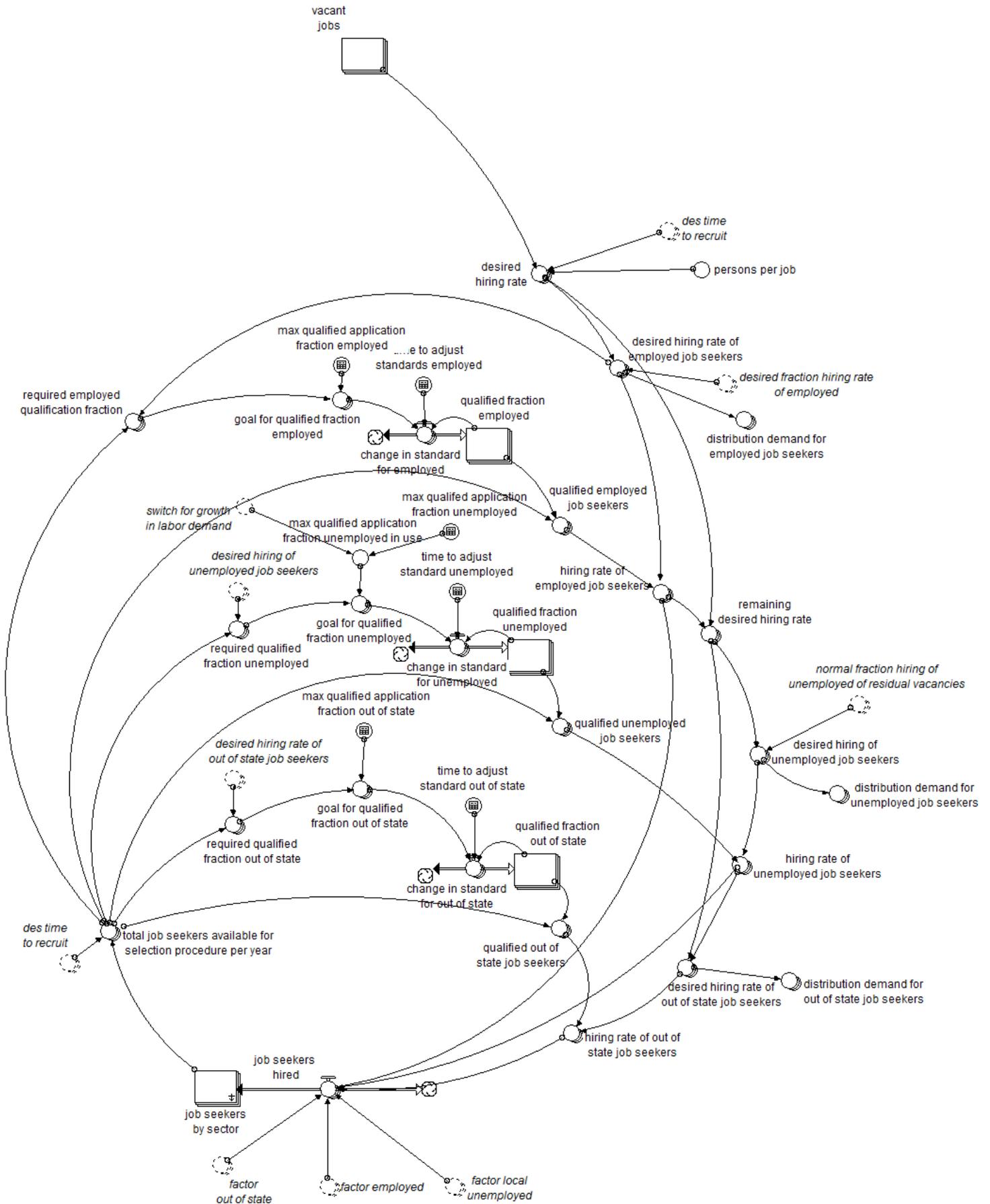
(2) Selection Process

The next step in the recruitment and selection process after creation of the vacancy is to gather the applications and select the best job seekers. The process of recruitment refers to the collection of applications, which happens as long as the vacancy is open and posted. The process of selection refers to the selection of a new hire out of the pool of job seeker. During the selection process, the team of recruiters will want to hire one job seeker for each vacancy. This process is modeled in simulation model 2. In the illustration, you can see that the job seekers going through the selection process can either be hired or rejected. When a job seekers is rejected for a vacancy, that persons is assumed to remain a job seeker in the same sector. If a job seeker is hired, one vacant job is filled, implying that the vacant jobs deplete and the filled jobs increase. As the amount of vacant jobs deplete, less vacancies are in need to be filled.

If vacant jobs would be instantaneous filled, the hiring rate would be equal to the number of vacant jobs. However, as we have discussed in chapter 6, the process of recruitment and selection of a job seeker takes time. Under the assumption that the recruiting organization has a timeframe in mind for the collection of the applications send by the job seekers, the desired hiring rate equals the number of vacant jobs divided by the desired time to recruit. This is similar to Sterman's (2000) model structure, he models the hiring rate by dividing the vacant jobs by the average time to fill the vacancies.

This research differentiates different types of job seekers, namely employed, unemployed or out-of-state. Because the hiring of each type of job seekers has different consequences for the labor supply, the selection process is also disaggregated in these different types. Whether the industry hires employed, unemployed or out-of-state job seekers depends on the hiring preferences of the industry and the availability of qualified job seekers of the three types of job seekers. Following from personal conversations, we assume the following order of hiring preferences for each sector:

- (1) Employed - own sector
- (2) Employed - different sectors
- (3) Unemployed
- (4) Out-of-state



simulation model 2 - selection process

Hiring employed workers of the own sector has the first preference, since those workers have the experience and are most productive. Second, employed workers from different sectors are assumed to be more productive than the unemployed, since being employed shows that they are able to work. Then, the unemployed are preferred above the out-of-state workers. The reasoning lies within the effect of out-of-state workers on the workforce or project group. The out-of-state workers are expected to have a lower retention rate. Organizations prefer to have a stable workforce or project group, because this enhances the productivity. Therefore, local workers are preferred over out-of-state workers.

Although employed workers are preferred above unemployed workers, some companies still hire unemployed workers. These unemployed workers (for example, students who just graduated), have the advantage for the organization of being cheaper. Some companies cannot afford the highly experienced workers, because they are too expensive (personal conversation). Therefore, some unemployed workers will always be hired.

In the model, we use a normal fraction for the hiring rate of employed workers. The higher this fraction, the higher the desired employed hiring rate. The hiring rate of the employed job seekers is the minimum of the desired hiring rate of the employed job seekers and available qualified employed job seekers. As we have seen in the conceptual model, the hiring rate is limited by the number of qualified job seekers. This is in the first place dependent on the number of job seekers which are available for the selection process of each sector within one year. The stock job seekers per sector only gives the current number of job seekers. To have the job seekers available for the selection process per year, the amount of job seekers have to be divided by the time to recruit. The job seekers can only search for a job within one sector.

The amount of job seekers available for the selection process will then be multiplied with the qualified fraction to derive the number of qualified job seekers. The qualified fraction relates to the hiring standard, which is discussed in model 3 and 11. The hiring standards is based on both the characteristics of the job, the experience of the job seekers, the desired motivation and fit to the organization. The hiring standards determines when a job seekers is assumed to be qualified enough to perform the job and thus gets hired. If the desired hiring rate increases because the vacant jobs increase and the amount of job seekers stay equal, there will be less job seekers assumed to be qualified than the desired hiring rate requires. To be able to hire more job seekers, the hiring standards have to be lowered. This means that the organization has less to demand of the qualities of the worker and the qualification fraction goes up. The

qualified fraction thus adjust to the required qualified fraction, which is the desired hiring rate of the job seekers divided by the total job seekers available for the selection process.

A maximum is set to the qualified fraction, because it is unrealistic to think that all job seekers can be qualified enough to perform a job within a sector. The adjustment time is 6 months, because organizations are however reluctant to lower the hiring standards. A lower hiring standard impacts their company's performance through a lower level of productivity of the new workers. Nevertheless, the hiring standards will be adjusted to the current condition of the market, because a less productive worker is better than a high shortage of workers.

As mentioned earlier, the hiring rate of the employed job seekers will be the minimum of the desired hiring rate and the qualified employed job seekers. If a sector does not have sufficient qualified, employed job seekers, the hiring rate will be less than desired. This means that more vacancies have to be filled by unemployed or out-of-state job seekers. The remaining is thus the desired hiring rate minus the hiring rate of employed job seekers. A normal fraction hiring of unemployed job seekers determines the desired hiring rate of unemployed job seekers. Again, if there will be not sufficient qualified unemployed job seekers, less unemployed job seekers get hired than desired. The part of the desired hiring rate that cannot be hired from local employed and unemployed job seekers is the desired hiring rate of out-of-state job seekers. Again this hiring rate is limited by the qualified out-of-state job seekers.

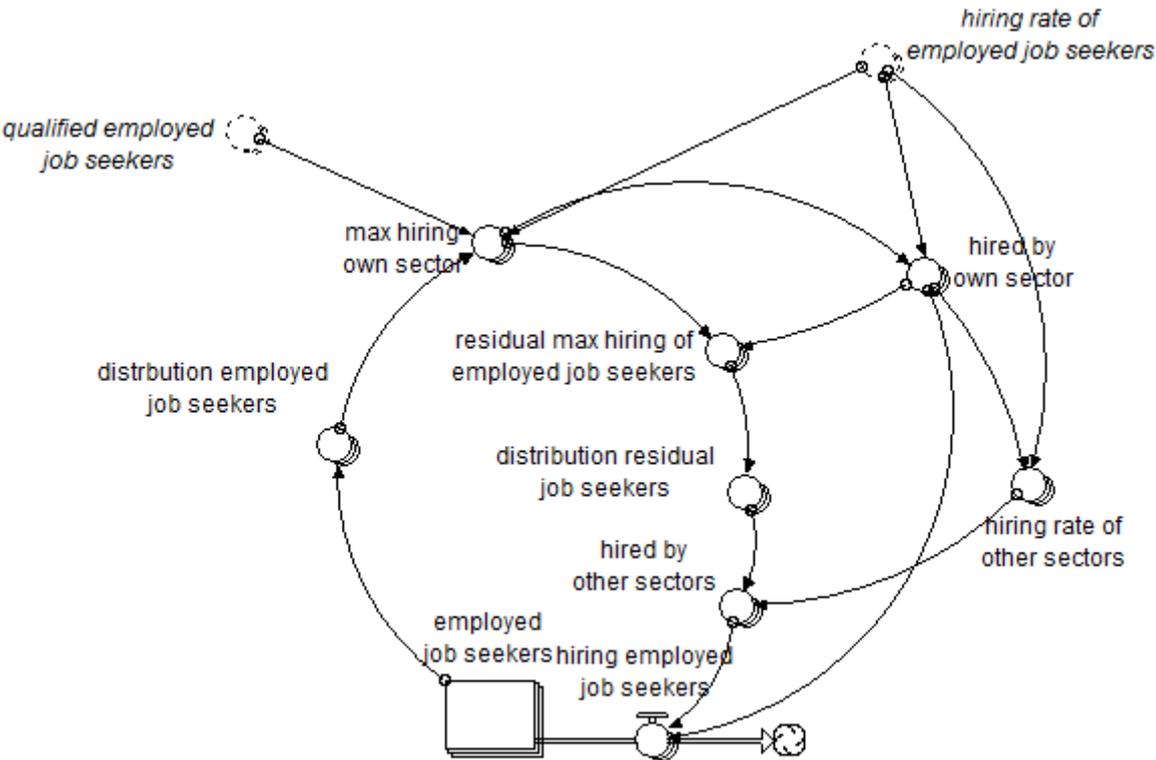
The total hiring rate will deplete the stock of job seekers and the stock of vacant jobs. This flow will accumulate in the stock of filled jobs, see simulation model 1.

(3) Hiring of employed job seekers

Employed job seekers who get hired have to leave their previous job. Employed job seekers can be hired by the same industry but also by another industry. In the hiring preferences of the organization we could have seen that companies would prefer to hire people from their own industry, since they have the experience. But if there are not sufficient job seekers from the own industry, companies prefer to hire people from other industries above unemployed job seekers.

Following the preference assumptions of the organization, an organization would thus prefer to maximize the hiring rate of the own sector. The hiring rate of the own sector is limited to the job seekers of the own sector. The maximum hiring of own sector is the total qualified employed applications times the distribution of the employed job seekers over the sectors.

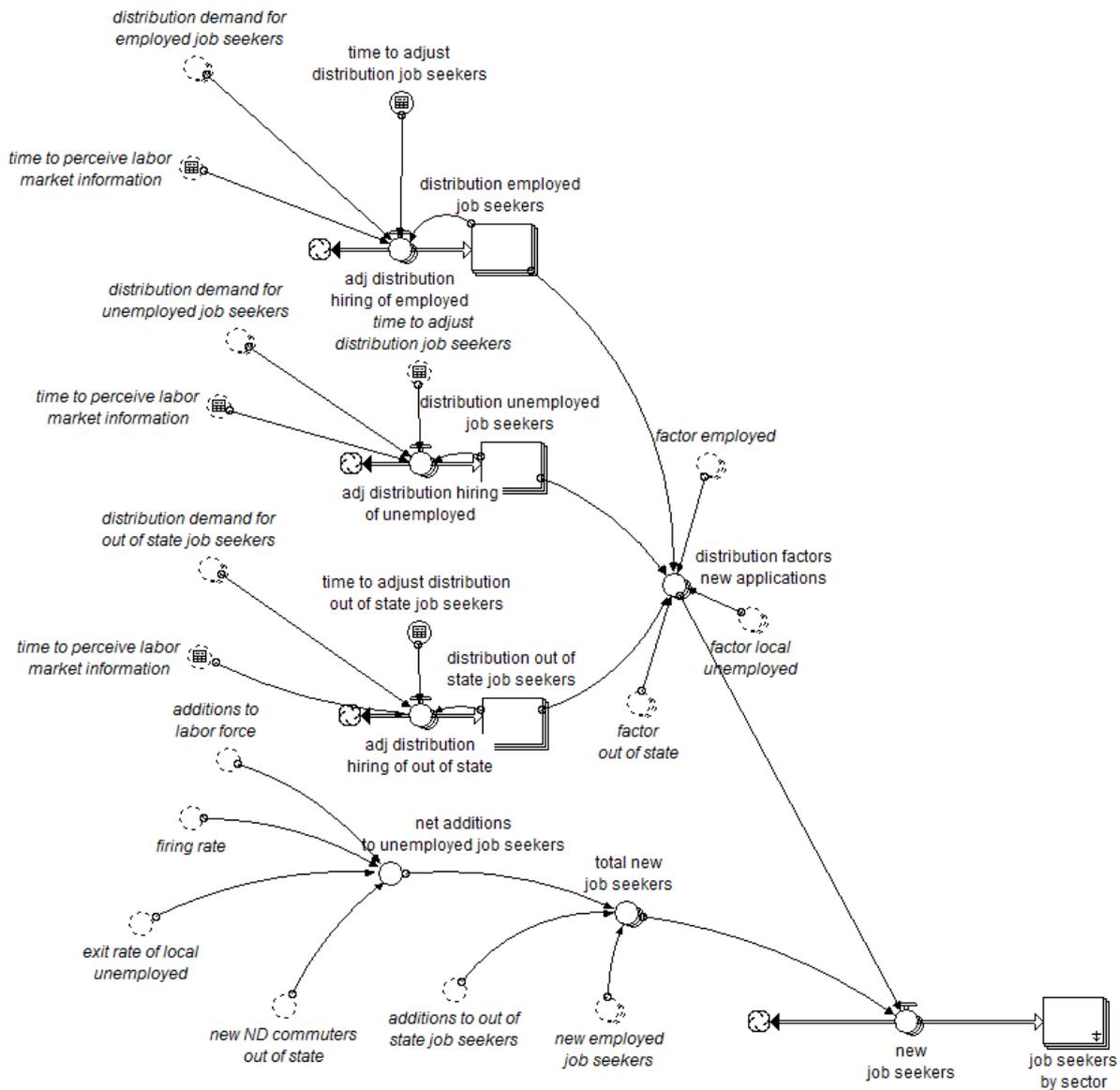
The hiring rate of the own sector would be the minimum of the employed hiring rate and the maximum hiring rate of that sector. That part of the employed hiring rate that cannot be hired from the own sector, will be hired from different sectors. Which specific sector will be hired from is dependent on the availability of the remaining job seekers, those who were not yet hired by the own sector. If there are more job seekers currently employed in the retail sector, more job seekers from the retail sector will be hired. This is modeled by the distribution of the maximum hiring of employed job seekers times the hiring rate of other sectors.



simulation model 3 - hiring of employed job seekers

(4) Application process

The hiring process is dependent on the number of job seekers that are active in each sector. This is illustrated in simulation model 3. As stated before there are employed, unemployed and out-of-state job seekers. The new job seekers are the net additions to unemployed job seekers (correcting for withdrawals from the unemployment), the additions to out-of-state job seekers and the new employed job seekers. The job seekers can apply for a vacancy in each of the sectors. They will base the decision to apply within one of the sectors on the demand for the specific groups of job seekers within the sector. The demand for each type of job seekers is presented as the desired hiring rate of each group of job seekers. The distribution of the job seekers over the sectors will therefore be adjusted to the distribution of the desired hiring rate. Chapter 6.3 gives a more extensive explanation of this adjustment process.

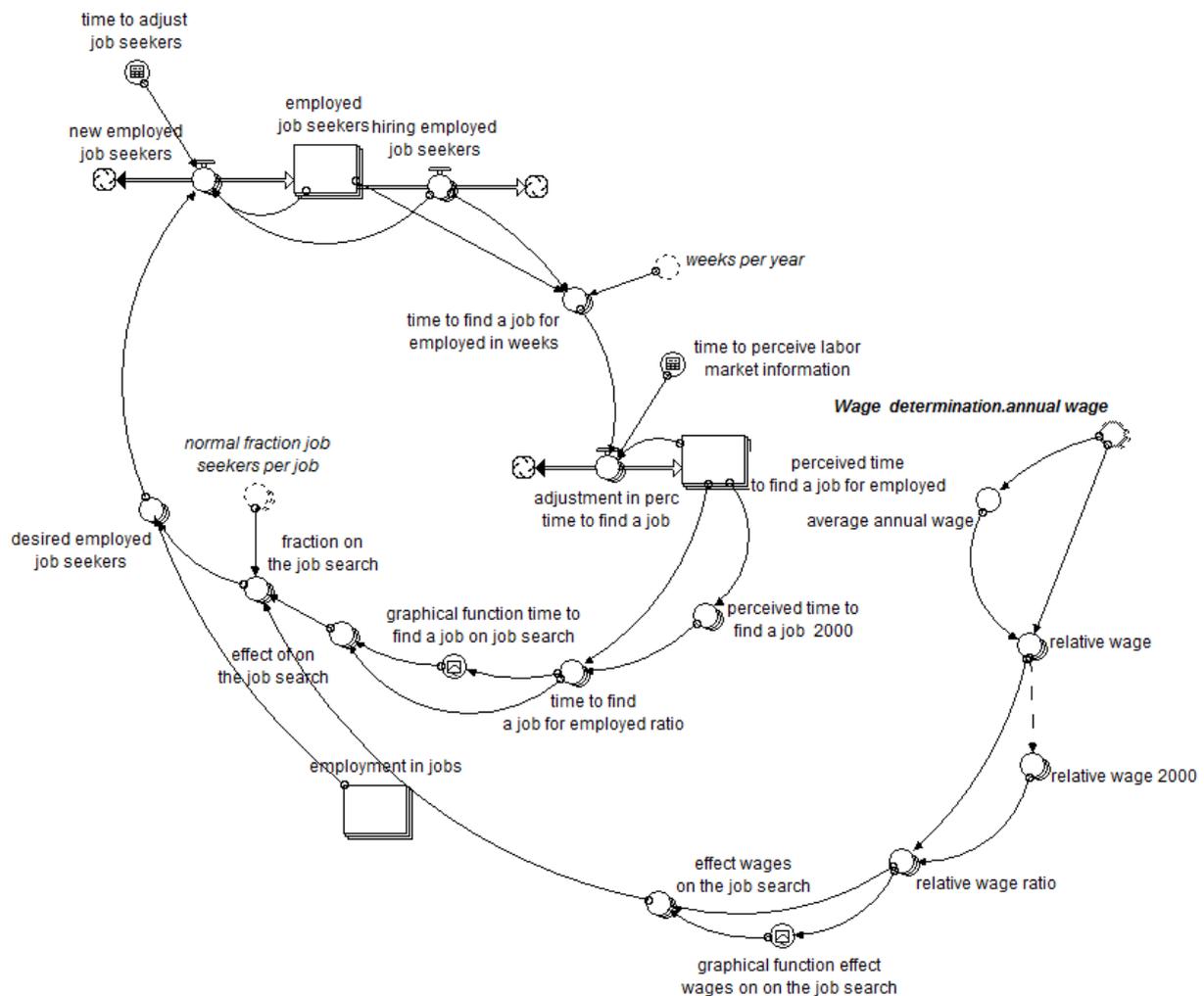


simulation model 4- new applications

(5) On the job search

New job seekers can be employed, unemployed and from out-of-state. We assume that there is always a fraction of the employed workers who are looking for another job. The decision process of the workers to become job seekers is dependent on the relative attractiveness of each sector. This process is modeled in simulation model 5. The underlying assumption we made to determine the fraction on the job search is that it is the worker's intention to maximize the value of the job search (Rogerson, Shimer and Wright, 2004). If the value of the job search is higher, more workers would prefer to start the job search. In terms of the model, this implies that the fraction on the job search is relying on the wages (wage ratio) and the market tightness (time to find a job ratio). An increase in the average wage compared to your own wage due to higher wages in other sectors, would increase the gain of switching to another job. The same effect would count for a decrease in wages in your own sector. The market tightness is perceived by job seekers as the time it takes them to find a job. The shorter the time that needs to be spend on searching for a job, the higher the value of the job search. Both the time to find a job and the wages will therefore have positive impact on the fraction on the job search.

The time to find a job is calculated by dividing the employed & searching by the attrition rate. In North Dakota the times it takes to find a job is really short. Job seekers coming to North Dakota to find a job even state that it only took them one hour to find a job, while the same job seekers were not able to find a job in their home state (Briody, in *The Fiscal Times*, November 5, 2013). The time to find a job is different in each sector. When the labor market becomes more tight, meaning that there are relatively more vacancies, more employed applicants will be hired and therefore the time to find a job goes down. The time to find a job is with a small delay perceived by the employed labor force. The perceived time to find a job is taken relative to the initial perceived time to find a job in 2000. Assumed is that the normal time before job search is a good representation of the labor market in 2000.



Simulation model5 - on the job search

The second factor influencing the fraction on the job search is the wages. In literature, employed workers are either willing to accept offers if the wage offered is higher than either their current wage (Rogerson, Shimer and Wright, 2004) or if the offered wage is above a certain wage rate called y (as in Burdett, 1978). In this research we use a simple approach. The time before job search is affected by the relative wage of a sector compared to the relative wage of the same sector in 2000. The relative wage is the current wage of the sector over the average wage of all sectors. The wages are subject to bargaining (Merz, 1995; Blanchard and Diamond, 1990). In North Dakota the bargaining power lies in the hands of the job seeker. As stated by a franchise owner of McDonalds in an interview in CNBC: 'In this area, I would be totally embarrassed to even try to hire someone at \$7.25' (Little, 2014, June 20). Business are raising wages to attract job seekers to apply for a job. With the tight state of the labor market in North Dakota over the last 10 years, business are unable to complete their selection processes and hire the amount of applicants they need. Firms have to: '...beg, borrow and steal to get them to apply at this point because [they] need them so badly,' as quoted in an interview

in *the Bismarck Tribune* (2015, July 6). In this research we therefore use the fraction of selection procedures completed as an approximation for the bargaining power of the players on both sides of the labor market. If the fraction is lower than one, the job seekers holds more power and the hourly wage rises. If the fraction is 1 the hourly wage will stay the same.

The wage determination process used in this research is basic and does not reflect the real, complex concept of wage determination. Neither is it a good representation of the literature on wage determination. However, with the overall purpose of the research in mind, this basic structure is able to show the effects of wage bargaining. Further explanation of the structure which models the earnings will follow.

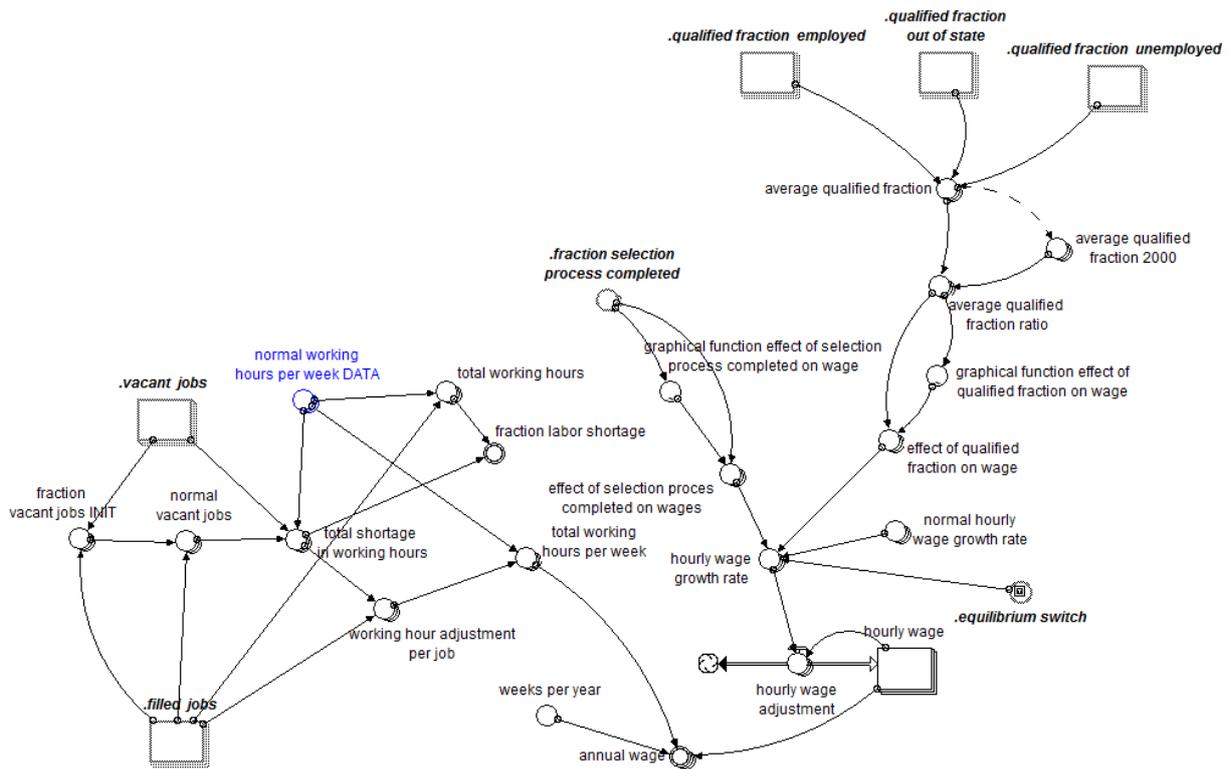
In 2013, McDonalds had to close its door for a couple of weeks because it could not hire the amount of workers it needs to run its business. More organizations have problems finding staff, since their employees run off to higher paid jobs and no one is willing to work for them (interviewee in *The faces of the oil patch*, 2013). Also in healthcare, employee attraction and retention is still the number one issue as mentioned in the *Bismarck Tribune* by Craig Lambrecht, *Sanford Health* (2015 April 25). The structure presented in simulation model 5 thus causes problems for especially the sectors offering low wages.

Employee retention and the attrition rate is related to the employee tenure. The Bureau of Labor Statistics presents the employee tenure for different industries within the United States (see appendix 2). Data for North Dakota is not available. This data shows that the employee tenure differs per industry from 1.9 years in Food and Accommodation (January, 2004) up to 13.3 years for workers working in Utilities (January, 2004). The Bureau of Labor Statistics indicates that the variation between industries in employee tenure can be partly explained by varying age distribution across sector (2014). Industries with on average a higher age would have a higher employee tenure. This is in line with Burdett (1978) assumption about the relation between age and employee tenure. Although the age is not specifically taken into account within this research, it does have an indirect impact on the normal employee tenure and thus the normal fraction on the job search. Data on the employee tenure is used to initialize the normal hiring rate of employed job seekers.

(6) Earnings

The fraction of the selection processes completed and the qualified fraction impact the hourly wage. The selection process completed has a direct effect on the growth rate, assuming that if the organizations complete all the selection processes they will increase the wage. Also if they have to lower their hiring standards (increasing qualified fraction), they will be willing to offer more money to attract more job seekers, so they can raise their hiring standards again. Therefore, also the average qualified fraction has an impact on the growth rate of the hourly wage. Previously, only an effect on the hourly wage is assumed. However, it is more plausible that workers base their decision on the relative annual earnings. Under this assumption, it is not only the hourly wage which determines the annual earnings, but also the working hours. From March 2007 till March 2015, the average working hours within construction has increased from 34,5 till 41,7 hours per week (Current Employment Statistics). If the workers get paid for the additional hours of work, the overtime work pushes the annual earnings even higher. Furthermore, North Dakota's minimum wage & working conditions summary, containing the official regulation concerning the minimum wage (as on August 1, 2013), indicates that during overtime hours one needs to be paid 1,5 times the regular wage per hour (N.D. Admin. Code § 46-02-07-02(4)). Although the wages in North Dakota are already exceeding the minimum wage level, the assumption could be made that overtime hours will still be paid at a higher wage rate. Simulation model 6 illustrates the effect of overtime hours.

In this research the assumption is made that the vacant jobs represent the additional amount of jobs which are desired and necessary to be filled to accomplish the work within the normal working hours per week. Therefore, an increase in the vacant jobs implies a higher shortage in labor hours. The shortage in labor hours is calculated by the vacant jobs times the normal working hours per employee. The current workforce has to cope with the shortage in labor hours. As a result on average every employee has to work overtime. The overtime hours is calculated by dividing the shortage of labor hours over all employees (equal to filled jobs). The overtime hours add to the total annual earnings.

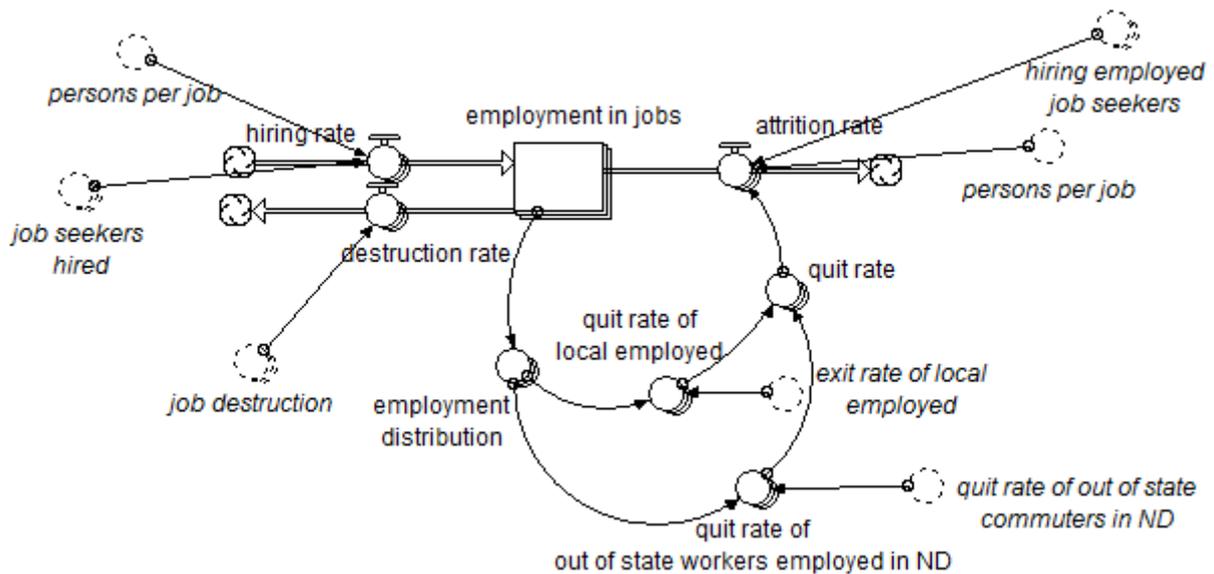


simulation model 6 -earnings

(7) Employment in jobs

Previously we have discussed the selection process. The applications which are accepted represents jobs which are being filled. The hiring rate is accumulated in the employment in jobs. Job destruction reduces the employment in jobs. We also have discussed the hiring of employed job seekers. The hiring of employed job seekers by industry is composed out of hiring by the own sector and hiring by other sectors. In the end, the hiring of each sector depletes the employment in jobs of that sector. There is an assumption made that all the flows of people represent one job per person. The attrition rate does not only include workers who are quitting their current job for a different job in North Dakota, but also those who get a job outside North Dakota's borders. Another reason to quit would be to retire. Retirements are assumed to be divided equally over the different sectors, based on the employment distribution. Deaths are also incorporated in the quit rates, under exit rate of local employed. Important to note is that we do not include workers who quit their current job to be unemployed. We assume that the income is necessary for the workers to survive, so they would not become unemployed voluntarily. However, in reality people will quit because they might not be willing to work anymore. For example, because they become a parents, they

return to school, they are ill, or because the partner earns enough money to care for the other person (or family) as well.

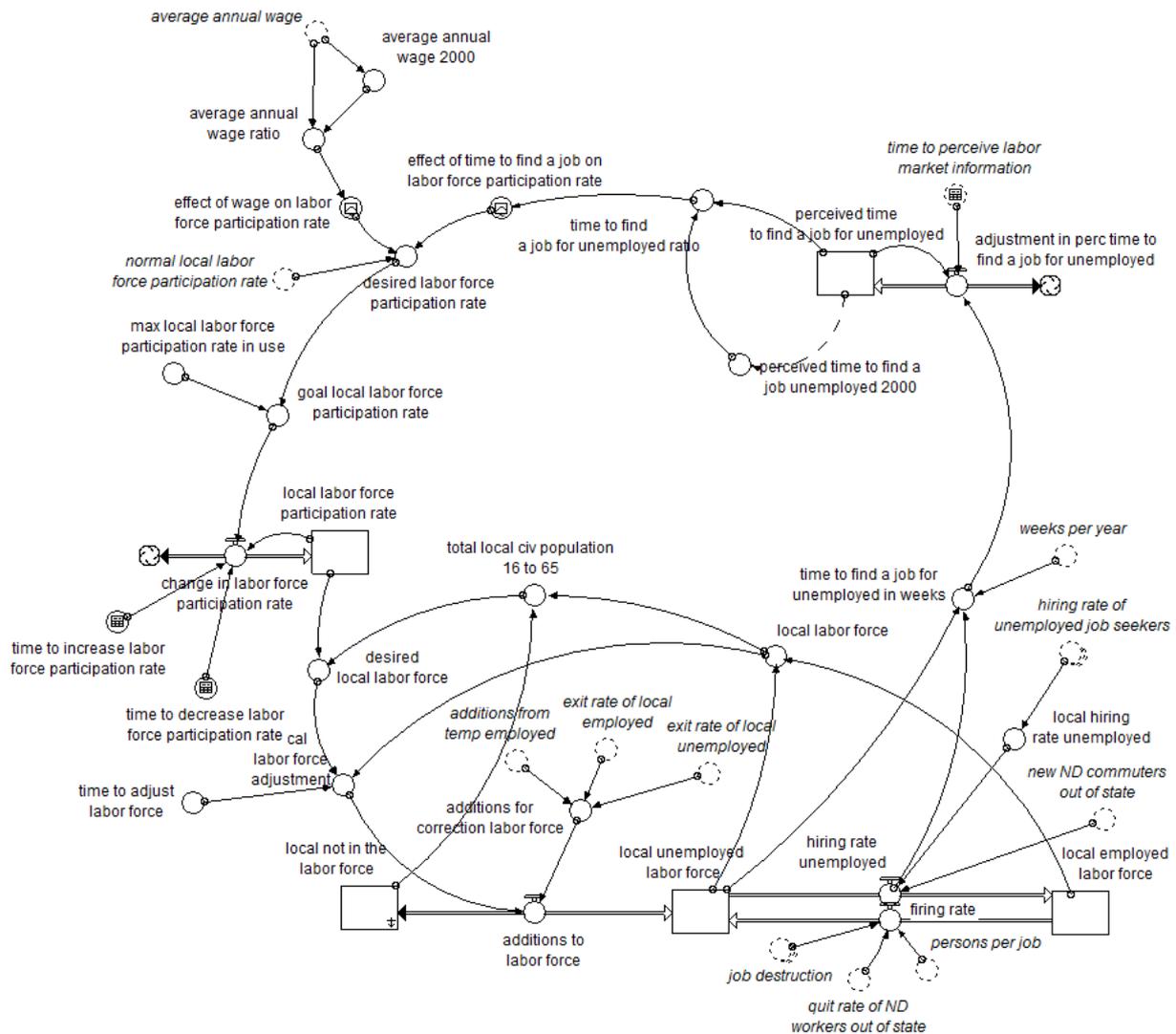


simulation model 7 -employment in jobs

(8) The local labor force

The structure in simulation model 8 presents the local labor supply. This model only considers the working age population between 16 and 65 years old, who are either native or already integrated. Assumed is that on average residents who are 65 are going to retire and residents who are 16 are allowed to work and will join the working age population. In the working age population a differentiation is made between the population in the labor force, either unemployed or employed and the population not in the labor force. The main difference with the employment in jobs is that the employed labor force uses the place of residence as the horizon, while the employment in jobs is concentrating on the place of work.

The stock of the local employed labor force increases with the hiring rate and decreases with the firing rate. The hiring rate includes besides the North Dakota residents hired in North Dakota also the hires of North Dakota residents in other states. The same holds for the firing rate of North Dakota residents in other states.



simulation model 8 -the labor force

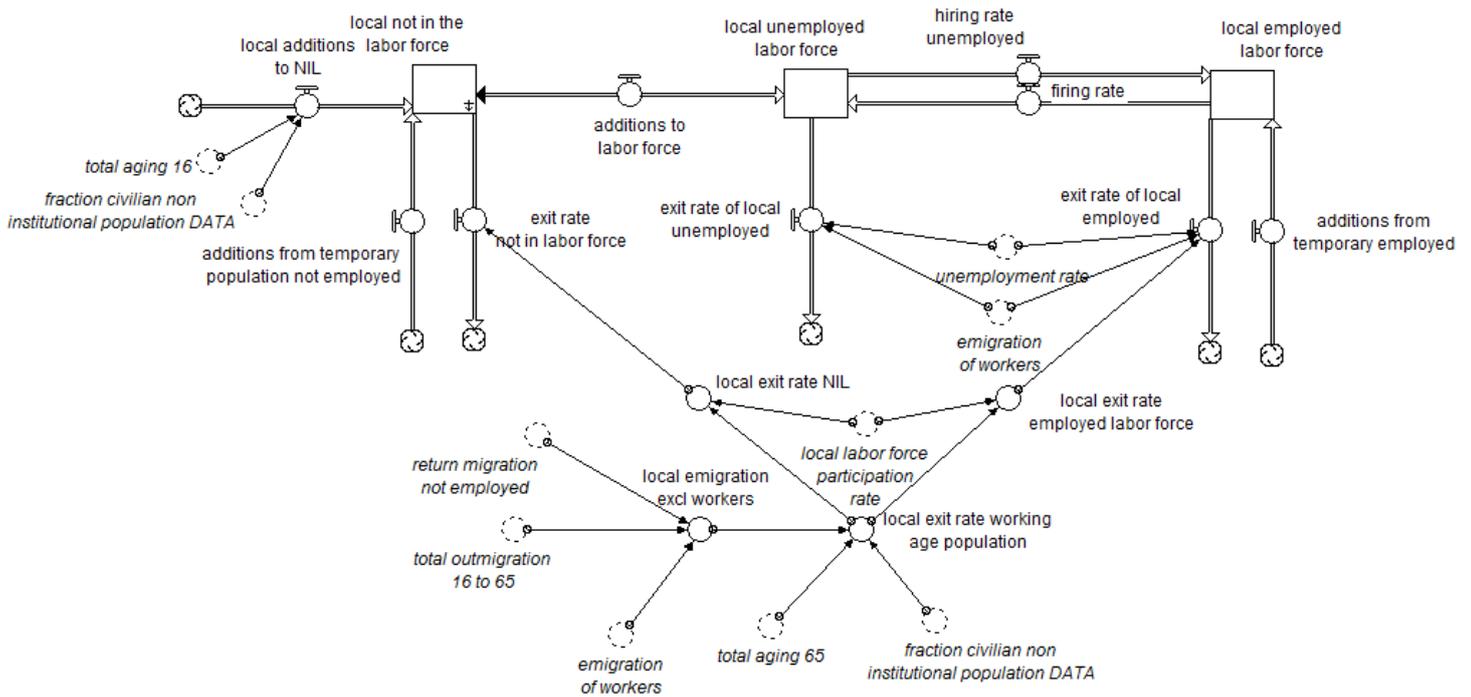
The local working age population will respond to the current labor market conditions, the time to find a job for unemployed and the wages. These are the same factors influencing the job search decision for people who are already employed. Remember that an increase in the pay off of the job search can be caused by a decrease in the time to find a job and/or an increase in the annual earnings. If the pay off increases more people will be willing to look for a job. When it is hard to find a job and the time to find a job is high, the payoff is low. More people will be discouraged and will not join the labor force. The same people will be willing to return to the labor market when the labor market conditions improve.

The desired local labor force participation rate is thus estimated based on the wages and the time to find a job. The actual local labor force participation rate adjusts to the desired labor force participation rate. A maximum has been set to the labor force participation rate, because not all people will be able to work. Some might be in college, others have to take care of the

children. The persons will respond immediately to every fluctuation. The time to increase the labor force participation rate is higher than the time to decrease the labor force participation rate. The reason is that job seekers are more reluctant to accept a non-working status which involves no earnings, than that non-job seekers want to start job search with the potential of earning money. The desired labor force is the labor force times the labor force participation rate. The working-age population will respond to adjust the labor force will to match the desired labor force.

(9) Growth of local working age population

Previously we have stated that the local working-age population does only include the population 16-65. The working-age population will thus increase with the civilian non-institutionalized persons aging 16, and decrease with the civilian non-institutionalized persons aging 65. A person is counted as civilian non-institutionalized if that person is not an inmate of an institution, e.g., penal and mental facilities, homes for the aged, and is not on active duty in the Armed Forces (Bureau of Labor Statistics). To correct for people who are not counted as civilian non-institutionalized, the persons aging 16 and 65 are corrected. Persons aging 16 were not allowed to have a job previously, so they will first join the not in the labor force. Local additions to not in the labor force are thus the total persons aging 16 times the fraction of the population which is counted as the civilian non-institutionalized population. Persons aging 65 can either be employed or not in the labor force. Assumed is that the people aging 65 are represented in the different stocks based on the local labor force participation rate. The people aging 65 times the labor force participation rate will thus deplete the stock of employed. The people aging 65 times one minus the labor force participation rate will thus deplete the stock of not in the labor force. Assumed is that a person who is soon going to retire at the age of 65 will not be searching for a job, so therefore the unemployed labor force will not be affected.



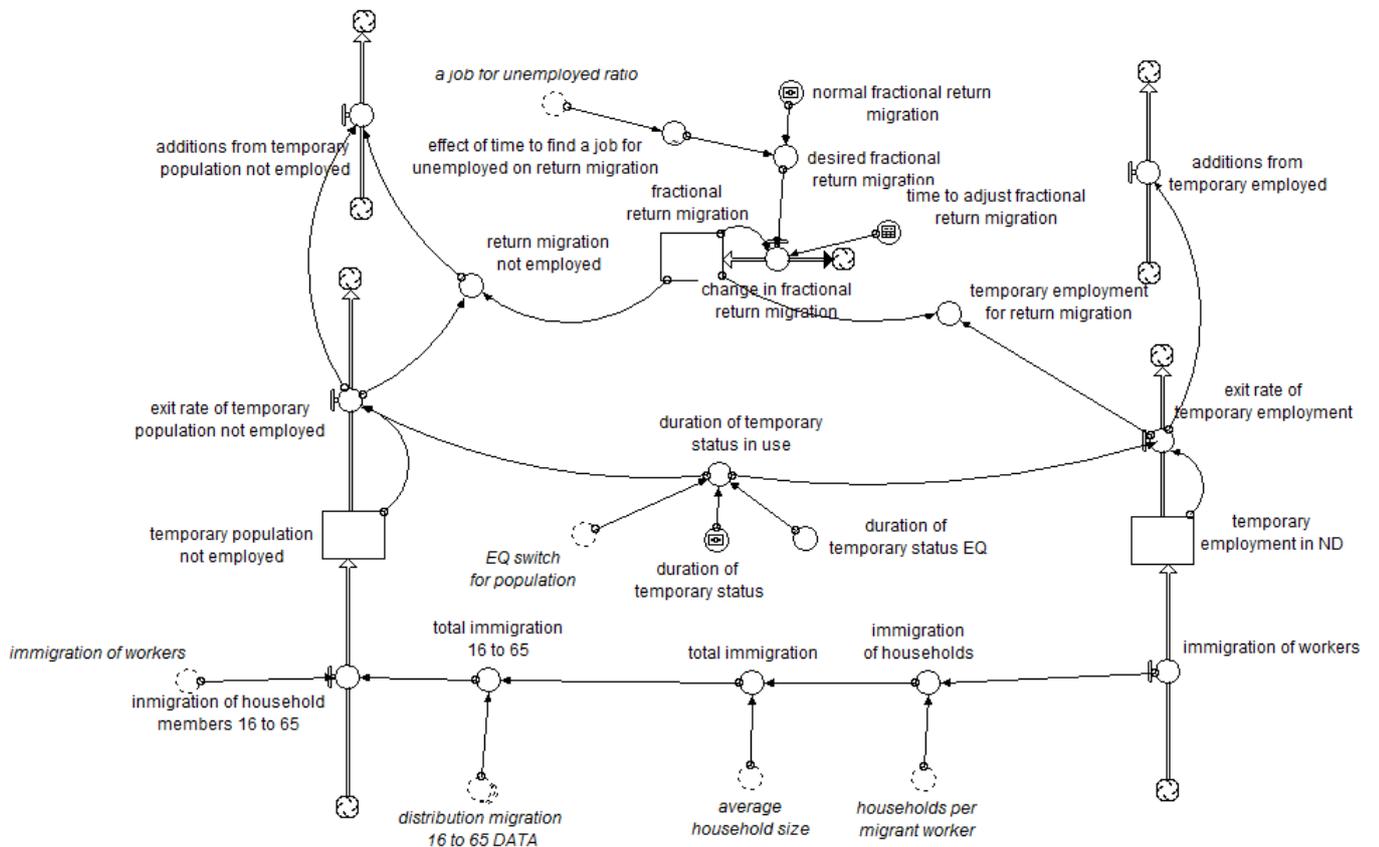
simulation model 9 -growth of the working-age population

Next to changes in the working-age population from local sources, from within North Dakota, there are also changes in the working-age population from external sources, from out-of-state. North Dakota residents who find a job in another state or country will deplete the labor force. Since they were job seekers, these outflow will deplete either the employed labor force or the unemployed labor force. The exit rate of local unemployed is thus emigration of workers times unemployment rate. Other emigrants age 16-65 (excluding the workers and the return migration) will deplete both the employed labor force and the not in the labor force stock, which is again dependent on the labor force participation rate.

In addition to emigration, immigration will add to North Dakota's working-age population. The immigrant are, however, first assumed to be part of the temporary population. After a few years they will integrate into the labor market and join the local working-age population. Assumed is that if persons are able to migrate, they will not be an inmate of an institutions or on active duty in the Armed Forces. All migrants age 16-65 are thus assumed to be civilian non-institutionalized.

(10) The temporary population

Simulation model 10 shows the temporary population. Workers who immigrate will become part of the temporary employment in North Dakota. Research shows that 20% to 50% of the migrants who have moved to a different country, leave within five years after the arrival (Dumont and Spielvogel, 2008). Assumed is that the average return migration between the states will be lower than the average return migration between countries, since the culture is relative more in line with the culture of the home state. Therefore, we have assumed that after three years (duration of temporary stay), the immigrant worker will decide whether to stay and integrate or to return to the home state or somewhere else. The fraction of return migration is dependent on the labor market attractiveness, measured as the time to find a job. If there relative labor market attractiveness decreases more people will look for a job in other states. The fractional return migration might also be affected by the perceived adequacy of facilities, this is, however, not included in this research.



simulation model 10 - temporary population

Workers who migrate to North Dakota will bring their household. Assumed is that every worker has one household. The number of households immigrating times the average size of households will thus be the total immigration. The distribution of migration over the ages 16-65 is used to calculate the working-age immigrants. Only after the household has determined to stay in North Dakota, the household members will join the local working age population and therefore might decide to join the labor force.

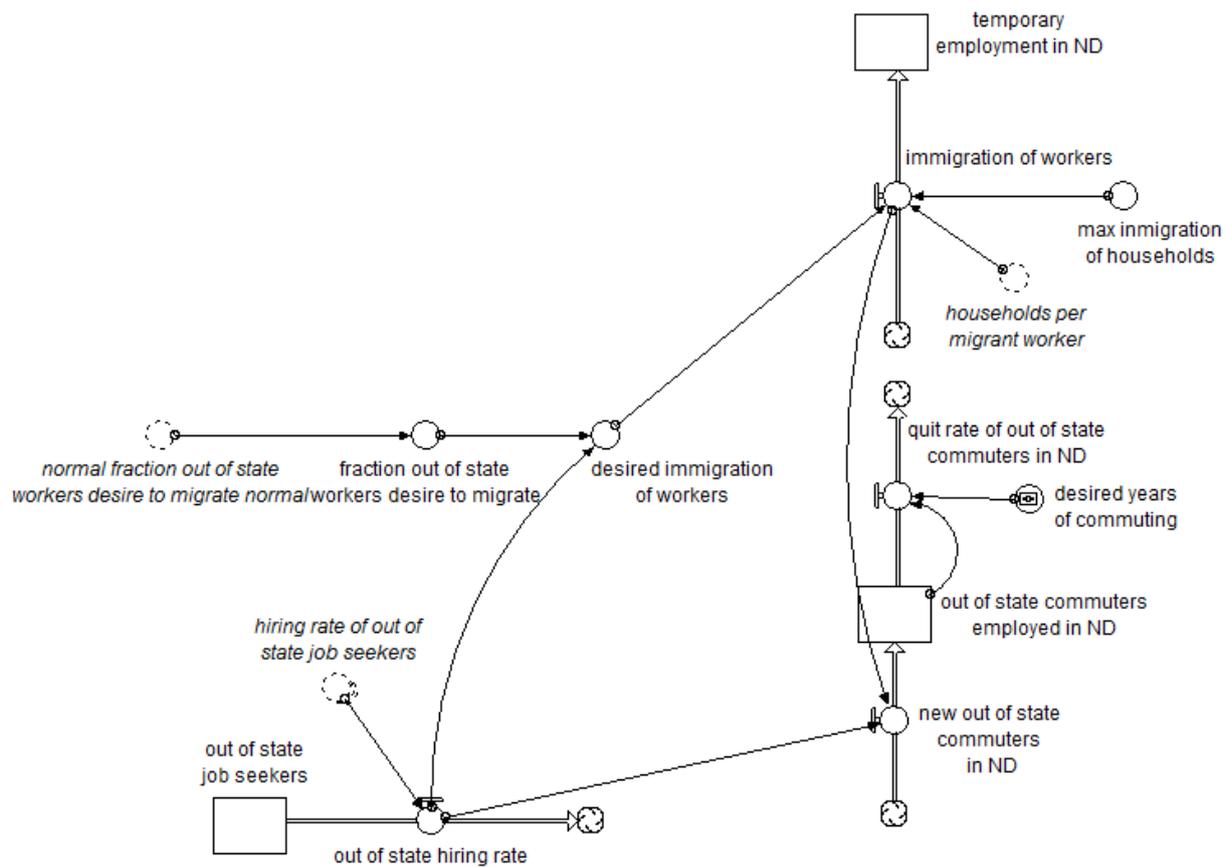
(11) Immigrate or commute

Before a household will make the decision to migrate, one of the members in the households needs to have found a job in North Dakota. Not before an out-of-state job seeker is hired the decision to move is being made. There is always a fraction of the out-of-state job seekers who get hired who decide to commute. The reason is that many of those out-of-state job seekers might live close to the border between North Dakota and their own state. The actual commuting time from home-work is relative short, so there is no necessity of moving.

Besides the daily commuters, there are long-distance commuters. Most of the times, they will work two weeks on - two weeks off in North Dakota. During their stay in North Dakota they will work double hours and sleep in temporary housing. Many workers at the oil field go from oil field to oil field and remain commuters. There are also commuters who would have been willing to move to North Dakota, but were unable to find housing.

The fraction who are willing to move is taken as a constant. In reality, this fraction might be subjected to the quality of life in North Dakota, the decrease in adequacy of facilities, as well as the average distance of the out-of-state job seekers from North Dakota to their home base. The desired immigration of workers is thus the fraction of out-of-state workers desire to migrate times the newly hired out-of-state workers. The immigration is, however, limited by the housing availability for immigrants. If there are no houses the immigrants can move in to, more workers need to commute. The actual immigration of workers is thus the minimum of the desired immigration of workers and the maximum immigration of households (one household, one worker). The new out-of-state commuters in North Dakota is the out-of-state hiring rate minus the immigration of workers.

The commuters then to be willing to commute to another state only for a certain time period. The quit rate of out-of-state commuters is thus the commuters divided by the desired time to commute. The quit rate will impact the attrition rate in simulation model 7.



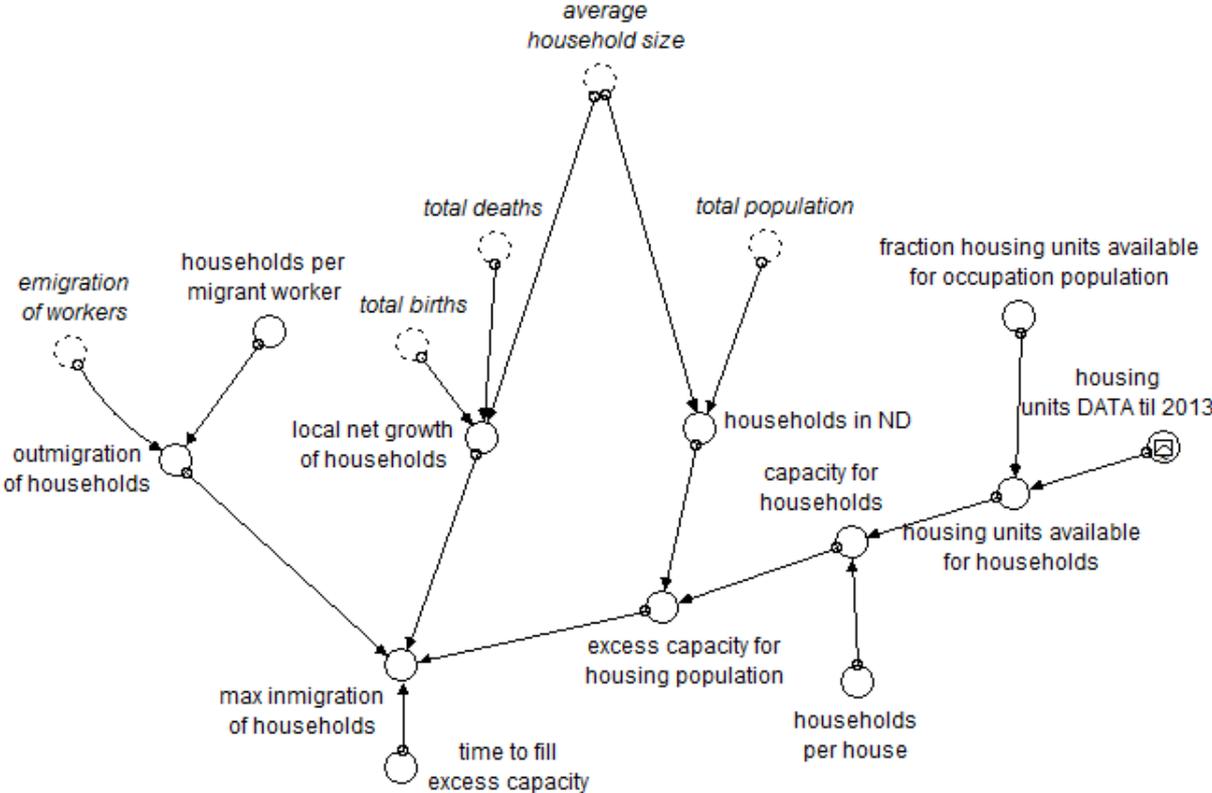
simulation model 11 - immigrate or commute

(12) Housing constraints

Explained is that the maximum immigration of households is a result of the housings constraints. The houses available for immigrants are modeled in simulation model 12. The total housing units available for households is the total housing units times the fraction housing units available for occupation. The housings units are taken exogenous. The housing units with seasonal, recreational, or occasional use are not available for the housing of households. Also vacant houses which are not open for sale or rent, for example due to double housing for one household, are excluded in the fraction housing units available for occupation. The housing units available for households gives the capacity for households.

Assumed is that the local households first will be housed. Local households are the population divided by the average household size. The local net growth of households are the growth in persons (births minus deaths) divided by the average households size. The remaining capacity after subtracting the housing units necessary for the local population from the total housing

units available for households plus the houses which become vacant through emigration are then available for new immigrants.



simulation model 12 - housing constraint

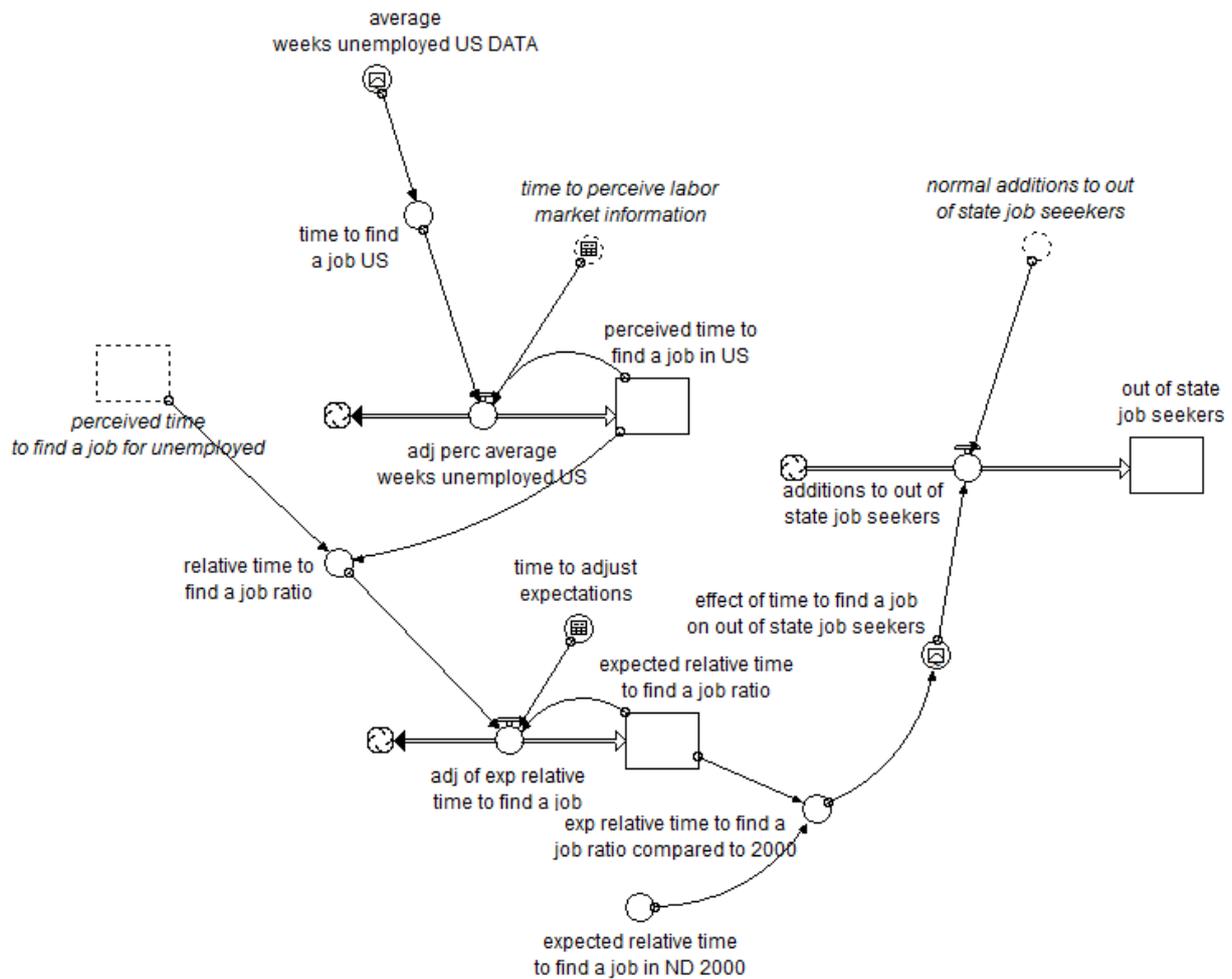
(13) New out-of-state job seekers in North Dakota

As we have seen earlier, the hiring rate of out-of-state workers is constrained by the out-of-state job seekers. The additions to out-of-state job seekers is affected by the labor market attractiveness, which is here presented as the relative time to find a job in North Dakota. The additions to out-of-state job seekers is the effect of time to find a job on out-of-state job seekers times normal additions to out-of-state job seekers. The reasoning is that people from other states and countries will go to North Dakota to find a job when the labor market is relative more attractive, which is the case when the time to find a job is relative lower. Many people have, however, searched for jobs in North Dakota for the high wages. Since endogenizing the relative wages of North Dakota compared to other states is more sensitive to other factors than just the labor market, we did not include this factor. We, however, acknowledge the big impact of the wages on the attractiveness. The assumption is that the effect of wages on the new job seekers from outside North Dakota will follow the same trends

as the time to find a job. Therefore, without including the wages the out-of-state job seekers can be modeled.

In the decision to move to a different place, migrants optimize their earnings according to employment options and possibilities in both the current state of residence and the potential new state of residence. They want to improve their economic, social, and personal situation in every move (Constant and Zimmermann, 2011). The time to find a job in North Dakota is thus taken relative to time to find a job in the current state of residence. The data reveals that most out-of-state job seekers come from the first, second or third neighbor states. In the best case, North Dakota's time to find a job would be compared to the time to find a job in these states. Data is however limited available for these states. The time to find a job in North Dakota is therefore compared to the U.S. average.

The information on the time to find a job is perceived with a delay. The perceived time to find a job for unemployed divided by the perceived time to find a job in US is the relative time to find a job ratio. The expectations are adjusted to the actual perceived time to find a job ratio. Important to note is that the normal additions to out-of-state job seekers are based on the year 2000. The expected relative time to find a job ratio is therefore also compared to the ratio in 2000. The expected relative time to find a job ratio compared to 2000 is then the input for the effect on the normal additions to out-of-state job seekers. The effect is based on the assumption that if the relative time to find a job in North Dakota compared to the U.S. decreases and the relative labor market attractiveness thus improves, more job seekers will come to North Dakota.



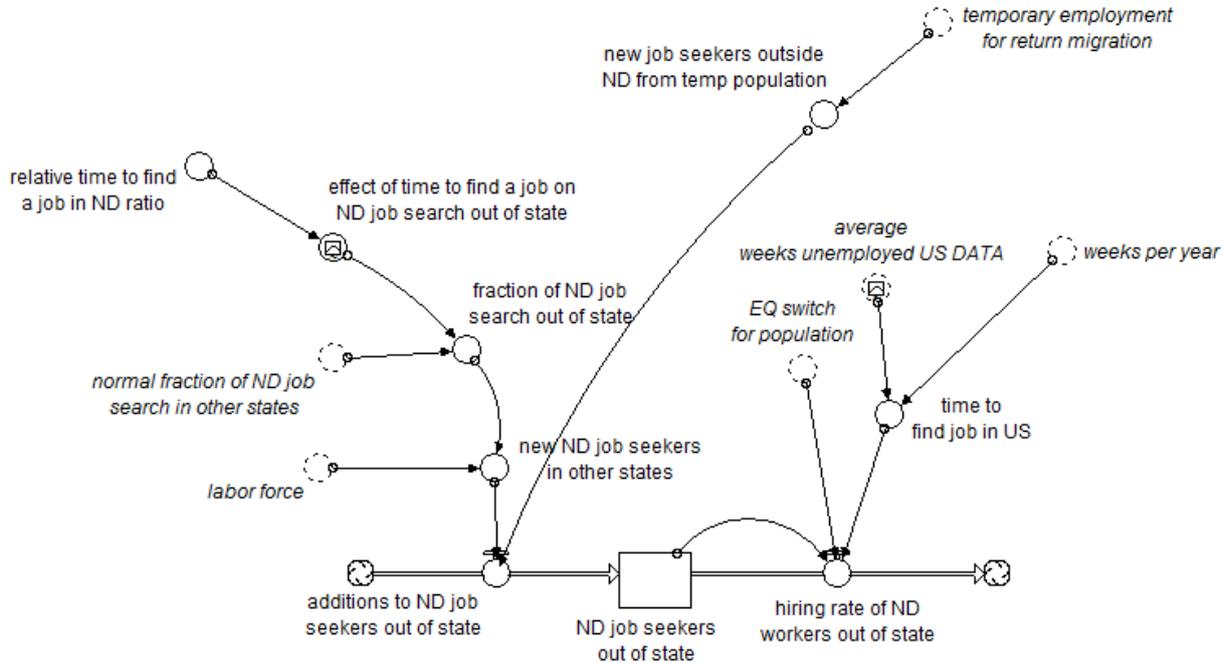
simulation model 13 - new out-of-state job seekers in North Dakota

(14) New North Dakota job seekers out-of-state

The opposite effect counts for North Dakota job seekers applying for jobs in other states or countries. If the relative time to find a job in North Dakota compared to the U.S. decreases and the relative labor market attractiveness of North Dakota thus improves, less North Dakota job seekers search for a job in other states. This effect impact the fraction of ND job search in other states. In contrast to the structure for out-of-state job seekers, a fraction of ND job search is used. This fraction is multiplied with the labor force. Only North Dakota's labor force are potential job seekers outside North Dakota, since only this part of the working age population is willing to work. The additions to out-of-state job seekers is not affected by the labor force in other states, since the amount of potential job seekers for North Dakota are unknown.

The hiring rate of North Dakota job seekers out-of-state is dependent on the average time to find a job in the U.S. For simplification purposes, there is assumed that these workers will

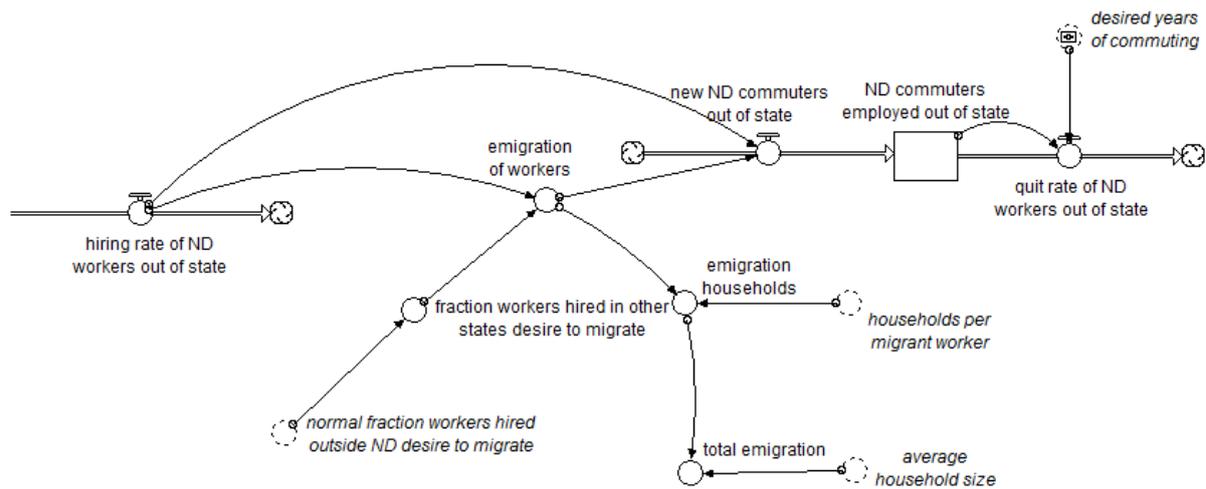
eventually always get a job somewhere, dependent on the average time to find a job in the U.S..



simulation model 14 - new North Dakota job seekers out-of-state

(15) Emigrate or commute for North Dakota workers hired out-of-state

Whether North Dakota workers who are hired in other states or countries will decide to stay in North Dakota or migrate to another state depends on the same decision structure as already explained for out-of-state workers deciding to migrate to North Dakota. The only difference is that there is assumed to be always sufficient housing available outside North Dakota.

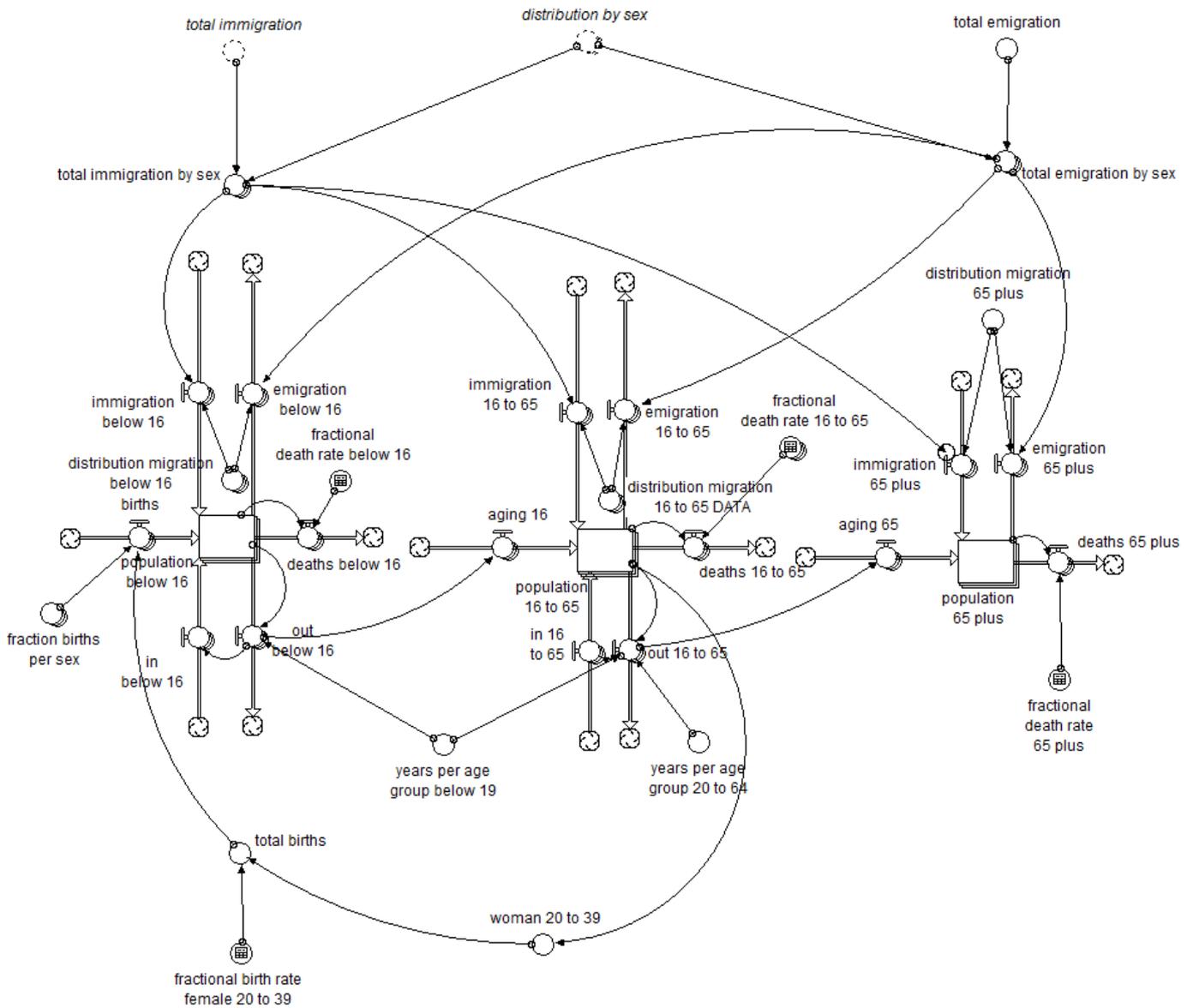


simulation model 15 - emigrate or commute for North Dakota workers hired out-of-state

(16) Population chain

The remaining part to explain is the population chain. The population chain determines the size of the working-age population and is thus important for the size of the labor force. The population chain differentiates different age groups and sexes. The population below 16 is divided in age groups of 4 years. For example, 0-3 years old, 4-7 years old, and so on. The population 16 to 65 is divided in age groups of 5 years. The population 65 plus is aggregated. The population 16 to 65 is isolated because this is the working-age population. A small number of years per age group is taken because it is important for the labor force to have a good estimation of the working age population. Every year, 1/4 of the number of residents in each age group below 16 flows out of one age group and into the next one in order.

The total population depletes with the deaths and increases with the births. Each year a fraction of each age group dies. The fractional death rate is different per age group and highest for the population 65 plus. The total births per year are the fractional birth rate 20 to 39 times the amount of woman 20 to 39 years old. The fractional birth rate is based on the total births per year divided by the number of woman 20 to 39 years old in the same year. The years 20 to 39 are taken since this group has the highest potential to give birth. The total births are multiplied with the fraction births per sex to get the births per sex. The birth will only flow into the age group 0-3.



simulation model 15 - population chain

The population increases with immigration and decreases with emigration. Data on migration per age group from the American Community Survey 1-Year Estimates is taken to derive an average distribution factor of migration over the different age groups. The total of the distribution factors is thus 1. In reality, the factors might change due to different reasons for migration. For simplification purposes, these distribution factors are taken as a constant.

The total immigration times the distribution by sex times the distribution factor for that age group gives the immigration per age group per sex. The same calculation is made for the emigration.

Appendix 2 - Data overview

Variable	Units	Categories	Data source	Time horizon (2000+)	Remarks
Active resumes in-state/out-of-state	Resumes	per occupation	Online Job Openings Report (OJOR)	June 2008 - June 2015	
Alternative Measures of Labor Underutilization	Persons	State level	Bureau of Labor Statistics	2003-2014	<i>Includes data for unemployed 15+ weeks, discouraged workers, all marginally attached</i>
Average mean duration of becoming employed	Weeks	US level	Issues in Labor Statistics article, How long before the unemployed find jobs or quit looking?.	2000-2010	<i>Time horizon limited</i>
Average mean duration of becoming employed	Weeks	US level	Issues in Labor Statistics article, How long before the unemployed find jobs or quit looking?.	2000-2010	<i>Time horizon limited</i>
Average mean duration of unemployment	Weeks	US level	U.S. Bureau of Labor Statistics	2000-2015	<i>Includes becoming employed and leaving labor force</i>
Births per year	Persons	US level	Population Estimates Program, Population Division, U.S. Census Bureau	1995-1999	<i>No information on births per age-group is found. The birth rate is derived by dividing the total births per years by the woman of the age 20-39 measured by Census 2000.</i>
Deaths per year	Persons	US level	Census, Death rates by 10-year age groups: United States and each state	2000	<i>The number death rates per age group are rearranged in the age group used in this research. Based on year 2000.</i>
Demographics	Persons	per age (group) and sex	Population Estimates Program, Population Division, U.S. Census Bureau	2000 and 2010	

Employed job seekers	Fraction	state level	Needs Assessment of Long Term Care, North Dakota: 2002	2002	0,42
Employee tenure	Years	per industry	Current Population Survey	2004-2014	
Employment	Persons	state level	Local Area Unemployment Statistics (LAUS)	Jan 2000 - June 2015	<i>Also non paid workers, measures ND residents employed (also residents working out-of-state)</i>
Employment	Jobs	per industry	Quarterly Census Employment and Wages (QCEW)	2000-2013	<i>The Quarterly Census Employment and Wages derives the employment counts from quarterly contribution reports filled by almost every employer. This count is based on the place of work, not on the place of residence. Commuters, workers commuting from other states, are also count. Also, agriculture is only partly included.</i>
Employment	Jobs	per industry	Current Employment Statistics	2000-2015	<i>Agriculture not included</i>
Hourly wage	Wage per hour	per industry	Current Employment Statistics	2007-2015	
Immigration	Persons	per age/sex/income/education/previous state of residence	American Community Survey 1-Year Estimates	2005-2013	<i>Differentiation US immigration/foreign immigration</i>
Vacant jobs	Jobs	per occupation	Online Job Openings Report (OJOR)	June 2008 - June 2015	<i>Data is rearranged from job openings per occupation into job openings per industry. Job openings per industry is not available. This data does only reflect the online job openings and is only available since June 2008. For simplification purposes, the online job openings are assumed to cover all the job opening. In reality, this number might be underestimating the total</i>

					<i>level of job openings. Since the data is only available since 2008, an estimation is being made before 2008, multiplying the US job openings rate with North Dakota's employment data. Since the initialization is not based on a real number, the simulation may start of with a imbalance in the system.</i>
Labor force	Persons	state level	Local Area Unemployment Statistics (LAUS)	2000-2015	
Life expectancy	Years	by sex	CDC, National Vital Statistics System, Behavioral Risk Factor Survey System, U.S. Census Bureau.	2000-2015	
Mean vacancy duration	Workweeks	per industry - US level	Dice Hiring Indicators	2001-2013	<i>No data for state only US</i>
Multiple job holders	Percent points	state level	U.S. Bureau of Labor Statistics, Current Population Survey (CPS)		<i>Multiple jobholders as a percentage of total employment by State, annual averages</i>
Normal migration non workrelated	persons	US level	U.S. Census Bureau, Current Population Survey	2000-2014	
Emigration	Persons	per new state of residence	American Community Survey 1-Year Estimates	2005-2013	<i>No foreign emigration specified</i>
Out-of-state commuters working in ND	fraction	state level	U S Census Bureau, 2011 American Community Survey	2011	11,6
Population	Persons	all states	Population Estimates Program, Population Division, U.S. Census Bureau		
Unemployment	Persons	state level	Local Area Unemployment Statistics (LAUS)	Jan 2000 - June 2015	
Unemployment rate	Percent points	all states	LAUS	2000-2014	

Vacant houses	Housing units	state level	American Community Survey 1-Year Estimates	2000-2013	
Weekly hours	Hours per week	per industry	Current Employment Statistics	2007-2015	
Fraction housing units for housing households	Fraction	state level	American Community Survey 1-Year Estimates	2000-2013	<i>Average is taken of the period 2000-2013. Excluding housing units with seasonal, recreational, or occasional use. Excluding vacant houses which are not open for sale or rent, i.o. (temporary) double housing for one household.</i>
Housing units	Housing units	state level	American Community Survey 1-Year Estimates	2000-2013	
Fraction civilian non-institutionalized population	Fraction	state level	Local Area Unemployment Statistics (LAUS)	2000-2015	<i>This fraction is measured by the civilian noninstitutionalized population (source: Local Area Unemployment Statistics) divided by the population above 16 according to Census population estimates 2000 and 2010.</i>
Distribution migration	fraction	state level	American Community Survey 1-Year Estimates	2005-2013	<i>Fraction derived from the average immigration by age-group divided by the total immigration (2005-2013).</i>
Average household size	Persons	state level	American Community Survey 1-Year Estimates	2000-2013	<i>For immigration the same number of persons per household is taken as in North Dakota, however, those households are original from different states, which might imply a different average size of household</i>
Out-of-state workers employed in ND			Longitudinal Employer-Household Dynamics, Home Destination Report - Where Workers Live Who are		<i>This dataset produces data on employers and employees under the Local Employment Dynamics (LED). The Home-Destination Report which produces data on in- and outflows of workers</i>

			Employed in the Selection Area - by States	<i>bases its data on a total level of employment, which is lower than the count by the QCEW. To correct for the difference in total employment, the fraction out-of-state workers employed in North Dakota of the total employment in primary jobs is taken from the LEHD and multiplied with the total employment in QCEW.</i>
ND workers employed in other states			Longitudinal Employer-Household Dynamics, Home Destination Report - Where Workers Live Who are Employed in the Selection Area - by States	<i>This dataset produces data on employers and employees under the Local Employment Dynamics (LED). The Home-Destination Report which produces data on in- and outflows of workers bases its data on a total level of employment, which is lower than the count by the QCEW. To correct for the difference in total employment, the fraction out-of-state workers employed in North Dakota of the total employment in primary jobs is taken from the LEHD and multiplied with the total employment in QCEW.</i>

Appendix 3 - Validation of estimations

Variable	Units	Estimation	Source	Remarks
Time to perceive labor shortage	years	1/12		<i>Assumed is that in general, it takes one month before a labor shortage is noticed at the management level.</i>
Desired time to fill labor shortage	years	1/4		<i>The desired time to fill a labor shortage is assumed to be 3 months. These months should take away the fluctuations which can be expected in production between different weeks, and is fast enough to prevent a permanent working of overtime.</i>
Time to adjust hiring strategy	years	1/12		<i>Assumed is that it will take one month, before the vacancy announcement are created and other preparations are made for the adjustment of the hiring strategy</i>
Desired years of temporary stay	years	2		<i>Estimation is made of a temporary stay of 2 years. After 2 years a household will decide whether it will move to another state or remain in North Dakota and integrate. No information is published on this variable. More research would be necessary to make a more valid estimation of the desired years of temporary stay.</i>
Desired years of commuting	years	3		<i>Estimation is based on news papers and personal conversations. Most commuters who have to travel a lot remain, are only willing to deal with the worse living condition in the camps during their working period for a short period of time. Mainly to earn a lot of money. This time is lower than the normal employee tenure of the local workforce. No data is available on the years of commuting, so an estimation of 3 years is made.</i>
Fraction of return migration			Dumont, Jean-Christophe and Gilles Spielvogel (OECD) (2008), <i>Edition Return Migration: A New Perspective</i> , Internatio	<i>An estimation is being made of 30% moving back to the home country. There is no information on the duration of migration between different states within the U.S. However, research shows that 20% to 50% of the migrants who have moved to a different country, leave within five years after the arrival. Assumed is that the average return migration between the states will be lower than the average return migration between countries, since the culture is relative more in line with the culture of the home state. Therefore, an estimation of 30% is being made. This might also be affected by the perceived adequacy of facilities.</i>

			nal Migratio n Outlook	
Time to process labor force adjustment	years	1/52		<i>The labor market can respond quickly to changes in the conditions of the labor market. Therefore, there is assumed that the labor market will respond each week to the desired labor force.</i>
Maximum local labor force participation rate	Fracti on	0.96		<i>The potential job seekers are based on the number of marginally attached workers, discouraged workers and the unemployment 15+ weeks (Bureau of Labor Statistics). The total of the potential job seekers plus the labor force divided by the local civilian non-institutionalized population (not including temporary residents) is assumed to be the maximum local labor force participation rate.</i>
Normal fraction of ND job search in other states	fracti on			<i>Based on the number of North Dakota's residents working outside North Dakota in the same year divided by an estimation of the desired years of commuting, a normal hiring rate of commuters can be estimated. The total of the normal hiring rate of migrant workers and commuters is the normal total hiring of North Dakota workers in other states. In equilibrium the new ND job seekers in other states, need to be equal to the total normal hiring rate of out-of-state workers. Based on the migration data (source: American Community Survey) and the average size of households, the emigration of households can be calculated. Assuming that for each household who migrates, one worker needs to be hired in another state before moving, the normal hiring rate of migrant workers can be estimated. New North Dakota job seekers in other states can stem from two sources. Either from workers who are originally from other states and are willing to return to the home state or another state, or from workers who are original North Dakota residents and want to have a job somewhere else. The normal fraction of ND job search out-of-state only focusses on the second type of job search. If</i>

				<p><i>assumed that only people who are already part of the labor force in North Dakota will apply for jobs in other states, a normal fraction of North Dakota's labor force for job search in other states can be calculated</i></p> <p><i>(init(hiring_of_ND_workers_in_other_states_EQ)-init(temporary_employment_for_return_migration))/init(labor_force))</i></p>
normal fraction workers hired outside ND desire to migrate	fraction			<p><i>Based on the migration data (source: American Community Survey) and the average size of households, the emigration of households can be calculated. Assuming that for each household who migrates, one worker needs to be hired in another state before moving, the normal hiring rate of migrant workers can be estimated. Based on the number of North Dakota's residents working outside North Dakota in the same year divided by an estimation of the desired years of commuting, a normal hiring rate of commuters can be estimated. The total of the normal hiring rate of migrant workers and commuters is the normal total hiring of North Dakota workers in other states. Dividing the normal hiring of migrant workers by the total hiring of out-of-state workers, results in an estimation of the fraction of North Dakota workers hired outside North Dakota who are willing to migrate.</i></p>
Normal fraction out-of-state workers desire to migrate normal	fraction			<p><i>Based on the migration data (source: American Community Survey) and the average size of households, the immigration of households can be calculated. Assuming that for each household who migrates, one worker needs to be hired in another state before moving, the normal hiring rate of immigrant workers can be estimated. Based on the number of North Dakota jobs which are filled by workers from other states in the same year divided by an estimation of the desired years of commuting, a normal hiring rate of commuters can be estimated. The total of the normal hiring rate of migrant workers and commuters is the normal total hiring of out-of-state workers in North Dakota. Dividing the normal hiring of migrant workers by the total hiring of out-of-state workers, results in an estimation of the fraction of out-</i></p>

				<i>of-state workers who are willing to migrate.</i>
Normal additions to out-of-state job seekers	fraction			<i>Based on the migration data (source: American Community Survey) and the average size of households, the emigration of households can be calculated. Assuming that for each household who migrates, one worker needs to be hired in another state before moving, the normal hiring rate of migrant workers can be estimated. Based on the number of North Dakota's residents working outside North Dakota in the same year divided by an estimation of the desired years of commuting, a normal hiring rate of commuters can be estimated. The total of the normal hiring rate of migrant workers and commuters is the normal total hiring of North Dakota workers in other states. In equilibrium the new ND job seekers in other states, need to be equal to the total normal hiring rate of out-of-state workers.</i>
Vacancies	Jobs			<i>The estimation of the vacant jobs is based on the job openings per occupation in North Dakota in the Online Job Openings Report and the job openings rates per industry for the U.S. in the Labor Turnover and Job Openings Survey. The Online Job Openings Report presents North Dakota data since June 2008. Unfortunately, the data is categorized in occupations instead of industries. Many occupations can, however, be practiced in different sectors. To be able to make a realistic rearrangement of the data, we use the occupational employment distribution per industry from the ND Workforce Intelligence Network. On this webpage there is a profile created for each industry with the top 10 occupations and the estimated employment for the year 2012. We reorganized this data per occupation. For each occupation, the sectors in which that occupation is active, are presented with the estimated employment. After that a weighted factor is assigned for the representation of that occupation in each sector. Below an example:</i>

			<p><i>Sales and Related Occupations</i> <i>Utilities 3%</i> <i>Other sectors 15%</i> <i>Retail, Food and Lodging 65%</i> <i>Wholesale Trade and Transportation 16%</i></p> <p><i>Per occupation, the vacancies are now redistributed over the sectors using these weighted factors. This will result in a total vacancies per sector.</i> <i>Until 2008, an estimation is made based on the U.S. rates of job openings over total employment (job openings plus employment). The US rates are compared to the North Dakota rate since 2008, to create an estimation of behavior of job openings rates. Assumed is that before the oil boom, North Dakota's job openings rates will behave in the same patterns as the U.S. job openings rates.</i></p>
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Appendix 4 - Extreme validation tests

Some examples of the extreme validation tests which are conducted will be presented. Not all simulation graphs are presented, because of the size of the different simulation outcomes.

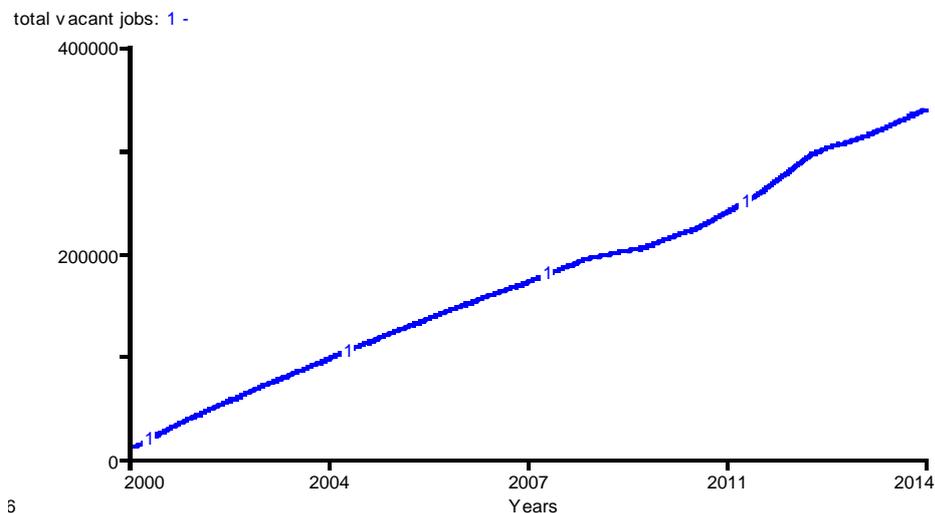
(1) Hiring standards extremely high

The hiring standards are set extremely high by setting the qualified fraction extremely low. As a result the hiring rate drops and the vacancies increase.

Qualified fraction unemployed: 0.01

Qualified fraction employed: 0.01

Qualified fraction out-of-state: 0.01



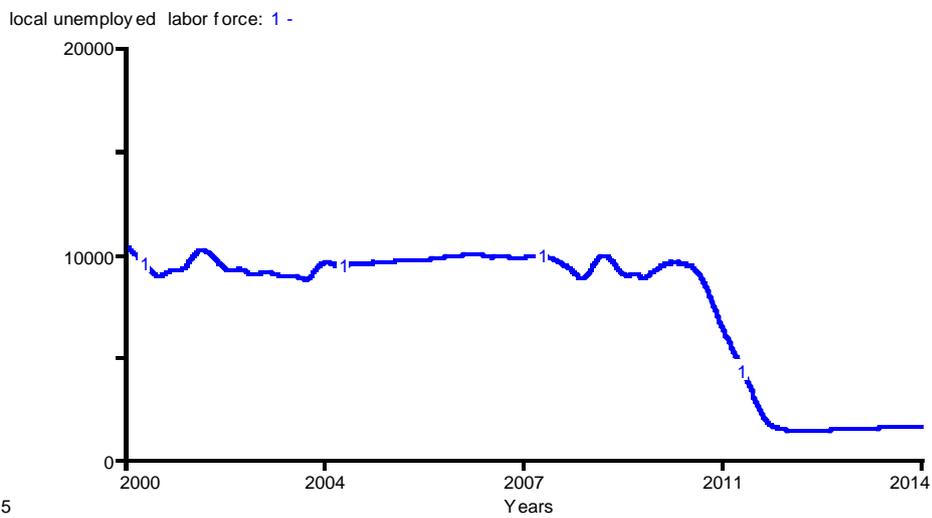
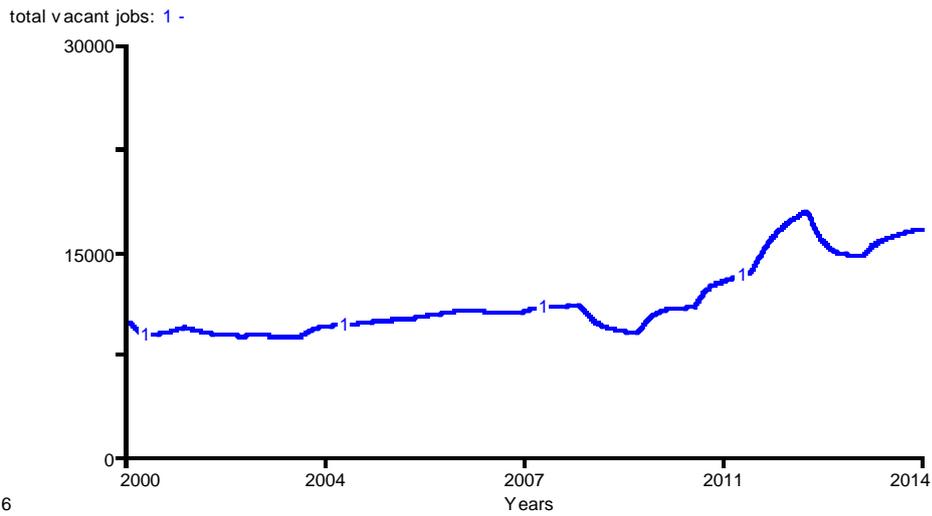
(2) Hiring standards extremely low

The hiring standards are set extremely low by decreasing the qualified fraction to 1. The vacancies still increase because most vacancies are created for replacement. The unemployed labor force depletes during the oil boom to an extreme low level. Since there is always a new inflow of unemployed job seekers, the unemployment does not decrease to zero.

Qualified fraction unemployed: 1

Qualified fraction employed: 1

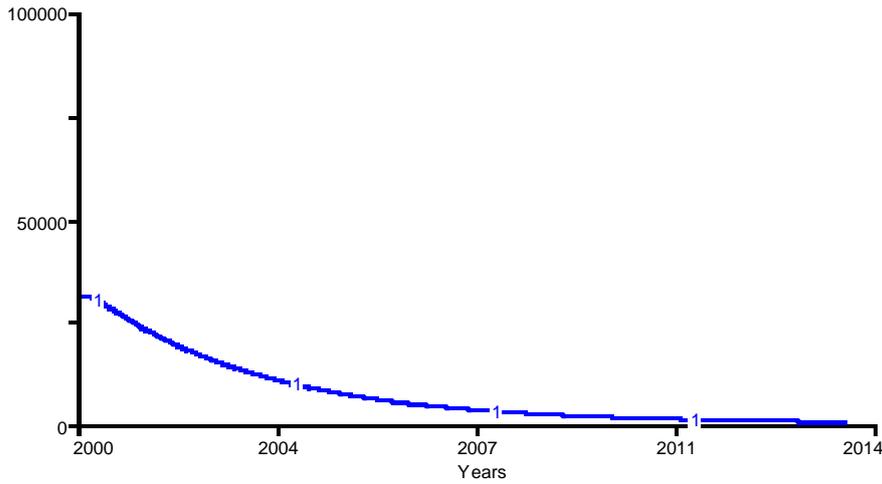
Qualified fraction out-of-state: 1



(3) No inflow of new job seekers

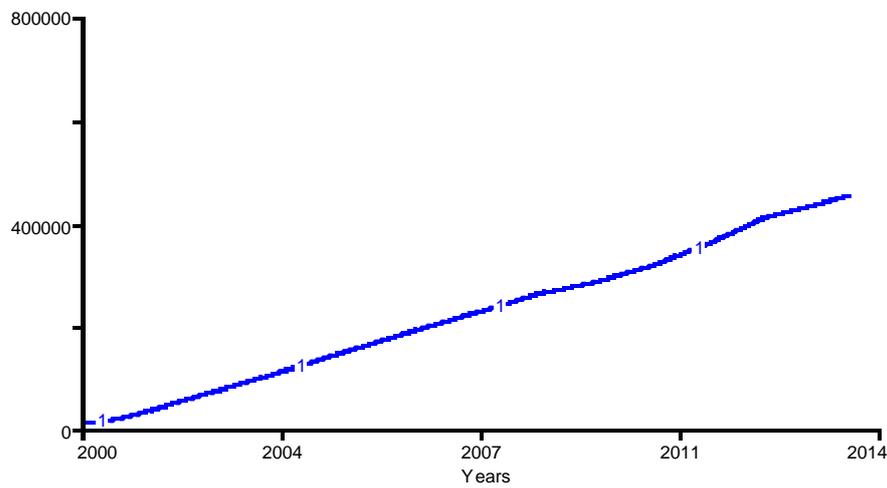
The inflow of applications from new job seekers are set at zero. There will still be applications from current job seekers. The out-of-state commuters run to zero and vacancies increase because there are no job seekers to fill them.

out of state commuters employed in ND: 1 -



2

total vacant jobs: 1 -

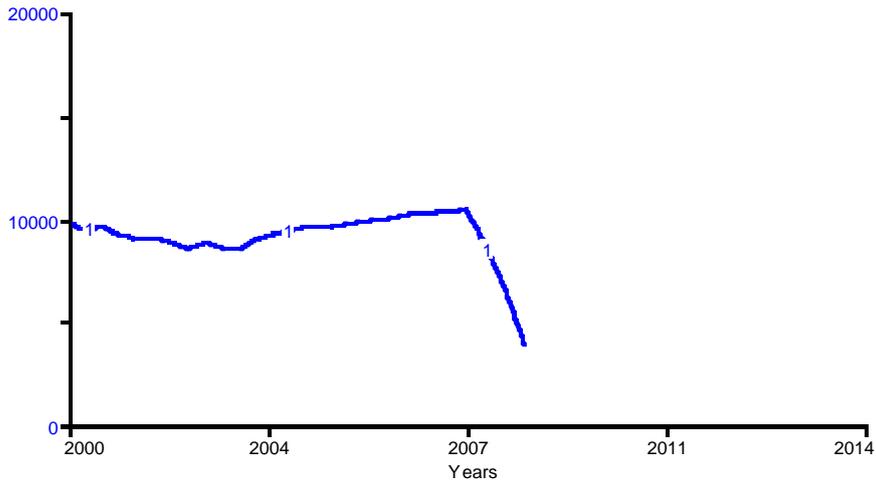


6

(4) labor demand of all sectors run to zero in 2008

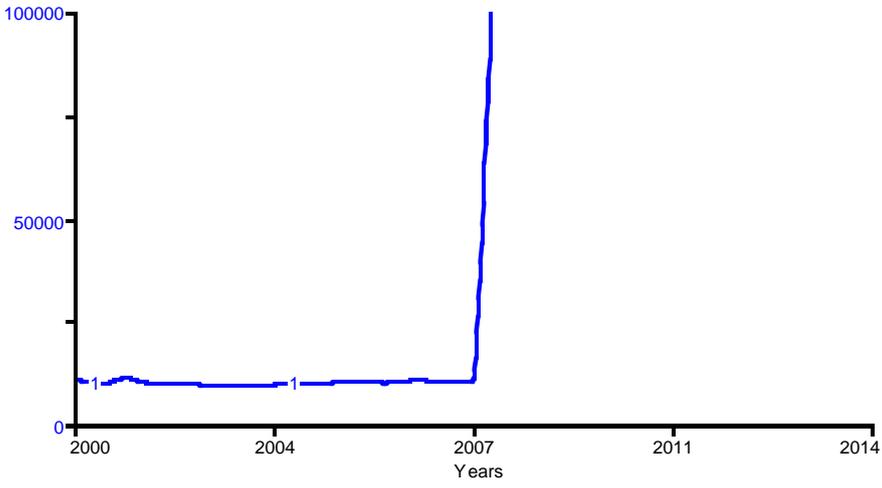
If the employment runs to zero, all workers will be fired. The unemployed labor force increases immediately to extreme high values. The vacancies deplete to zero. The model is unable to continue the simulation, because of division by zero.

1: total vacant jobs



6

1: local unemployed labor force



5

Appendix 5 - Total vacant jobs and employment in North Dakota

	Agriculture, Forestry, Fishery and Hunting	Construction	Manufacturing	Mining	Other sectors	Retail, Food and Lodging	Utilities	Wholesale Trade and Transportation
2000	2725	17334	24823	3411	155117	70253	15867	29427
2001	2845	16978	24917	3575	156587	70027	16942	29576
2002	2874	16378	24404	3248	157347	69540	16508	29157
2003	2997	17183	24140	3349	159536	69791	15444	29190
2004	3103	18526	25577	3603	161836	71068	15761	29827
2005	3111	18790	26968	4199	164569	72747	16629	30439
2006	3197	19937	27161	4832	168476	74190	16949	31077
2007	3452	20843	27274	5391	171577	75054	17384	31720
2008	3755	22570	27713	7445	175222	75470	17435	33196
2009	3857	22131	24349	7268	175274	74808	16481	33068
2010	3961	22970	23502	11132	178733	76222	15931	35085
2011	4327	26497	25090	17685	182560	79395	17244	40667
2012	4626	31871	26869	25449	190421	84951	18416	48472
2013	4887	34665	27082	27168	194515	87566	18565	50953
2014	5081	37361	27814	31049	200624	90589	19517	54149

Appendix 6 - Estimation vacancies per sector in North Dakota

	Agriculture, Forestry, Fishery and Hunting	Construction	Manufacturing	Mining	Other sectors	Retail, Food and Lodging	Utilities	Wholesale Trade and Transportation
2000	202	426	463	84	4796	2526	491	745
2001	211	417	465	88	4841	2518	524	749
2002	213	283	372	56	3842	1878	403	600
2003	222	272	332	53	3669	1858	355	596
2004	230	335	458	65	3898	2123	380	701
2005	230	395	555	88	4402	2422	445	794
2006	283	506	650	163	4774	2361	453	908
2007	364	639	758	292	5149	2284	464	1039
2008	537	836	895	648	5570	2196	464	1218
2009	427	417	377	309	3735	1441	256	712
2010	294	592	607	471	3707	1783	333	1076
2011	478	1108	1026	898	5533	2536	557	1896
2012	530	1338	1451	1072	8295	3400	802	2477
2013	614	1209	1423	970	7794	3119	744	2419
2014	708	1474	1625	1174	9419	3452	851	2823

Appendix 7 - Vacancies per occupation in North Dakota

	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
	2008	2008	2008	2008	2008	2008	2008	2009	2009	2009	2009	2009	2009
JOB OPENINGS													
Management	878	937	773	706	688	648	533	590	585	513	473	530	645
Business and Financial Operations	293	240	236	254	260	212	163	193	195	161	164	168	195
Computer and Mathematical	297	340	263	295	214	223	183	221	186	214	185	155	151
Architecture and Engineering	380	305	352	383	251	249	212	184	211	176	145	128	158
Life, Physical, and Social Science	102	79	91	84	72	41	71	124	146	151	83	36	52
Community and Social Service	295	308	193	176	211	173	188	200	192	195	216	190	223
Legal	26	20	17	23	30	28	16	32	29	25	30	27	25
Education, Training, and Library	460	410	329	304	236	232	200	216	261	349	337	407	417
Arts, Design, Entertainment, Sports, and Media	224	231	261	220	172	176	131	130	131	116	158	162	145
Healthcare Practitioners and Technical	1148	1088	961	953	983	1080	935	824	895	895	751	691	945
Healthcare Support	354	373	389	342	372	351	355	358	365	313	296	273	303
Protective Service	379	384	392	339	322	301	137	137	120	130	265	197	94
Food Preparation and Serving Related	814	775	820	1180	1236	882	643	570	572	499	533	564	540
Building and Grounds Cleaning and Maintenance	379	368	453	425	337	254	194	171	208	234	267	312	289
Personal Care and Service	265	271	371	291	276	250	169	182	215	242	180	108	124
Sales and Related	1366	1363	1472	1494	1479	1201	1034	970	1104	1245	979	884	881
Office and Administrative Support	1391	1483	1393	1400	2080	1902	1568	1389	1298	780	870	793	914
Farming, Fishing, and Forestry	1012	566	343	397	304	265	420	629	731	763	734	539	375
Construction and Extraction	1005	993	1204	1993	1795	695	316	296	319	506	568	433	437
Installation, Maintenance, and Repair	425	503	531	492	471	438	305	323	332	525	361	316	332
Production	785	1555	974	968	674	414	213	213	198	227	280	285	237
Transportation and Material Moving	851	846	1211	1323	1124	808	478	405	470	477	449	483	446
Military Specific	9	5	6	2	1	8	8	3	3	1	2	6	2
INA	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL JOB OPENINGS	13138	13443	13035	14044	13588	10831	8472	8360	8766	8737	8326	7687	7930

Source: Online Job Openings Report

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
	2009	2009	2009	2009	2009	2009	2010	2010	2010	2010	2010	2010	2010
JOB OPENINGS													
Management	625	578	486	388	389	414	483	367	399	398	408	442	534
Business and Financial Operations	146	121	134	120	107	121	115	142	129	144	157	144	156
Computer and Mathematical	128	152	109	81	74	90	83	104	93	114	104	126	159
Architecture and Engineering	152	127	123	103	97	106	88	127	137	121	118	111	99
Life, Physical, and Social Science	41	41	41	45	39	90	137	135	158	43	45	44	57
Community and Social Service	190	122	137	181	130	187	118	126	178	201	212	146	126
Legal	30	7	35	26	16	7	10	13	14	15	12	24	26
Education, Training, and Library	470	241	265	182	158	168	163	231	324	331	337	286	284
Arts, Design, Entertainment, Sports, and Media	175	109	129	113	111	119	110	148	184	137	137	155	152
Healthcare Practitioners and Technical	723	598	584	744	767	789	661	552	552	529	586	693	538
Healthcare Support	338	295	339	263	250	301	242	210	241	227	228	263	237
Protective Service	135	124	93	89	81	99	93	130	171	150	118	129	118
Food Preparation and Serving Related	617	647	774	583	469	551	382	441	545	726	639	910	858
Building and Grounds Cleaning and Maintenance	356	238	247	244	239	202	158	196	238	322	300	307	332
Personal Care and Service	159	166	169	158	112	110	167	167	232	303	205	247	237
Sales and Related	1041	965	951	997	712	724	799	861	1048	1051	1009	1058	1168
Office and Administrative Support	890	634	693	660	640	761	861	963	867	834	1000	970	886
Farming, Fishing, and Forestry	241	132	107	93	157	235	336	428	510	278	133	95	179
Construction and Extraction	682	704	659	581	428	392	379	515	593	850	814	721	844
Installation, Maintenance, and Repair	349	341	334	340	246	316	328	396	431	430	413	456	490
Production	310	374	399	230	291	310	328	288	395	420	533	557	673
Transportation and Material Moving	534	582	619	524	432	407	462	545	710	801	910	881	1057
Military Specific	7	7	1	3	6	6	6	3	6	6	2	4	3
INA	0	1006	965	748	768	805	744	691	597	786	719	820	716
TOTAL JOB OPENINGS	8339	8311	8393	7496	6719	7310	7253	7779	8752	9217	9139	9589	9929

Source: Online Job Openings Report

	AUG	SEP	OCT	NOV	DE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
	2010	2010	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011
JOB OPENINGS													
Management	546	574	622	536	521	521	570	737	686	660	715	668	796
Business and Financial Operations	170	187	196	188	158	173	158	182	201	217	287	241	296
Computer and Mathematical	169	226	244	281	172	221	208	217	201	207	249	335	334
Architecture and Engineering	149	157	161	187	202	216	241	213	218	241	297	271	313
Life, Physical, and Social Science	52	100	70	72	75	156	173	192	92	98	98	175	147
Community and Social Service	175	119	140	104	80	86	118	155	186	167	123	137	136
Legal	34	34	16	16	7	16	9	13	14	10	17	12	11
Education, Training, and Library	227	227	177	162	180	186	237	314	355	358	365	321	315
Arts, Design, Entertainment, Sports, and Media	156	146	149	170	129	130	151	186	177	179	195	163	199
Healthcare Practitioners and Technical	573	649	702	719	588	704	884	922	903	904	967	1112	1022
Healthcare Support	259	264	294	337	381	344	317	466	508	443	302	317	284
Protective Service	157	130	182	181	89	87	172	218	194	217	142	149	174
Food Preparation and Serving Related	931	816	989	842	686	552	595	692	814	874	881	820	946
Building and Grounds Cleaning and Maintenance	346	295	303	269	237	261	335	490	592	574	517	466	548
Personal Care and Service	264	280	250	208	216	230	307	357	302	274	154	172	248
Sales and Related	1249	1451	1731	1634	1228	1237	1234	1207	1460	1639	1810	1606	1632
Office and Administrative Support	877	930	928	789	670	723	799	1016	1186	1306	1230	1355	1192
Farming, Fishing, and Forestry	175	191	164	162	240	484	616	656	657	645	153	119	132
Construction and Extraction	939	974	856	744	751	783	943	1083	1346	1309	1188	1130	1731
Installation, Maintenance, and Repair	531	541	610	587	576	626	650	724	784	795	788	1226	1317
Production	719	708	640	617	572	578	621	849	846	875	767	692	829
Transportation and Material Moving	1261	1352	1204	1125	1120	1251	1364	1599	1756	1910	1796	1769	1963
Military Specific	5	1	16	4	5	1	1	4	0	0	5	6	11
INA	956	837	886	830	733	714	878	911	997	1086	1328	1380	1636
TOTAL JOB OPENINGS	10920	11189	11530	10764	9616	10280	11581	13403	14475	14988	14374	14642	16212

Source: Online Job Openings Report

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	2011	2011	2011	2011	2012	2012	2012	2012	2012	2012	2012	2012	2012
JOB OPENINGS													
Management	889	934	1004	1061	937	1203	1262	1393	1256	1232	1129	1092	1073
Business and Financial Operations	310	323	333	394	359	411	383	388	402	456	457	507	543
Computer and Mathematical	321	294	323	378	370	408	372	463	488	514	427	502	430
Architecture and Engineering	406	382	426	482	469	562	700	606	651	686	559	509	489
Life, Physical, and Social Science	132	139	165	197	160	210	237	256	162	154	139	144	157
Community and Social Service	137	118	95	149	119	171	212	281	221	252	144	155	164
Legal	21	22	14	13	17	38	34	52	34	24	28	32	23
Education, Training, and Library	280	301	273	316	244	319	487	803	876	814	856	657	528
Arts, Design, Entertainment, Sports, and Media	169	191	176	199	171	170	216	349	378	337	306	272	274
Healthcare Practitioners and Technical	978	940	1189	1197	1120	1125	1198	1394	1314	1385	1217	1237	1302
Healthcare Support	383	363	475	466	415	386	450	469	447	465	378	408	457
Protective Service	161	148	176	161	129	196	221	305	299	239	234	264	240
Food Preparation and Serving Related	1062	1375	1425	1422	979	703	875	1055	1088	1213	1339	1398	1511
Building and Grounds Cleaning and Maintenance	450	490	489	631	581	604	771	941	886	839	704	827	929
Personal Care and Service	310	389	282	425	273	369	493	566	569	476	469	551	528
Sales and Related	1802	2097	2288	2127	1610	1523	1957	2224	2259	2290	1945	2137	2310
Office and Administrative Support	1201	1534	1654	1752	1516	1805	2219	2346	2234	2385	2352	2531	2750
Farming, Fishing, and Forestry	233	328	274	311	165	759	851	683	479	316	225	307	276
Construction and Extraction	1990	1990	1886	1695	1363	1157	1376	1870	1967	1915	1744	1746	1774
Installation, Maintenance, and Repair	1423	990	1109	1317	1005	1044	1315	1470	1362	1332	1180	1310	1266
Production	861	915	1099	1416	888	980	998	1385	1509	1129	1043	1420	1326
Transportation and Material Moving	2049	2262	2118	1855	1575	1592	2377	2669	2678	2298	2385	2198	2150
Military Specific	11	11	1	10	7	9	15	24	21	16	13	14	9
INA	1594	1771	1838	1867	1664	1736	1729	2067	1770	1928	1706	1854	1860
TOTAL JOB OPENINGS	1717	1830	1911	1984	1613	1748	2074	2405	2335	2269	2097	2207	2236
	3	7	2	1	6	0	8	9	0	5	9	2	9

Source: Online Job Openings Report

	OCT	NOV	DEC	JAN	FEB	MA	APR	MA	JUN	JUL	AUG	SEP	OCT
	2012	2012	2012	2013	2013	R	2013	Y	2013	2013	2013	2013	2013
JOB OPENINGS													
Management	1036	1153	1195	1065	1217	1082	1151	1306	1316	1201	1129	1212	943
Business and Financial Operations	461	502	479	451	479	447	513	436	472	512	553	519	418
Computer and Mathematical	424	622	590	349	551	361	402	370	293	473	336	449	351
Architecture and Engineering	473	524	487	425	645	600	538	503	518	479	504	547	453
Life, Physical, and Social Science	168	150	144	140	211	213	217	132	108	114	130	118	97
Community and Social Service	160	149	149	134	152	171	211	187	256	197	153	211	166
Legal	22	36	31	22	31	18	31	28	43	46	46	41	32
Education, Training, and Library	495	413	366	351	443	592	802	799	894	752	619	535	513
Arts, Design, Entertainment, Sports, and Media	280	248	254	222	274	314	266	307	323	287	364	397	325
Healthcare Practitioners and Technical	1237	1281	1242	1103	1076	936	1092	1111	1211	1105	1078	1212	840
Healthcare Support	460	503	420	428	440	435	431	376	444	446	405	439	329
Protective Service	187	166	219	198	195	196	180	215	184	151	113	157	174
Food Preparation and Serving Related	1443	1629	1364	1281	738	748	818	1481	1146	1036	1274	1382	1319
Building and Grounds Cleaning and Maintenance	909	751	649	559	603	650	765	863	662	606	682	668	479
Personal Care and Service	531	485	464	438	373	296	351	354	364	378	412	365	359
Sales and Related	2764	2501	2233	1886	1650	1589	1854	1915	2330	2200	2103	2020	1999
Office and Administrative Support	2739	2532	1970	2041	1978	1959	1962	1975	2314	2202	2996	3040	2545
Farming, Fishing, and Forestry	252	229	310	578	935	1010	877	553	260	138	292	323	332
Construction and Extraction	1668	1395	1120	1018	1019	1169	1506	1910	1507	1381	1543	1558	1309
Installation, Maintenance, and Repair	1351	1490	1382	1199	1024	1107	1113	1331	1257	1380	1400	1379	1226
Production	1359	1081	1001	967	923	890	989	1059	1316	1233	1433	1481	1206
Transportation and Material Moving	2028	2329	2082	1980	2033	1871	1963	2180	2245	2171	2487	2721	2567
Military Specific	14	8	9	12	26	19	16	7	11	21	14	5	13
INA	1700	1750	1703	1654	1733	1651	1826	1938	2047	1927	1845	2227	1425
TOTAL JOB OPENINGS	2216	2192	1986	1850	1874	1832	1987	2133	2152	2043	2191	2300	1942
	1	7	3	1	9	4	4	6	1	6	1	6	0

Source: Online Job Openings Report

	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
	2013	2013	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014
JOB OPENINGS													
Management	1178	1143	1134	1235	1402	1502	1575	1507	1548	1811	1696	1636	1678
Business and Financial Operations	527	591	499	551	584	564	638	596	632	668	702	727	792
Computer and Mathematical	334	325	289	445	419	378	401	399	426	443	640	579	810
Architecture and Engineering	575	556	503	726	792	892	767	747	733	808	809	869	802
Life, Physical, and Social Science	119	136	135	87	105	121	127	121	162	179	152	157	150
Community and Social Service	212	197	162	156	194	251	270	271	237	247	241	253	218
Legal	36	44	41	46	69	32	43	42	38	63	44	64	56
Education, Training, and Library	485	444	361	592	670	913	902	1079	769	696	437	425	394
Arts, Design, Entertainment, Sports, and Media	310	314	286	325	354	349	371	349	332	440	401	388	321
Healthcare Practitioners and Technical	1151	943	891	1055	1097	1347	1463	1547	1462	1760	1433	1722	1756
Healthcare Support	409	403	354	406	424	428	497	452	439	536	442	490	472
Protective Service	160	153	171	218	249	263	218	218	179	157	202	248	216
Food Preparation and Serving Related	1002	855	734	719	834	1223	1540	1400	1035	1620	1204	1119	1543
Building and Grounds Cleaning and Maintenance	546	507	486	510	716	797	818	844	703	640	615	618	624
Personal Care and Service	436	346	347	317	444	581	553	404	329	627	645	549	492
Sales and Related	2130	1717	1408	1634	1652	1994	2309	2139	2089	2408	2685	2653	2460
Office and Administrative Support	2064	2407	1799	1974	2292	2524	2777	2508	2577	3039	3147	3128	2857
Farming, Fishing, and Forestry	301	302	764	1025	1265	991	625	288	224	423	364	282	265
Construction and Extraction	1371	951	817	1548	1694	2419	2579	2255	1867	1697	1552	1252	1047
Installation, Maintenance, and Repair	1357	1282	1186	1416	1819	1749	1903	1902	1794	1756	1690	1406	1310
Production	1278	1110	1154	1039	1293	1288	1177	1335	1201	1243	1404	1321	1201
Transportation and Material Moving	2132	1843	1769	2218	2294	2517	2916	2781	2512	2979	2972	2722	2302
Military Specific	11	15	10	16	13	18	18	17	25	23	28	19	7
INA	2096	1974	1577	1947	2257	2512	2641	2401	2188	2666	2332	2527	2453
TOTAL JOB OPENINGS	2022	1855	1687	2020	2293	2565	2712	2560	2350	2692	2583	2515	2422
	0	8	7	5	2	3	8	2	1	9	7	4	6

Source: Online Job Openings Report

	DEC	JAN	FEB	MAR	APR	MAY
	2014	2015	2015	2015	2015	2015
JOB OPENINGS						
Management	1583	1431	1437	1668	1886	1921
Business and Financial Operations	621	542	548	598	531	569
Computer and Mathematical	524	449	455	509	534	392
Architecture and Engineering	755	737	726	720	787	827
Life, Physical, and Social Science	146	206	175	185	166	162
Community and Social Service	238	179	219	231	295	283
Legal	51	32	54	55	41	58
Education, Training, and Library	377	420	526	690	850	1088
Arts, Design, Entertainment, Sports, and Media	367	396	383	398	356	328
Healthcare Practitioners and Technical	1896	1598	1786	2127	2177	2176
Healthcare Support	487	432	470	519	470	549
Protective Service	288	217	232	264	284	288
Food Preparation and Serving Related	1247	975	1091	1119	1188	1255
Building and Grounds Cleaning and Maintenance	531	481	406	565	678	707
Personal Care and Service	478	381	374	352	376	608
Sales and Related	2133	1623	1722	1891	2177	2441
Office and Administrative Support	2331	1935	1948	1881	1966	2166
Farming, Fishing, and Forestry	329	797	1226	1475	967	538
Construction and Extraction	957	912	1185	1510	1786	1896
Installation, Maintenance, and Repair	1198	1163	1181	1240	1259	1302
Production	997	862	996	1046	1083	1276
Transportation and Material Moving	2223	1751	1756	1843	2006	2018
Military Specific	17	4	4	4	10	23
INA	2597	2172	2181	2606	2885	2569
TOTAL JOB OPENINGS	22371	19695	21081	23496	24758	25440

Source: Online Job Openings Report

Appendix 8 - Employment in North Dakota

	Agriculture, Forestry, Fishery and Hunting	Construction	Manufacturing	Mining	Other sectors	Retail, Food and Lodging	Utilities	Wholesale Trade and Transportation	Total
2000	2523	16908	24360	3327	150321	67727	15376	28682	309224
2001	2634	16561	24452	3487	151746	67509	16418	28827	311634
2002	2661	16095	24032	3192	153505	67662	16105	28557	311809
2003	2775	16911	23808	3296	155867	67933	15089	28594	314273
2004	2873	18191	25119	3538	157938	68945	15381	29126	321111
2005	2881	18395	26413	4111	160167	70325	16184	29645	328121
2006	2914	19431	26511	4669	163702	71829	16496	30169	335721
2007	3088	20204	26516	5099	166428	72770	16920	30681	341706
2008	3218	21734	26818	6797	169652	73274	16971	31978	350442
2009	3430	21714	23972	6959	171539	73367	16225	32356	349562
2010	3667	22378	22895	10661	175026	74439	15598	34009	358673
2011	3849	25389	24064	16787	177027	76859	16687	38771	379433
2012	4096	30533	25418	24377	182126	81551	17614	45995	411710
2013	4273	33456	25659	26198	186721	84447	17821	48534	427109
2014	4373	35887	26189	29875	191205	87137	18666	51326	444658

Source: Quarterly Census Employment and Wages

Appendix 9 - Employment in North Dakota

	Total employment in jobs
2000	327700
2001	330300
2002	329400
2003	332300
2004	336900
2005	344700
2006	351700
2007	357800
2008	366800
2009	366600
2010	375000
2011	391700
2012	427800
2013	440900
2014	458200

Source: Current Employment Statistics

Appendix 10 - Labor force in North Dakota

	labor force	employed labor force	unemployed labor force	unemployment rate
JAN2000	341986	331490	10496	3,1
FEB2000	341827	331514	10313	3
MAR2000	341737	331592	10145	3
APR2000	341779	331737	10042	2,9
MAY2000	341940	331939	10001	2,9
JUN2000	342191	332171	10020	2,9
JUL2000	342494	332397	10097	2,9
AUG2000	342800	332621	10179	3
SEP2000	343088	332881	10207	3
OCT2000	343349	333208	10141	3
NOV2000	343579	333589	9990	2,9
DEC2000	343781	333977	9804	2,9
JAN2001	343963	334317	9646	2,8
FEB2001	344070	334512	9558	2,8
MAR2001	343973	334426	9547	2,8
APR2001	343597	334014	9583	2,8
MAY2001	342985	333328	9657	2,8
JUN2001	342210	332470	9740	2,8
JUL2001	341376	331554	9822	2,9
AUG2001	340603	330653	9950	2,9
SEP2001	340020	329847	10173	3
OCT2001	339682	329192	10490	3,1
NOV2001	339588	328698	10890	3,2
DEC2001	339689	328352	11337	3,3
JAN2002	339911	328119	11792	3,5
FEB2002	340179	327970	12209	3,6
MAR2002	340445	327903	12542	3,7
APR2002	340657	327898	12759	3,7
MAY2002	340765	327911	12854	3,8
JUN2002	340785	327920	12865	3,8
JUL2002	340751	327916	12835	3,8
AUG2002	340695	327898	12797	3,8
SEP2002	340654	327863	12791	3,8
OCT2002	340655	327816	12839	3,8
NOV2002	340726	327794	12932	3,8
DEC2002	340861	327825	13036	3,8
JAN2003	341065	327942	13123	3,8
FEB2003	341334	328169	13165	3,9
MAR2003	341702	328543	13159	3,9
APR2003	342210	329093	13117	3,8
MAY2003	342883	329847	13036	3,8
JUN2003	343741	330811	12930	3,8
JUL2003	344735	331924	12811	3,7
AUG2003	345787	333086	12701	3,7
SEP2003	346783	334189	12594	3,6
OCT2003	347650	335150	12500	3,6
NOV2003	348353	335947	12406	3,6
DEC2003	348925	336622	12303	3,5

Source: Local Area Unemployment Statistics

	labor force	employed labor force	unemployed labor force	unemployment rate
JAN2004	349414	337227	12187	3,5
FEB2004	349905	337845	12060	3,4
MAR2004	350469	338530	11939	3,4
APR2004	351094	339243	11851	3,4
MAY2004	351759	339925	11834	3,4
JUN2004	352402	340524	11878	3,4
JUL2004	352976	341017	11959	3,4
AUG2004	353455	341402	12053	3,4
SEP2004	353813	341685	12128	3,4
OCT2004	354041	341870	12171	3,4
NOV2004	354148	341973	12175	3,4
DEC2004	354179	342021	12158	3,4
JAN2005	354174	342038	12136	3,4
FEB2005	354160	342040	12120	3,4
MAR2005	354166	342061	12105	3,4
APR2005	354264	342174	12090	3,4
MAY2005	354507	342420	12087	3,4
JUN2005	354877	342782	12095	3,4
JUL2005	355333	343230	12103	3,4
AUG2005	355807	343727	12080	3,4
SEP2005	356264	344243	12021	3,4
OCT2005	356693	344769	11924	3,3
NOV2005	357107	345309	11798	3,3
DEC2005	357530	345867	11663	3,3
JAN2006	357999	346462	11537	3,2
FEB2006	358520	347065	11455	3,2
MAR2006	359065	347623	11442	3,2
APR2006	359596	348120	11476	3,2
MAY2006	360104	348589	11515	3,2
JUN2006	360660	349086	11574	3,2
JUL2006	361349	349682	11667	3,2
AUG2006	362195	350428	11767	3,2
SEP2006	363163	351321	11842	3,3
OCT2006	364162	352305	11857	3,3
NOV2006	365080	353267	11813	3,2
DEC2006	365808	354085	11723	3,2
JAN2007	366312	354692	11620	3,2
FEB2007	366629	355095	11534	3,1
MAR2007	366813	355336	11477	3,1
APR2007	366913	355452	11461	3,1
MAY2007	366980	355496	11484	3,1
JUN2007	367035	355537	11498	3,1
JUL2007	367116	355614	11502	3,1
AUG2007	367296	355765	11531	3,1
SEP2007	367600	356038	11562	3,1
OCT2007	368008	356461	11547	3,1
NOV2007	368498	357044	11454	3,1
DEC2007	369053	357763	11290	3,1
JAN2008	369629	358525	11104	3

Source: Local Area Unemployment Statistics

	labor force	employed labor force	unemployed labor force	unemployment rate
FEB2008	370214	359241	10973	3
MAR2008	370820	359853	10967	3
APR2008	371424	360319	11105	3
MAY2008	371949	360598	11351	3,1
JUN2008	372304	360665	11639	3,1
JUL2008	372384	360518	11866	3,2
AUG2008	372149	360146	12003	3,2
SEP2008	371710	359545	12165	3,3
OCT2008	371214	358750	12464	3,4
NOV2008	370742	357775	12967	3,5
DEC2008	370310	356651	13659	3,7
JAN2009	369912	355471	14441	3,9
FEB2009	369498	354357	15141	4,1
MAR2009	369020	353420	15600	4,2
APR2009	368510	352753	15757	4,3
MAY2009	368041	352387	15654	4,3
JUN2009	367708	352302	15406	4,2
JUL2009	367603	352443	15160	4,1
AUG2009	367758	352761	14997	4,1
SEP2009	368131	353232	14899	4
OCT2009	368732	353850	14882	4
NOV2009	369619	354699	14920	4
DEC2009	370803	355863	14940	4
JAN2010	372219	357320	14899	4
FEB2010	373751	358958	14793	4
MAR2010	375262	360616	14646	3,9
APR2010	376591	362104	14487	3,8
MAY2010	377636	363297	14339	3,8
JUN2010	378402	364187	14215	3,8
JUL2010	378992	364868	14124	3,7
AUG2010	379559	365504	14055	3,7
SEP2010	380232	366235	13997	3,7
OCT2010	381035	367122	13913	3,7
NOV2010	381914	368125	13789	3,6
DEC2010	382803	369149	13654	3,6
JAN2011	383638	370120	13518	3,5
FEB2011	384391	370992	13399	3,5
MAR2011	385108	371773	13335	3,5
APR2011	385895	372543	13352	3,5
MAY2011	386831	373385	13446	3,5
JUN2011	387910	374332	13578	3,5
JUL2011	389056	375377	13679	3,5
AUG2011	390176	376484	13692	3,5
SEP2011	391179	377590	13589	3,5
OCT2011	391994	378624	13370	3,4
NOV2011	392615	379555	13060	3,3
DEC2011	393099	380392	12707	3,2
JAN2012	393552	381179	12373	3,1
FEB2012	394083	381965	12118	3,1

Source: Local Area Unemployment Statistics

	labor force	employed labor force	unemployed labor force	unemployment rate
MAR2012	394731	382768	11963	3
APR2012	395482	383587	11895	3
MAY2012	396336	384435	11901	3
JUN2012	397250	385297	11953	3
JUL2012	398170	386142	12028	3
AUG2012	399061	386949	12112	3
SEP2012	399918	387728	12190	3
OCT2012	400792	388548	12244	3,1
NOV2012	401698	389412	12286	3,1
DEC2012	402618	390286	12332	3,1
JAN2013	403511	391142	12369	3,1
FEB2013	404314	391936	12378	3,1
MAR2013	404997	392659	12338	3
APR2013	405580	393338	12242	3
MAY2013	406079	393999	12080	3
JUN2013	406562	394693	11869	2,9
JUL2013	407090	395444	11646	2,9
AUG2013	407634	396186	11448	2,8
SEP2013	408158	396846	11312	2,8
OCT2013	408619	397368	11251	2,8
NOV2013	409034	397794	11240	2,7
DEC2013	409489	398244	11245	2,7
JAN2014	410099	398833	11266	2,7
FEB2014	410966	399672	11294	2,7
MAR2014	412109	400792	11317	2,7
APR2014	413453	402125	11328	2,7
MAY2014	414873	403539	11334	2,7
JUN2014	416246	404897	11349	2,7
JUL2014	417468	406084	11384	2,7
AUG2014	418538	407097	11441	2,7
SEP2014	419506	407997	11509	2,7
OCT2014	420411	408829	11582	2,8
NOV2014	421216	409565	11651	2,8
DEC2014	421847	410132	11715	2,8
JAN2015	422312	410367	11945	2,8
FEB2015	421879	409466	12413	2,9
MAR2015	421370	408358	13012	3,1

Source: Local Area Unemployment Statistics

Appendix 11 - Employment status of the civilian non-institutional population in North Dakota

Year	Civilian non-institutional population
2000	485.710
2001	484.574
2002	484.594
2003	485.108
2004	487.597
2005	490.814
2006	493.054
2007	494.942
2008	497.394
2009	501.410
2010	506.905
2011	529.048
2012	538.947
2013	552.582
2014	566.267
2015	578.490

Source: Local Area Unemployment Statistics (LAUS)

Appendix 12 - Commuters

	Fraction out-of-state workers employed in ND	Workers employed in North Dakota living in other states	Fraction North Dakota workers employed in other states	North Dakota residents who are employed in other states
2002	0,1001257	27001	0,038	9647
2003	0,1003191	27505	0,039	9893
2004	0,0856983	24067	0,044	11779
2005	0,0846706	24397	0,043	11947
2006	0,0873601	25627	0,041	11358
2007	0,0942549	28115	0,047	13405
2008	0,0997264	30540	0,044	12684
2009	0,1010529	31066	0,044	12690
2010	0,106136	34117	0,043	12931
2011	0,1169629	39755	0,043	13516
2012	0,1345668	50339	0,042	14099

Source: Longitudinal Employer-Household Dynamics, Home Destination Report

Appendix 13 - Potential unemployed job seekers

	unemployed 15+ weeks	discouraged workers	all marginally attached
2003	3.900	800	2.200
2004	3.200	800	2.500
2005	3.000	1.000	1.800
2006	2.600	700	1.500
2007	2.800	500	1.600
2008	2.800	700	1.900
2009	4.500	800	2.600
2010	4.100	800	2.100
2011	4.400	400	2.500
2012	4.000	700	2.600
2013	3.500	800	2.500
2014	3.200	600	3.100

Source: Alternative measurements for labor underutilization, Bureau of Labor Statistics

Appendix 14 - Housing units and household size in North Dakota

	Housing units	Occupied housing units	Vacant housing units	Household size
2000	289677	249612	40065	2,48
2001	292002	249124	42878	2,45
2002	294165	254689	39476	2,4
2003	296959	254464	42495	2,39
2004	300815	262585	38230	2,32
2005	304458	270437	34021	2,25
2006	306982	272352	34630	2,23
2007	310438	271724	38714	2,25
2008	313018	274743	38275	2,24
2009	315625	279014	36611	2,22
2010	318099	280412	37687	2,32
2011	320888	283440	37448	2,32
2012	329249	290944	38305	2,32
2013	339293	298298	40995	2,33

Source: American Community Survey 1-Year Estimates

Appendix 15 - Status of housing units

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total:	34021	34630	38714	38275	36611	37687	37448	38305	40995
For rent	6846	5681	7622	6227	7880	6424	4679	5755	7196
Rented, not occupied	1553	1357	2114	1486	1027	1321	1461	913	1137
For sale only	1655	2425	2028	2870	3508	2800	2409	2441	3036
Sold, not occupied	2379	3344	4151	3925	3109	1850	1434	1302	853
For seasonal, recreational, or occasional use	12293	11805	12178	13511	1192	13082	13249	14204	13445
For migrant workers	113	170	60	275	126	965	350	588	2191
Other vacant	9182	9848	10561	9981	9041	11245	13866	13102	13137

Appendix 16 - Demographics 2000

Age group	Population	
	Male	Female
0-3	15950	14918
4-7	17179	16753
8-11	18526	17393
12-15	20357	18818
16-19	22464	20609
20-24	26918	23730
25-29	20172	18637
30-34	19475	18332
35-39	23776	23971
40-44	25748	25146
45-49	24470	23298
50-54	19426	18270
55-59	14316	14304
60-64	12024	12623
65 plus	39894	54703

Source: Census 2000

Appendix 17 - Population

	Population
2000	642023
2001	639062
2002	638168
2003	638817
2004	644705
2005	646089
2006	649422
2007	652822
2008	657569
2009	664968
2010	674345
2011	685242
2012	701705
2013	723857
2014	739482

source: U.S. Census Bureau

Appendix 18 - Migration

	Immigration	Emigration	Net migration	Foreign immigration
2005	18594	21147	-2553	2706
2006	26260	25155	1105	2654
2007	22399	21057	1342	4179
2008	26746	24344	2402	4022
2009	29970	21343	8627	2209
2010	30100	24450	5650	3568
2011	32510	26563	5947	2832
2012	38213	23959	14254	3325
2013	38908	29808	9100	3155

Appendix 19 - Mean vacancy duration

Mean Vacancy Duration (Number of Working Days)								
By Industry and Time Period								
	2001 to 2003	2004 to 2005	2006	2008	2009	2010 to 2012	2013	Jan. 2014-June 2014
Resources	12.0	12.1	17.8	17.9	13.7	18.9	18.9	20.1
Construction	7.8	7.9	10.1	7.3	4.5	6.2	9.8	11.0
Manufacturing	17.4	19.4	24.2	21.5	13.6	23.5	28.3	29.2
Wholesale and Retail Trade	14.2	15.4	16.5	15.3	13.2	15.9	19.9	18.4
Warehouse, Trans. & Utilities	18.5	15.4	21.1	20.8	10.5	18.1	22.4	22.2
Information	25.9	31.7	45.2	34.5	24.8	41.1	36.4	38.9
Financial Services	28.0	31.0	34.7	27.6	25.7	33.8	35.6	37.0
Professional and Business Services	18.2	20.0	19.9	21.4	16.4	18.8	19.5	20.7
Education	21.2	24.1	26.4	22.5	18.3	20.8	23.4	24.2
Health Services	39.1	34.6	38.3	36.3	29.8	33.6	34.9	36.4
Leisure and Hospitality	13.8	14.2	16.2	14.9	10.6	13.4	16.7	20.1
Other Services	22.3	17.5	20.3	23.8	17.1	18.6	20.1	19.2
Government	32.9	29.7	32.6	35.9	32.2	33.1	35.5	36.7
Non-Farm	19.2	19.2	21.7	21.0	16.7	20.0	22.5	23.5

Source: Dice Hiring Indicators

Appendix 20 - Multiple jobs holding

	Multiple jobs holdings
2000	0,100
2001	0,099
2002	0,092
2003	0,097
2004	0,101
2005	0,099
2006	0,084
2007	0,087
2008	0,097
2009	0,098
2010	0,089
2011	0,090
2012	0,080
2013	0,079

Source: Current Population Survey

Appendix 21 - US average employee tenure per industry 2004-2014

		January	January	January	January	January	January
Sectors	Industries	2004	2006	2008	2010	2012	2014
Agriculture, Forestry, Fishery and Hunting	Agriculture and related industries	3,7	3,8	4,3	4,8	4,1	3,6
Construction	Construction	3	3	3,5	4,2	4,3	3,9
Manufacturing	Manufacturing	5,8	5,5	5,9	6,1	6	5,9
Mining	Mining, quarrying, and oil and gas extraction	5,2	3,8	4,1	4,8	3,5	4
Other sectors	Arts, entertainment, and recreation	2,8	3,1	2,8	3,3	3,1	3
	Information	4,3	4,8	4,7	5	5,4	4,8
	Financial activities	3,9	4	4,5	4,6	4,9	5
	Professional and business services	3,2	3,2	3,1	3,4	3,8	3,6
	Education and health services	3,6	4	4,1	4,1	4,4	4,5
	Other services	3,3	3,2	3,3	4	3,8	4
	Public sector	6,9	6,9	7,2	7,2	7,8	7,8
Retail, Food and Lodging	Retail trade	2,8	2,8	2,9	3,3	3,3	3,3
	Accommodation and food services	1,9	1,6	1,9	2,3	2,3	2,1
Utilities	Utilities	13,3	10,4	10,1	9,1	9,5	9,2
Wholesale, trade and transportation	Wholesale trade	4,3	4,6	5	5,2	5,5	5,8
	Transportation and warehousing	4,7	4,3	4,6	5	5,3	4,7

Source: Bureau of Labor Statistics

Appendix 22 - Working hours and wages

Working hours	Construction	Education and health care	Financial activities	Goods producing	Leisure and hospitality	Manufacturing	Private service providing	Professional and Business services	Total private	Trade, transportation and utilities	
May 2007	42	30,5	35,9	41,6	21,3	40,8	31,2	34,4	33,1	34,3	
May 2008	41,9	31,2	35,8	39	22,1	37,4	31,3	35,4	32,7	33,6	
May 2009	38,8	30,5	35,8	38,5	21,2	37,4	30,5	31,7	31,9	33,7	
May 2010	37,6	31,3	37,7	39	22,1	38,7	31,5	34	32,9	34,7	
May 2011	39	33,2	35,1	39,1	22,4	39,1	32,9	37	34,2	35,4	
May 2012	43,3	33,1	35,7	42,2	23,3	41,6	32,8	38	35	34,8	
May 2013	41,7	33,1	36,2	41,2	23,4	40,8	33,8	39	35,5	36,9	
May 2014	45,2	31,6	36,7	43,3	23,6	39,3	32,9	39,2	35,4	35,7	
Hourly wage	Construction	Education and health services	Financial Activities	Goods producing	Leisure and hospitality	Manufacturing	Other services	Private service providing	Professional and Business Services	Total private	Trade, transportation and utilities
May 2007	21,33	18,26	17,99	19,49	9,69	17,43	15,73	17,83	19,22	18,2	18,98
May 2008	19,12	17,92	17,12	19,97	10,19	18,66	12,99	17,82	21,54	18,3	18,97
May 2009	20,01	19,05	17,82	21,39	10,57	19,54	15,11	18,38	22,6	19,02	18,86
May 2010	20,21	21,49	19,41	21,89	11,02	20,11	16,02	19,72	23,39	20,2	19,96
May 2011	23,59	23,12	19,8	23,27	11,26	19,99	17,49	20,69	24,25	21,29	20,98
May 2012	25,1	23,17	20,15	24,12	12,09	21,42	18,65	21,85	26,87	22,48	22,04
May 2013	27,25	23,07	22,49	25,86	12,88	22,25	20,48	22,64	27,46	23,51	22,85
May 2014	27,89	23,56	24	27,38	13,22	23,07	22,57	23,71	28,37	24,78	24,9

Source: Current Employment Statistics

Appendix 23 - Average weeks unemployed in the U.S.

	Average Weeks Unemployed						
2000M01	13,1	2004M03	19,8	2008M05	16,6	2012M07	39,2
2000M02	12,6	2004M04	19,6	2008M06	17,1	2012M08	39,4
2000M03	12,7	2004M05	19,8	2008M07	17	2012M09	39,7
2000M04	12,4	2004M06	20,5	2008M08	17,7	2012M10	39,9
2000M05	12,6	2004M07	18,8	2008M09	18,6	2012M11	39
2000M06	12,3	2004M08	18,8	2008M10	19,9	2012M12	37,8
2000M07	13,4	2004M09	19,4	2008M11	18,9	2013M01	35,5
2000M08	12,9	2004M10	19,5	2008M12	19,9	2013M02	36,7
2000M09	12,2	2004M11	19,7	2009M01	19,8	2013M03	36,9
2000M10	12,7	2004M12	19,4	2009M02	20,2	2013M04	36,5
2000M11	12,4	2005M01	19,5	2009M03	20,9	2013M05	36,9
2000M12	12,5	2005M02	19,1	2009M04	21,7	2013M06	35,9
2001M01	12,7	2005M03	19,5	2009M05	22,4	2013M07	37,1
2001M02	12,8	2005M04	19,6	2009M06	23,9	2013M08	37,4
2001M03	12,8	2005M05	18,6	2009M07	25,1	2013M09	37,2
2001M04	12,4	2005M06	17,9	2009M08	25,3	2013M10	35,5
2001M05	12,1	2005M07	17,6	2009M09	26,6	2013M11	36,8
2001M06	12,7	2005M08	18,4	2009M10	27,5	2013M12	36,8
2001M07	12,9	2005M09	17,9	2009M11	28,9	2014M01	35,3
2001M08	13,3	2005M10	17,9	2009M12	29,7	2014M02	36,9
2001M09	13,2	2005M11	17,5	2010M01	30,3	2014M03	35,2
2001M10	13,3	2005M12	17,5	2010M02	29,8	2014M04	34,8
2001M11	14,3	2006M01	16,9	2010M03	31,6	2014M05	34,3
2001M12	14,5	2006M02	17,8	2010M04	33,3	2014M06	33,3
2002M01	14,7	2006M03	17,1	2010M05	34	2014M07	32,5
2002M02	15	2006M04	16,7	2010M06	34,5	2014M08	31,9
2002M03	15,4	2006M05	17,1	2010M07	33,9	2014M09	31,8
2002M04	16,3	2006M06	16,6	2010M08	33,7	2014M10	32,9
2002M05	16,8	2006M07	17,1	2010M09	33,4	2014M11	33
2002M06	16,9	2006M08	17,1	2010M10	34	2014M12	32,8
2002M07	16,9	2006M09	17,1	2010M11	33,9	2015M01	32,3
2002M08	16,5	2006M10	16,3	2010M12	34,7	2015M02	31,7
2002M09	17,6	2006M11	16,2	2011M01	37,3	2015M03	30,7
2002M10	17,8	2006M12	16,1	2011M02	37,4	2015M04	30,8
2002M11	17,6	2007M01	16,3	2011M03	39,1	2015M05	30,7
2002M12	18,5	2007M02	16,7	2011M04	38,7	2015M06	28,1
2003M01	18,5	2007M03	17,8	2011M05	39,5		
2003M02	18,5	2007M04	16,9	2011M06	39,8		
2003M03	18,1	2007M05	16,6	2011M07	40,6		
2003M04	19,4	2007M06	16,5	2011M08	40,4		
2003M05	19	2007M07	17,2	2011M09	40,4		
2003M06	19,9	2007M08	17	2011M10	38,8		
2003M07	19,7	2007M09	16,3	2011M11	40,2		

2003M08	19,2	2007M10	17	2011M12	40,5		
2003M09	19,5	2007M11	17,3	2012M01	40,3		
2003M10	19,3	2007M12	16,6	2012M02	39,9		
2003M11	19,9	2008M01	17,5	2012M03	39,3		
2003M12	19,8	2008M02	16,9	2012M04	39,3		
2004M01	19,9	2008M03	16,5	2012M05	39,5		
2004M02	20,1	2008M04	16,9	2012M06	40,1		

Source: Current Population Survey

Appendix 24 - Equations

$job_seekers_by_sector[sector, employment_status](t) = job_seekers_by_sector[sector, employment_status](t - dt) + (new_job_seekers[sector, employment_status] - job_seekers_hired[sector, employment_status]) * dt$
 INIT $job_seekers_by_sector[sector, employment_status] = total_job_seekers_per_sector_INIT$

INFLOWS:

$new_job_seekers[sector, employment_status] = total_new_job_seekers[employment_status]*distribution_factors_new_applications$

OUTFLOWS:

$job_seekers_hired[sector, employment_status] = hiring_rate_of_employed_job_seekers[sector]*factor_employed[employment_status]+hiring_rate_of_unemployed_job_seekers[sector]*factor_local_unemployed[employment_status]+hiring_rate_of_out_of_state_job_seekers[sector]*factor_out_of_state[employment_status]$

$local_not_in_the_labor_force(t) = local_not_in_the_labor_force(t - dt) + (local_additions_to_NIL + additions_from_temporary_population_not_employed - additions_to_labor_force - exit_rate_not_in_labor_force) * dt$

INIT $local_not_in_the_labor_force = civ_noninstitutional_population_16_to_65-$

$local_unemployed_labor_force-local_employed_labor_force-temporary_employment_in_ND-temporary_population_not_employed$

INFLOWS:

$local_additions_to_NIL = total_aging_16*fraction_civilian_non_institutional_population_DATA$

$additions_from_temporary_population_not_employed = exit_rate_of_temporary_population_not_employed-return_migration_not_employed$

OUTFLOWS:

$additions_to_labor_force = (local_labor_force_adjustment+additions_for_correction_labor_force)$

$exit_rate_not_in_labor_force = local_exit_rate_NIL$

$distribution_employed_job_seekers[sector](t) = distribution_employed_job_seekers[sector](t - dt) + (adj_distribution_hiring_of_employed[sector]) * dt$

INIT $distribution_employed_job_seekers[sector] = distribution_demand_for_employed_job_seekers$

INFLOWS:

$adj_distribution_hiring_of_employed[sector] = (SMTH1(distribution_demand_for_employed_job_seekers, time_to_perceive_labor_market_information)-distribution_employed_job_seekers)/time_to_adjust_distribution_job_seekers$

$distribution_out_of_state_job_seekers[sector](t) = distribution_out_of_state_job_seekers[sector](t - dt) + (adj_distribution_hiring_of_out_of_state[sector]) * dt$

INIT $distribution_out_of_state_job_seekers[sector] = distribution_demand_for_out_of_state_job_seekers$

INFLOWS:

$adj_distribution_hiring_of_out_of_state[sector] = (SMTH1(distribution_demand_for_out_of_state_job_seekers, time_to_perceive_labor_market_information)-distribution_out_of_state_job_seekers)/time_to_adjust_distribution_out_of_state_job_seekers$

$distribution_unemployed_job_seekers[sector](t) = distribution_unemployed_job_seekers[sector](t - dt) + (adj_distribution_hiring_of_unemployed[sector]) * dt$

INIT $distribution_unemployed_job_seekers[sector] = distribution_demand_for_unemployed_job_seekers$

INFLOWS:

$adj_distribution_hiring_of_unemployed[sector] = (SMTH1(distribution_demand_for_unemployed_job_seekers, time_to_perceive_labor_market_information)-distribution_unemployed_job_seekers)/time_to_adjust_distribution_job_seekers$

$employed_job_seekers[sector](t) = employed_job_seekers[sector](t - dt) +$

$(new_employed_job_seekers[sector] - hiring_employed_job_seekers[sector]) * dt$

INIT $employed_job_seekers[sector] = employed_job_seekers_INIT$

INFLOWS:

$new_employed_job_seekers[sector] = (desired_employed_job_seekers-employed_job_seekers)/time_to_adjust_job_seekers+SMTH1(hiring_employed_job_seekers, time_to_adjust_job_seekers)*0+hiring_employed_job_seekers$

OUTFLOWS:

$hiring_employed_job_seekers[sector] = hired_by_own_sector+hired_by_other_sectors$

$employment_in_jobs[sector](t) = employment_in_jobs[sector](t - dt) + (hiring_rate[sector] - destruction_rate[sector] - attrition_rate[sector]) * dt$

INIT $employment_in_jobs[sector] = employment_DATA$

INFLOWS:

$hiring_rate[sector] = \text{SUM}(job_seekers_hired[sector, *]) / \text{persons_per_job}$
OUTFLOWS:
 $destruction_rate[sector] = job_destruction$
 $attrition_rate[sector] = (hiring_employed_job_seekers + quit_rate) / \text{persons_per_job}$
 $expected_relative_time_to_find_a_job_ratio(t) = expected_relative_time_to_find_a_job_ratio(t - dt) + (adj_of_exp_relative_time_to_find_a_job) * dt$
INIT $expected_relative_time_to_find_a_job_ratio = relative_time_to_find_a_job_ratio$
INFLOWS:
 $adj_of_exp_relative_time_to_find_a_job = (relative_time_to_find_a_job_ratio - expected_relative_time_to_find_a_job_ratio) / \text{time_to_adjust_expectations}$
 $filled_jobs[sector](t) = filled_jobs[sector](t - dt) + (vacancies_filled[sector] - new_vacancies_for_replacement[sector] - job_destruction[sector]) * dt$
INIT $filled_jobs[sector] = employment_DATA$
INFLOWS:
 $vacancies_filled[sector] = \text{SUM}(job_seekers_hired[sector, *]) / \text{persons_per_job}$
OUTFLOWS:
 $new_vacancies_for_replacement[sector] = attrition_rate$
 $job_destruction[sector] = \text{IF } desired_job_adjustment < 0 \text{ THEN } -desired_job_adjustment \text{ ELSE } 0$
 $fractional_return_migration(t) = fractional_return_migration(t - dt) + (change_in_fractional_return_migration) * dt$
INIT $fractional_return_migration = normal_fractional_return_migration$
INFLOWS:
 $change_in_fractional_return_migration = (desired_fractional_return_migration - fractional_return_migration) / \text{time_to_adjust_fractional_return_migration}$
 $local_employed_labor_force(t) = local_employed_labor_force(t - dt) + (hiring_rate_unemployed + additions_from_temporary_employed - exit_rate_of_local_employed - firing_rate) * dt$
INIT $local_employed_labor_force = employed_labor_force_DATA - temporary_employment_in_ND$
INFLOWS:
 $hiring_rate_unemployed = local_hiring_rate_unemployed + new_ND_commuters_out_of_state$
 $additions_from_temporary_employed = exit_rate_of_temporary_employment$
OUTFLOWS:
 $exit_rate_of_local_employed = local_exit_rate_employed_labor_force + (1 - unemployment_rate) * emigration_of_workers$
 $firing_rate = \text{SUM}(job_destruction[*]) * \text{persons_per_job} + quit_rate_of_ND_workers_out_of_state$
 $local_labor_force_participation_rate(t) = local_labor_force_participation_rate(t - dt) + (change_in_labor_force_participation_rate) * dt$
INIT $local_labor_force_participation_rate = goal_local_labor_force_participation_rate$
INFLOWS:
 $change_in_labor_force_participation_rate = \text{IF } goal_local_labor_force_participation_rate > local_labor_force_participation_rate \text{ THEN } (goal_local_labor_force_participation_rate - local_labor_force_participation_rate) / \text{time_to_increase_labor_force_participation_rate} \text{ ELSE } (goal_local_labor_force_participation_rate - local_labor_force_participation_rate) / \text{time_to_decrease_labor_force_participation_rate}$
 $local_unemployed_labor_force(t) = local_unemployed_labor_force(t - dt) + (additions_to_labor_force + firing_rate - hiring_rate_unemployed - exit_rate_of_local_unemployed) * dt$
INIT $local_unemployed_labor_force = unemployed_labor_force_DATA$
INFLOWS:
 $additions_to_labor_force = (local_labor_force_adjustment + additions_for_correction_labor_force)$
 $firing_rate = \text{SUM}(job_destruction[*]) * \text{persons_per_job} + quit_rate_of_ND_workers_out_of_state$
OUTFLOWS:
 $hiring_rate_unemployed = local_hiring_rate_unemployed + new_ND_commuters_out_of_state$
 $exit_rate_of_local_unemployed = unemployment_rate * emigration_of_workers$
 $ND_commuters_employed_out_of_state(t) = ND_commuters_employed_out_of_state(t - dt) + (new_ND_commuters_out_of_state - quit_rate_of_ND_workers_out_of_state) * dt$
INIT $ND_commuters_employed_out_of_state = additions_to_out_of_state_workers_employed_in_ND * desired_years_of_commuting * EQ_switch_for_population + ND_commuters_employed_in_other_states_DATA_EST * (1 - EQ_switch_for_population)$
INFLOWS:
 $new_ND_commuters_out_of_state = hiring_rate_of_ND_workers_out_of_state - emigration_of_workers$

OUTFLOWS:

quit_rate_of_ND_workers_out_of_state =
ND_commuters_employed_out_of_state/desired_years_of_commuting
ND_job_seekers_out_of_state(t) = ND_job_seekers_out_of_state(t - dt) +
(additions_to_ND_job_seekers_out_of_state - hiring_rate_of_ND_workers_out_of_state) * dt
INIT ND_job_seekers_out_of_state =
hiring_of_ND_workers_in_other_states_INIT*time_to_find_job_in_US*(1-
EQ_switch_for_population)+hiring_of_ND_workers_in_other_states_EQ*time_to_find_job_in_US*(EQ_swit
ch_for_population)

INFLOWS:

additions_to_ND_job_seekers_out_of_state =
new_ND_job_seekers_in_other_states+new_job_seekers_outside_ND_from_temp_population

OUTFLOWS:

hiring_rate_of_ND_workers_out_of_state = ND_job_seekers_out_of_state/time_to_find_job_in_US*(1-
EQ_switch_for_population)+ND_job_seekers_out_of_state/init(time_to_find_job_in_US)*(EQ_switch_for
_population)

out_of_state_commuters_employed_in_ND(t) = out_of_state_commuters_employed_in_ND(t - dt) +
(new_out_of_state_commuters_in_ND - quit_rate_of_out_of_state_commuters_in_ND) * dt

INIT out_of_state_commuters_employed_in_ND = out_of_state_commuters_employed_in_ND_DATA_EST

INFLOWS:

new_out_of_state_commuters_in_ND = out_of_state_hiring_rate-immigration_of_workers

OUTFLOWS:

quit_rate_of_out_of_state_commuters_in_ND =
out_of_state_commuters_employed_in_ND/desired_years_of_commuting
out_of_state_job_seekers(t) = out_of_state_job_seekers(t - dt) + (additions_to_out_of_state_job_seekers -
out_of_state_hiring_rate) * dt

INIT out_of_state_job_seekers = SUM(out_of_state_job_seekers_INIT[*])

INFLOWS:

additions_to_out_of_state_job_seekers =
normal_additions_to_out_of_state_job_seekers*effect_of_time_to_find_a_job_on_out_of_state_job_seekers*(
1-
EQ_switch_for_population)+EQ_switch_for_population*effect_of_time_to_find_a_job_on_out_of_state_job
_seekers*normal_additions_to_out_of_state_job_seekers

OUTFLOWS:

out_of_state_hiring_rate = SUM(hiring_rate_of_out_of_state_job_seekers[*])
perceived_time_to_find_a_job_in_US(t) = perceived_time_to_find_a_job_in_US(t - dt) +
(adj_perc_average_weeks_unemployed_US) * dt

INIT perceived_time_to_find_a_job_in_US = time_to_find_a_job_US

INFLOWS:

adj_perc_average_weeks_unemployed_US = (time_to_find_a_job_US-
perceived_time_to_find_a_job_in_US)/time_to_perceive_labor_market_information

perceived_time_to_find_a_job_for_employed[sector](t) =
perceived_time_to_find_a_job_for_employed[sector](t - dt) +
(adjustment_in_perc_time_to_find_a_job[sector]) * dt

INIT perceived_time_to_find_a_job_for_employed[sector] = time_to_find_a_job_for_employed_in_weeks

INFLOWS:

adjustment_in_perc_time_to_find_a_job[sector] = (time_to_find_a_job_for_employed_in_weeks-
perceived_time_to_find_a_job_for_employed)/time_to_perceive_labor_market_information
perceived_time_to_find_a_job_for_unemployed(t) = perceived_time_to_find_a_job_for_unemployed(t - dt) +
(adjustment_in_perc_time_to_find_a_job_for_unemployed) * dt

INIT perceived_time_to_find_a_job_for_unemployed = time_to_find_a_job_for_unemployed_in_weeks

INFLOWS:

adjustment_in_perc_time_to_find_a_job_for_unemployed = (time_to_find_a_job_for_unemployed_in_weeks-
perceived_time_to_find_a_job_for_unemployed)/time_to_perceive_labor_market_information
population_below_16[From_0_to_3, Male](t) = population_below_16[From_0_to_3, Male](t - dt) +
(births[age_group_below_16, sex] + in_below_16[age_group_below_16, sex] +
immigration_below_16[age_group_below_16, sex] - out_below_16[age_group_below_16, sex] -
emigration_below_16[age_group_below_16, sex] - deaths_below_16[age_group_below_16, sex]) * dt

INIT population_below_16[From_0_to_3, Male] = 15950*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Male]*ye
ars_per_age_group_below_19

population_below_16[From_0_to_3, Female](t) = population_below_16[From_0_to_3, Female](t - dt) +
(births[age_group_below_16, sex] + in__below_16[age_group_below_16, sex] +
immigration__below_16[age_group_below_16, sex] - out__below_16[age_group_below_16, sex] -
emigration__below_16[age_group_below_16, sex] - deaths_below_16[age_group_below_16, sex]) * dt
INIT population_below_16[From_0_to_3, Female] = 14918*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Female]*
years_per_age_group_below_19

population_below_16[From_4_to_7, Male](t) = population_below_16[From_4_to_7, Male](t - dt) +
(births[age_group_below_16, sex] + in__below_16[age_group_below_16, sex] +
immigration__below_16[age_group_below_16, sex] - out__below_16[age_group_below_16, sex] -
emigration__below_16[age_group_below_16, sex] - deaths_below_16[age_group_below_16, sex]) * dt
INIT population_below_16[From_4_to_7, Male] = 17179*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Male]*ye
ars_per_age_group_below_19

population_below_16[From_4_to_7, Female](t) = population_below_16[From_4_to_7, Female](t - dt) +
(births[age_group_below_16, sex] + in__below_16[age_group_below_16, sex] +
immigration__below_16[age_group_below_16, sex] - out__below_16[age_group_below_16, sex] -
emigration__below_16[age_group_below_16, sex] - deaths_below_16[age_group_below_16, sex]) * dt
INIT population_below_16[From_4_to_7, Female] = 16753*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Female]*
years_per_age_group_below_19

population_below_16[From_8_to_11, Male](t) = population_below_16[From_8_to_11, Male](t - dt) +
(births[age_group_below_16, sex] + in__below_16[age_group_below_16, sex] +
immigration__below_16[age_group_below_16, sex] - out__below_16[age_group_below_16, sex] -
emigration__below_16[age_group_below_16, sex] - deaths_below_16[age_group_below_16, sex]) * dt
INIT population_below_16[From_8_to_11, Male] = 18526*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Male]*ye
ars_per_age_group_below_19

population_below_16[From_8_to_11, Female](t) = population_below_16[From_8_to_11, Female](t - dt) +
(births[age_group_below_16, sex] + in__below_16[age_group_below_16, sex] +
immigration__below_16[age_group_below_16, sex] - out__below_16[age_group_below_16, sex] -
emigration__below_16[age_group_below_16, sex] - deaths_below_16[age_group_below_16, sex]) * dt
INIT population_below_16[From_8_to_11, Female] = 17393*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Female]*
years_per_age_group_below_19

population_below_16[From_12_to_15, Male](t) = population_below_16[From_12_to_15, Male](t - dt) +
(births[age_group_below_16, sex] + in__below_16[age_group_below_16, sex] +
immigration__below_16[age_group_below_16, sex] - out__below_16[age_group_below_16, sex] -
emigration__below_16[age_group_below_16, sex] - deaths_below_16[age_group_below_16, sex]) * dt
INIT population_below_16[From_12_to_15, Male] = 20357*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Male]*ye
ars_per_age_group_below_19

population_below_16[From_12_to_15, Female](t) = population_below_16[From_12_to_15, Female](t - dt) +
(births[age_group_below_16, sex] + in__below_16[age_group_below_16, sex] +
immigration__below_16[age_group_below_16, sex] - out__below_16[age_group_below_16, sex] -
emigration__below_16[age_group_below_16, sex] - deaths_below_16[age_group_below_16, sex]) * dt

INIT population_below_16[From_12_to_15, Female] = 18818*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Female]*
years_per_age_group_below_19

INFLOWS:

births[From_0_to_3, Male] = total_births*fraction_births_per_sex[Male]

births[From_0_to_3, Female] = total_births*fraction_births_per_sex[Female]

births[From_4_to_7, Male] = 0

births[From_4_to_7, Female] = 0

births[From_8_to_11, Male] = 0

births[From_8_to_11, Female] = 0

births[From_12_to_15, Male] = 0

births[From_12_to_15, Female] = 0

in__below_16[From_0_to_3, Male] = 0

in__below_16[From_0_to_3, Female] = 0

in__below_16[From_4_to_7, Male] = out__below_16[From_0_to_3, Male]

in__below_16[From_4_to_7, Female] = out__below_16[From_0_to_3, Female]

in__below_16[From_8_to_11, Male] = out__below_16[From_4_to_7, Male]

in__below_16[From_8_to_11, Female] = out__below_16[From_4_to_7, Female]

in__below_16[From_12_to_15, Male] = out__below_16[From_8_to_11, Male]

in__below_16[From_12_to_15, Female] = out__below_16[From_8_to_11, Female]

immigration__below_16[age_group_below_16, sex] =

(total_immigration_by_sex[sex]*distribution_migration__below_16[age_group_below_16])

OUTFLOWS:

out__below_16[age_group_below_16, sex] = population_below_16/years_per_age_group_below_19

emigration__below_16[age_group_below_16, sex] =

(total_emigration_by_sex[sex]*distribution_migration__below_16[age_group_below_16])

deaths_below_16[age_group_below_16, sex] = population_below_16*fractional__death_rate_below_16*(1-
EQ_switch_for_population)

population__16_to_65[From_16_to_19, Male](t) = population__16_to_65[From_16_to_19, Male](t - dt) +

(aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +

immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -

emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt

INIT population__16_to_65[From_16_to_19, Male] = 22464*(1-

EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Male]*ye
ars_per_age_group_below_19

population__16_to_65[From_16_to_19, Female](t) = population__16_to_65[From_16_to_19, Female](t - dt) +

(aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +

immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -

emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt

INIT population__16_to_65[From_16_to_19, Female] = 20609

*(1-

EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Female]*
years_per_age_group_below_19

population__16_to_65[From_20_to_24, Male](t) = population__16_to_65[From_20_to_24, Male](t - dt) +

(aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +

immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -

emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt

INIT population__16_to_65[From_20_to_24, Male] = 26918*(1-

EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Male]*ye
ars_per_age_group_20_to_64

population__16_to_65[From_20_to_24, Female](t) = population__16_to_65[From_20_to_24, Female](t - dt) +

(aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +

immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -

emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt

INIT population__16_to_65[From_20_to_24, Female] = 23730

*(1-

EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Female]*
years_per_age_group_20_to_64

INIT population__16_to_65[From_40_to_44, Male] = 25748
 *(1-
 EQ_switch__for_population)+EQ_switch__for_population*EQ_population_by__single_year_and_sex[Male]*ye
 ars_per_age__group_20_to_64

population__16_to_65[From_40_to_44, Female](t) = population__16_to_65[From_40_to_44, Female](t - dt) +
 (aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +
 immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -
 emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt
 INIT population__16_to_65[From_40_to_44, Female] = 25146
 *(1-
 EQ_switch__for_population)+EQ_switch__for_population*EQ_population_by__single_year_and_sex[Female]*
 years_per_age__group_20_to_64

population__16_to_65[From_45_to_49, Male](t) = population__16_to_65[From_45_to_49, Male](t - dt) +
 (aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +
 immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -
 emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt
 INIT population__16_to_65[From_45_to_49, Male] = 24470
 *(1-
 EQ_switch__for_population)+EQ_switch__for_population*EQ_population_by__single_year_and_sex[Male]*ye
 ars_per_age__group_20_to_64

population__16_to_65[From_45_to_49, Female](t) = population__16_to_65[From_45_to_49, Female](t - dt) +
 (aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +
 immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -
 emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt
 INIT population__16_to_65[From_45_to_49, Female] = 23298
 *(1-
 EQ_switch__for_population)+EQ_switch__for_population*EQ_population_by__single_year_and_sex[Female]*
 years_per_age__group_20_to_64

population__16_to_65[From_50_to_54, Male](t) = population__16_to_65[From_50_to_54, Male](t - dt) +
 (aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +
 immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -
 emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt
 INIT population__16_to_65[From_50_to_54, Male] = 19426
 *(1-
 EQ_switch__for_population)+EQ_switch__for_population*EQ_population_by__single_year_and_sex[Male]*ye
 ars_per_age__group_20_to_64

population__16_to_65[From_50_to_54, Female](t) = population__16_to_65[From_50_to_54, Female](t - dt) +
 (aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +
 immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -
 emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt
 INIT population__16_to_65[From_50_to_54, Female] = 18270
 *(1-
 EQ_switch__for_population)+EQ_switch__for_population*EQ_population_by__single_year_and_sex[Female]*
 years_per_age__group_20_to_64

population__16_to_65[From_55_to_59, Male](t) = population__16_to_65[From_55_to_59, Male](t - dt) +
 (aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +
 immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -
 emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt
 INIT population__16_to_65[From_55_to_59, Male] = 14316

*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Male]*ye
ars_per_age__group_20_to_64

population__16_to_65[From_55_to_59, Female](t) = population__16_to_65[From_55_to_59, Female](t - dt) +
(aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +
immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -
emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt
INIT population__16_to_65[From_55_to_59, Female] = 14304

*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Female]*
years_per_age__group_20_to_64

population__16_to_65[From_60_to_64, Male](t) = population__16_to_65[From_60_to_64, Male](t - dt) +
(aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +
immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -
emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt
INIT population__16_to_65[From_60_to_64, Male] = 12024

*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Male]*ye
ars_per_age__group_20_to_64

population__16_to_65[From_60_to_64, Female](t) = population__16_to_65[From_60_to_64, Female](t - dt) +
(aging_16[age_group_16_to_65, sex] + in_16__to_65[age_group_16_to_65, sex] +
immigration__16_to_65[age_group_16_to_65, sex] - out_16_to_65[age_group_16_to_65, sex] -
emigration__16_to_65[age_group_16_to_65, sex] - deaths_16_to_65[age_group_16_to_65, sex]) * dt
INIT population__16_to_65[From_60_to_64, Female] = 12623

*(1-
EQ_switch_for_population)+EQ_switch_for_population*EQ_population_by__single_year_and_sex[Female]*
years_per_age__group_20_to_64

INFLOWS:

aging_16[From_16_to_19, Male] = out__below_16[From_12_to_15, Male]
aging_16[From_16_to_19, Female] = out__below_16[From_12_to_15, Female]
aging_16[From_20_to_24, Male] = 0
aging_16[From_20_to_24, Female] = 0
aging_16[From_25_to_29, Male] = 0
aging_16[From_25_to_29, Female] = 0
aging_16[From_30_to_34, Male] = 0
aging_16[From_30_to_34, Female] = 0
aging_16[From_35_to_39, Male] = 0
aging_16[From_35_to_39, Female] = 0
aging_16[From_40_to_44, Male] = 0
aging_16[From_40_to_44, Female] = 0
aging_16[From_45_to_49, Male] = 0
aging_16[From_45_to_49, Female] = 0
aging_16[From_50_to_54, Male] = 0
aging_16[From_50_to_54, Female] = 0
aging_16[From_55_to_59, Male] = 0
aging_16[From_55_to_59, Female] = 0
aging_16[From_60_to_64, Male] = 0
aging_16[From_60_to_64, Female] = 0
in_16__to_65[From_16_to_19, Male] = 0
in_16__to_65[From_16_to_19, Female] = 0
in_16__to_65[From_20_to_24, Male] = out_16_to_65[From_16_to_19, Male]
in_16__to_65[From_20_to_24, Female] = out_16_to_65[From_16_to_19, Female]
in_16__to_65[From_25_to_29, Male] = out_16_to_65[From_20_to_24, Male]
in_16__to_65[From_25_to_29, Female] = out_16_to_65[From_20_to_24, Female]

in_16_to_65[From_30_to_34, Male] = out_16_to_65[From_25_to_29, Male]
 in_16_to_65[From_30_to_34, Female] = out_16_to_65[From_25_to_29, Female]
 in_16_to_65[From_35_to_39, Male] = out_16_to_65[From_30_to_34, Male]
 in_16_to_65[From_35_to_39, Female] = out_16_to_65[From_30_to_34, Female]
 in_16_to_65[From_40_to_44, Male] = out_16_to_65[From_35_to_39, Male]
 in_16_to_65[From_40_to_44, Female] = out_16_to_65[From_35_to_39, Female]
 in_16_to_65[From_45_to_49, Male] = out_16_to_65[From_40_to_44, Male]
 in_16_to_65[From_45_to_49, Female] = out_16_to_65[From_40_to_44, Female]
 in_16_to_65[From_50_to_54, Male] = out_16_to_65[From_45_to_49, Male]
 in_16_to_65[From_50_to_54, Female] = out_16_to_65[From_45_to_49, Female]
 in_16_to_65[From_55_to_59, Male] = out_16_to_65[From_50_to_54, Male]
 in_16_to_65[From_55_to_59, Female] = out_16_to_65[From_50_to_54, Female]
 in_16_to_65[From_60_to_64, Male] = out_16_to_65[From_55_to_59, Male]
 in_16_to_65[From_60_to_64, Female] = out_16_to_65[From_55_to_59, Female]
 immigration__16_to_65[age_group_16_to_65, sex] =
 (total_immigration_by_sex[sex]*distribution_migration__16_to_65_DATA[age_group_16_to_65])

OUTFLOWS:

out_16_to_65[From_16_to_19, Male] = population__16_to_65[From_16_to_19, Male]/years_per_age__group_below_19
 out_16_to_65[From_16_to_19, Female] = population__16_to_65[From_16_to_19, Female]/years_per_age__group_below_19
 out_16_to_65[From_20_to_24, Male] = population__16_to_65[From_20_to_24, Male]/years_per_age__group_20_to_64
 out_16_to_65[From_20_to_24, Female] = population__16_to_65[From_20_to_24, Female]/years_per_age__group_20_to_64
 out_16_to_65[From_25_to_29, Male] = population__16_to_65[From_25_to_29, Male]/years_per_age__group_20_to_64
 out_16_to_65[From_25_to_29, Female] = population__16_to_65[From_25_to_29, Female]/years_per_age__group_20_to_64
 out_16_to_65[From_30_to_34, Male] = population__16_to_65[From_30_to_34, Male]/years_per_age__group_20_to_64
 out_16_to_65[From_30_to_34, Female] = population__16_to_65[From_30_to_34, Female]/years_per_age__group_20_to_64
 out_16_to_65[From_35_to_39, Male] = population__16_to_65[From_35_to_39, Male]/years_per_age__group_20_to_64
 out_16_to_65[From_35_to_39, Female] = population__16_to_65[From_35_to_39, Female]/years_per_age__group_20_to_64
 out_16_to_65[From_40_to_44, Male] = population__16_to_65[From_40_to_44, Male]/years_per_age__group_20_to_64
 out_16_to_65[From_40_to_44, Female] = population__16_to_65[From_40_to_44, Female]/years_per_age__group_20_to_64
 out_16_to_65[From_45_to_49, Male] = population__16_to_65[From_45_to_49, Male]/years_per_age__group_20_to_64
 out_16_to_65[From_45_to_49, Female] = population__16_to_65[From_45_to_49, Female]/years_per_age__group_20_to_64
 out_16_to_65[From_50_to_54, Male] = population__16_to_65[From_50_to_54, Male]/years_per_age__group_20_to_64
 out_16_to_65[From_50_to_54, Female] = population__16_to_65[From_50_to_54, Female]/years_per_age__group_20_to_64
 out_16_to_65[From_55_to_59, Male] = population__16_to_65[From_55_to_59, Male]/years_per_age__group_20_to_64
 out_16_to_65[From_55_to_59, Female] = population__16_to_65[From_55_to_59, Female]/years_per_age__group_20_to_64
 out_16_to_65[From_60_to_64, Male] = population__16_to_65[From_60_to_64, Male]/years_per_age__group_20_to_64
 out_16_to_65[From_60_to_64, Female] = population__16_to_65[From_60_to_64, Female]/years_per_age__group_20_to_64
 emigration__16_to_65[age_group_16_to_65, sex] =
 (total_emigration_by_sex[sex]*distribution_migration__16_to_65_DATA[age_group_16_to_65])

$deaths_{16_to_65}[age_group_{16_to_65}, sex] =$
 $population_{16_to_65} * fractional_death_rate_{16_to_65}[age_group_{16_to_65}] * (1 - EQ_switch_for_population)$
 $population_{65_plus}[Male](t) = population_{65_plus}[Male](t - dt) + (aging_{65}[sex] +$
 $immigration_{65_plus}[sex] - deaths_{65_plus}[sex] - emigration_{65_plus}[sex]) * dt$
 INIT $population_{65_plus}[Male] = 39894$
 $*(1 -$
 $EQ_switch_for_population) + EQ_switch_for_population * EQ_population_by_single_year_and_sex[Male] * E$
 $Q_life_expectancy_at_{65}$
 $population_{65_plus}[Female](t) = population_{65_plus}[Female](t - dt) + (aging_{65}[sex] +$
 $immigration_{65_plus}[sex] - deaths_{65_plus}[sex] - emigration_{65_plus}[sex]) * dt$
 INIT $population_{65_plus}[Female] = 54703$
 $*(1 -$
 $EQ_switch_for_population) + EQ_switch_for_population * EQ_population_by_single_year_and_sex[Female] * E$
 $Q_life_expectancy_at_{65}$
 INFLOWS:
 $aging_{65}[sex] = out_{16_to_65}[From_{60_to_64}, sex]$
 $immigration_{65_plus}[sex] = total_immigration_by_sex * distribution_migration_{65_plus}$
 OUTFLOWS:
 $deaths_{65_plus}[Male] = population_{65_plus}[Male] * fractional_death_rate_{65_plus} * (1 -$
 $EQ_switch_for_population) + EQ_switch_for_population * population_{65_plus}[Male] / EQ_life_expectancy_a$
 t_{65}
 $deaths_{65_plus}[Female] = population_{65_plus}[Female] * fractional_death_rate_{65_plus} * (1 -$
 $EQ_switch_for_population) + EQ_switch_for_population * population_{65_plus}[Female] / EQ_life_expectancy$
 $_at_{65}$
 $emigration_{65_plus}[sex] = total_emigration_by_sex * distribution_migration_{65_plus}$
 $qualified_fraction_employed[sector](t) = qualified_fraction_employed[sector](t - dt) +$
 $(change_in_standard_for_employed[sector]) * dt$
 INIT $qualified_fraction_employed[sector] = goal_for_qualified_fraction_employed$
 INFLOWS:
 $change_in_standard_for_employed[sector] = (goal_for_qualified_fraction_employed -$
 $qualified_fraction_employed) / time_to_adjust_standards_employed$
 $qualified_fraction_out_of_state[sector](t) = qualified_fraction_out_of_state[sector](t - dt) +$
 $(change_in_standard_for_out_of_state[sector]) * dt$
 INIT $qualified_fraction_out_of_state[sector] = goal_for_qualified_fraction_out_of_state$
 INFLOWS:
 $change_in_standard_for_out_of_state[sector] = (goal_for_qualified_fraction_out_of_state -$
 $qualified_fraction_out_of_state) / time_to_adjust_standard_out_of_state$
 $qualified_fraction_unemployed[sector](t) = qualified_fraction_unemployed[sector](t - dt) +$
 $(change_in_standard_for_unemployed[sector]) * dt$
 INIT $qualified_fraction_unemployed[sector] = goal_for_qualified_fraction_unemployed$
 INFLOWS:
 $change_in_standard_for_unemployed[sector] = (goal_for_qualified_fraction_unemployed -$
 $qualified_fraction_unemployed) / time_to_adjust_standard_unemployed$
 $temporary_population_not_employed(t) = temporary_population_not_employed(t - dt) +$
 $(immigration_of_household_members_{16_to_65} - exit_rate_of_temporary_population_not_employed) * dt$
 INIT $temporary_population_not_employed = immigration_of_NIL_INIT * duration_of_temporary_status_in_use$
 INFLOWS:
 $immigration_of_household_members_{16_to_65} = total_immigration_{16_to_65} - immigration_of_workers$
 OUTFLOWS:
 $exit_rate_of_temporary_population_not_employed =$
 $temporary_population_not_employed / duration_of_temporary_status_in_use$
 $temporary_employment_in_ND(t) = temporary_employment_in_ND(t - dt) + (immigration_of_workers -$
 $exit_rate_of_temporary_employment) * dt$
 INIT $temporary_employment_in_ND = temporary_employment_in_ND_INIT$
 INFLOWS:
 $immigration_of_workers = MIN(desired_immigration_of_workers,$
 $max_immigration_of_households / households_per_migrant_worker)$
 OUTFLOWS:
 $exit_rate_of_temporary_employment = temporary_employment_in_ND / duration_of_temporary_status_in_use$

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vacant__jobs[sector](t) = vacant__jobs[sector](t - dt) + (new_vacancies_for__job_creation[sector] +
new_vacancies_for_replacement[sector] - vacancies_filled[sector]) * dt
INIT vacant__jobs[sector] = vacant_jobs_DATA
INFLOWS:
new_vacancies_for__job_creation[sector] = IF desired_job__adjustment>0 THEN desired_job__adjustment
ELSE 0
new_vacancies_for_replacement[sector] = attrition_rate
OUTFLOWS:
vacancies_filled[sector] = SUM(job_seekers__hired[sector, *])/persons_per_job
additions_for_correction_labor_force = exit_rate_of_local__employed-
additions_from__temporary_employed+exit_rate_of_local__unemployed
additions_to_commuters_from_ND_to_other_states = quit_rate_ND_workers_in_other_states
additions_to_out_of_state_workers_employed_in_ND = quit_rate__out_of_state_workers
age_65 = 65
amount_of_single_years = 20
attrition_due_to_job_change[sector] = attrition_rate_INIT-hiring_of_unemployed_and_out_of_state_EQ
attrition_rate_INIT[sector] = init(employment__DATA)/employee__tenure_DATA*persons_per_job
average_annual_wage = SUM(Wage__determination.annual_wage[*])/8
average_annual_wage_2000 = init(average_annual_wage)
average_annual_wage_ratio = average_annual_wage/average_annual_wage_2000
average_selfemployed_or_non_paid_DATA = 44793
average__household_size = average__household_size_DATA*(1-
EQ_switch__for_population)+EQ_switch__for_population*init(average__household_size_DATA)
average__household_size_DATA = GRAPH(TIME)
(2000, 2.48), (2001, 2.45), (2002, 2.40), (2003, 2.39), (2004, 2.32), (2005, 2.25), (2006, 2.23), (2007, 2.25),
(2008, 2.24), (2009, 2.22), (2010, 2.32), (2011, 2.32), (2012, 2.32), (2013, 2.33)
average__weeks_unemployed_US_DATA = GRAPH(TIME)
(2000, 13.1), (2000, 12.6), (2000, 12.7), (2000, 12.4), (2000, 12.6), (2000, 12.3), (2001, 13.4), (2001, 12.9),
(2001, 12.2), (2001, 12.7), (2001, 12.4), (2001, 12.5), (2001, 12.7), (2001, 12.8), (2001, 12.8), (2001, 12.4),
(2001, 12.1), (2001, 12.7), (2002, 12.9), (2002, 13.3), (2002, 13.2), (2002, 13.3), (2002, 14.3), (2002, 14.5),
(2002, 14.7), (2002, 15.0), (2002, 15.4), (2002, 16.3), (2002, 16.8), (2002, 16.9), (2003, 16.9), (2003, 16.5),
(2003, 17.6), (2003, 17.8), (2003, 17.6), (2003, 18.5), (2003, 18.5), (2003, 18.5), (2003, 18.1), (2003, 19.4),
(2003, 19.0), (2003, 19.9), (2004, 19.7), (2004, 19.2), (2004, 19.5), (2004, 19.3), (2004, 19.9), (2004, 19.8),
(2004, 19.9), (2004, 20.1), (2004, 19.8), (2004, 19.6), (2004, 19.8), (2004, 20.5), (2005, 18.8), (2005, 18.8),
(2005, 19.4), (2005, 19.5), (2005, 19.7), (2005, 19.4), (2005, 19.5), (2005, 19.1), (2005, 19.5), (2005, 19.6),
(2005, 18.6), (2005, 17.9), (2006, 17.6), (2006, 18.4), (2006, 17.9), (2006, 17.9), (2006, 17.5), (2006, 17.5),
(2006, 16.9), (2006, 17.8), (2006, 17.1), (2006, 16.7), (2006, 17.1), (2006, 16.6), (2007, 17.1), (2007, 17.1),
(2007, 17.1), (2007, 16.3), (2007, 16.2), (2007, 16.1), (2007, 16.3), (2007, 16.7), (2007, 17.8), (2007, 16.9),
(2007, 16.6), (2007, 16.5), (2008, 17.2), (2008, 17.0), (2008, 16.3), (2008, 17.0), (2008, 17.3), (2008, 16.6),
(2008, 17.5), (2008, 16.9), (2008, 16.5), (2008, 16.9), (2008, 16.6), (2008, 17.1), (2009, 17.0), (2009, 17.7),
(2009, 18.6), (2009, 19.9), (2009, 18.9), (2009, 19.9), (2009, 19.8), (2009, 20.2), (2009, 20.9), (2009, 21.7),
(2009, 22.4), (2009, 23.9), (2010, 25.1), (2010, 25.3), (2010, 26.6), (2010, 27.5), (2010, 28.9), (2010, 29.7),
(2010, 30.3), (2010, 29.8), (2010, 31.6), (2010, 33.3), (2010, 34.0), (2010, 34.5), (2011, 33.9), (2011, 33.7),
(2011, 33.4), (2011, 34.0), (2011, 33.9), (2011, 34.7), (2011, 37.3), (2011, 37.4), (2011, 39.1), (2011, 38.7),
(2011, 39.5), (2011, 39.8), (2012, 40.6), (2012, 40.4), (2012, 40.4), (2012, 38.8), (2012, 40.2), (2012, 40.5),
(2012, 40.3), (2012, 39.9), (2012, 39.3), (2012, 39.3), (2012, 39.5), (2012, 40.1), (2013, 39.2), (2013, 39.4),
(2013, 39.7), (2013, 39.9), (2013, 39.0), (2013, 37.8), (2013, 35.5), (2013, 36.7), (2013, 36.9), (2013, 36.5),
(2013, 36.9), (2013, 35.9), (2014, 37.1), (2014, 37.4), (2014, 37.2), (2014, 35.5), (2014, 36.8), (2014, 36.8),
(2014, 35.3), (2014, 36.9), (2014, 35.2), (2014, 34.8), (2014, 34.3), (2014, 33.3), (2015, 32.5), (2015, 31.9),
(2015, 31.8), (2015, 32.9), (2015, 33.0), (2015, 32.8), (2015, 32.3), (2015, 31.7), (2015, 30.7), (2015, 30.8),
(2015, 30.7), (2015, 28.1)
capacity_for__households = housing_units_available_for_households*households__per_house
civ_noninstitutional_population_16_to_65 =
population__15_to_65*fraction_civilian_non_institutional_population_DATA
civ_population__16_to_65 = labor_force+not_in_the_labor_force
desired_employed__job_seekers[sector] = employment_in_jobs*fraction_on_the_job_search
desired_fractional__return_migration =
normal_fractional_return__migration*effect_of_time_to_find_a_job_for_unemployed_on_return_migration
desired_fraction_hiring_rate__of_employed[sector] = init(attrition_due_to_job_change)/init(attrition_rate_INIT)

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desired_hiring_of_unemployed_job_seekers[sector] =
remaining_desired_hiring_rate*normal_fraction_hiring_of_unemployed_of_residual_vacancies
desired_hiring_rate_of_employed_job_seekers[sector] =
desired_hiring_rate*desired_fraction_hiring_rate_of_employed
desired_hiring_rate_of_out_of_state_job_seekers[sector] = remaining_desired_hiring_rate-
hiring_rate_of_unemployed_job_seekers
desired_immigration_of_workers = out_of_state_hiring_rate*fraction_out_of_state_workers_desire_to_migrate
desired_jobs[sector] =
desired_total_vacant_and_filled_jobs_DATA_til_2014*switch_for_growth_in_labor_demand+(1-
switch_for_growth_in_labor_demand)*init(total_vacant_and_filled_jobs_DATA)
desired_job_adjustment[sector] = gap_in_jobs/time_to_adjust_vacant_jobs
desired_labor_force_participation_rate =
normal_local_labor_force_participation_rate*effect_of_wage_on_labor_force_participation_rate*effect_of_time
_to_find_a_job_on_labor_force_participation_rate
desired_total_vacant_and_filled_jobs_DATA_til_2014[AG] = GRAPH(TIME)
(2000, 2725), (2001, 2845), (2002, 2874), (2003, 2997), (2004, 3103), (2005, 3111), (2006, 3197), (2007, 3452),
(2008, 3755), (2009, 3857), (2010, 3961), (2011, 4327), (2012, 4626), (2013, 4887), (2014, 5081), (2015, 5312),
(2016, 5554), (2017, 5807), (2018, 6071), (2019, 6347), (2020, 6636)
desired_total_vacant_and_filled_jobs_DATA_til_2014[CO] = GRAPH(TIME)
(2000, 17334), (2001, 16978), (2002, 16378), (2003, 17183), (2004, 18526), (2005, 18790), (2006, 19937),
(2007, 20843), (2008, 22570), (2009, 22131), (2010, 22970), (2011, 26497), (2012, 31871), (2013, 34665),
(2014, 37361), (2015, 39467), (2016, 41693), (2017, 44044), (2018, 46527), (2019, 49151), (2020, 51922)
desired_total_vacant_and_filled_jobs_DATA_til_2014[MA] = GRAPH(TIME)
(2000, 24823), (2001, 24917), (2002, 24404), (2003, 24140), (2004, 25577), (2005, 26968), (2006, 27161),
(2007, 27274), (2008, 27713), (2009, 24349), (2010, 23502), (2011, 25090), (2012, 26869), (2013, 27082),
(2014, 27814), (2015, 28041), (2016, 28270), (2017, 28501), (2018, 28733), (2019, 28968), (2020, 29204)
desired_total_vacant_and_filled_jobs_DATA_til_2014[MI] = GRAPH(TIME)
(2000, 3411), (2001, 3575), (2002, 3248), (2003, 3349), (2004, 3603), (2005, 4199), (2006, 4832), (2007, 5391),
(2008, 7445), (2009, 7268), (2010, 11132), (2011, 17685), (2012, 25449), (2013, 27168), (2014, 31049), (2015,
36355), (2016, 42567), (2017, 49841), (2018, 58358), (2019, 68331), (2020, 80007)
desired_total_vacant_and_filled_jobs_DATA_til_2014[OS] = GRAPH(TIME)
(2000, 155117), (2001, 156587), (2002, 157347), (2003, 159536), (2004, 161836), (2005, 164569), (2006,
168476), (2007, 171577), (2008, 175222), (2009, 175274), (2010, 178733), (2011, 182560), (2012, 190421),
(2013, 194515), (2014, 200624), (2015, 204345), (2016, 208135), (2017, 211995), (2018, 215926), (2019,
219930), (2020, 224009)
desired_total_vacant_and_filled_jobs_DATA_til_2014[RFL] = GRAPH(TIME)
(2000, 70253), (2001, 70027), (2002, 69540), (2003, 69791), (2004, 71068), (2005, 72747), (2006, 74190),
(2007, 75054), (2008, 75470), (2009, 74808), (2010, 76222), (2011, 79395), (2012, 84951), (2013, 87566),
(2014, 90589), (2015, 92249), (2016, 93940), (2017, 95661), (2018, 97414), (2019, 99199), (2020, 101017)
desired_total_vacant_and_filled_jobs_DATA_til_2014[U] = GRAPH(TIME)
(2000, 15867), (2001, 16942), (2002, 16508), (2003, 15444), (2004, 15761), (2005, 16629), (2006, 16949),
(2007, 17384), (2008, 17435), (2009, 16481), (2010, 15931), (2011, 17244), (2012, 18416), (2013, 18565),
(2014, 19517), (2015, 19808), (2016, 20103), (2017, 20403), (2018, 20707), (2019, 21015), (2020, 21328)
desired_total_vacant_and_filled_jobs_DATA_til_2014[WTT] = GRAPH(TIME)
(2000, 29427), (2001, 29576), (2002, 29157), (2003, 29190), (2004, 29827), (2005, 30439), (2006, 31077),
(2007, 31720), (2008, 33196), (2009, 33068), (2010, 35085), (2011, 40667), (2012, 48472), (2013, 50953),
(2014, 54149), (2015, 56560), (2016, 59078), (2017, 61708), (2018, 64456), (2019, 67325), (2020, 70322)
desired_years_of_commuting = 3
desired_hiring_rate[sector] = vacant_jobs/des_time_to_recruit*persons_per_job
desired_local_labor_force = total_local_civ_population_16_to_65*local_labor_force_participation_rate
des_time_to_recruit[sector] = ((1-
switch_for_growth_in_labor_demand)*EQ_time_to_recruit+switch_for_growth_in_labor_demand*normal_time
_to_recruit_in_US_DATA)
distribution_employed_job_seekers[sector] = employed_job_seekers/SUM(employed_job_seekers)
distribution_by_sex[Male] = total_population_by_sex[Male]/SUM(total_population_by_sex[*])
distribution_by_sex[Female] = total_population_by_sex[Female]/SUM(total_population_by_sex[*])
distribution_demand_for_employed_job_seekers[sector] =
desired_hiring_rate_of_employed_job_seekers/SUM(desired_hiring_rate_of_employed_job_seekers)
distribution_demand_for_out_of_state_job_seekers[sector] =
desired_hiring_rate_of_out_of_state_job_seekers/SUM(desired_hiring_rate_of_out_of_state_job_seekers)

```

distribution_demand_for_unemployed_job_seekers[sector] =
desired_hiring_of_unemployed_job_seekers/SUM(desired_hiring_of_unemployed_job_seekers)
distribution_factors_new_applications[sector, employment_status] =
distribution_employed_job_seekers[sector]*factor_employed[employment_status]+distribution_unemployed_jo
b_seekers[sector]*factor_local__unemployed[employment_status]+distribution_out_of_state_job_seekers[sector
]*factor__out_of_state[employment_status]
distribution_hiring_of_unemploye_and_out_of_state_INIT[sector] =
hiring_of_unemployed_and_out_of_state_EQ/SUM(hiring_of_unemployed_and_out_of_state_EQ)
distribution_job_seekers_on_employment_status[Unemployed] =
local_unemployed__labor_force/total_searching__labor_force
distribution_job_seekers_on_employment_status[Employed] =
SUM(employed__job_seekers[*])/total_searching__labor_force
distribution_job_seekers_on_employment_status[Out_of_state] =
out_of_state__job_seekers/total_searching__labor_force
distribution_migration__16_to_65_DATA[From_16_to_19] = 0.192
distribution_migration__16_to_65_DATA[From_20_to_24] = 0.239
distribution_migration__16_to_65_DATA[From_25_to_29] = 0.130
distribution_migration__16_to_65_DATA[From_30_to_34] = 0.069
distribution_migration__16_to_65_DATA[From_35_to_39] = 0.049
distribution_migration__16_to_65_DATA[From_40_to_44] = 0.030
distribution_migration__16_to_65_DATA[From_45_to_49] = 0.038
distribution_migration__16_to_65_DATA[From_50_to_54] = 0.029
distribution_migration__16_to_65_DATA[From_55_to_59] = 0.026
distribution_migration__16_to_65_DATA[From_60_to_64] = 0.018
distribution_migration__65_plus = 0.027
distribution_migration__below_16[From_0_to_3] = 0.049
distribution_migration__below_16[From_4_to_7] = 0.037
distribution_migration__below_16[From_8_to_11] = 0.033
distribution_migration__below_16[From_12_to_15] = 0.033
distribution_residual_job_seekers[sector] = IF residual_max_hiring_of_employed_job_seekers=0 THEN 0
ELSE residual_max_hiring_of_employed_job_seekers/SUM(residual_max_hiring_of_employed_job_seekers)
duration_of_temporary_status_in_use = (EQ_switch__for_population*duration_of__temporary_status_EQ+(1-
EQ_switch__for_population)*duration_of__temporary_status)
duration_of__temporary_status = 3
duration_of__temporary_status_EQ = 1/52
effect_of_on_the_job_search[sector] = LOOKUP(graphical_function_time_to_find_a_job_on_job_search,
time_to_find__a_job_for_employed_ratio)
effect_of_time_to_find_a_job_for_unemployed_on_return_migration =
GRAPH(time_to_find__a_job_for_unemployed_ratio)
(0.00, 0.5), (0.2, 0.521), (0.4, 0.574), (0.6, 0.667), (0.8, 0.798), (1.00, 1.00), (1.20, 1.24), (1.40, 1.40), (1.60,
1.47), (1.80, 1.50), (2.00, 1.50)
effect_of_time_to_find_a_job_on_labor_force_participation_rate =
GRAPH(time_to_find__a_job_for_unemployed_ratio)
(0.6, 1.10), (0.65, 1.10), (0.7, 1.09), (0.75, 1.08), (0.8, 1.08), (0.85, 1.06), (0.9, 1.05), (0.95, 1.03), (1.00, 1.00),
(1.05, 0.986), (1.10, 0.976), (1.15, 0.968), (1.20, 0.962), (1.25, 0.958), (1.30, 0.953), (1.35, 0.95), (1.40, 0.95)
effect_of_time_to_find_a_job_on_ND_job_search_out_of_state =
GRAPH(exp_relative_time_to_find_a_job_ratio_compared_to_2000)
(1.00, 1.00), (1.05, 1.02), (1.10, 1.04), (1.15, 1.07), (1.20, 1.10), (1.25, 1.14), (1.30, 1.18), (1.35, 1.23), (1.40,
1.28), (1.45, 1.37), (1.50, 1.50)
effect_of_time_to_find_a_job_on_out_of_state_job_seekers =
GRAPH(exp_relative_time_to_find_a_job_ratio_compared_to_2000)
(0.5, 3.00), (0.533, 2.67), (0.567, 2.38), (0.6, 2.16), (0.633, 1.97), (0.667, 1.80), (0.7, 1.65), (0.733, 1.52), (0.767,
1.43), (0.8, 1.34), (0.833, 1.28), (0.867, 1.21), (0.9, 1.16), (0.933, 1.10), (0.967, 1.04), (1.00, 1.00)
effect_of_wage_on_labor_force_participation_rate = GRAPH(average_annual_wage_ratio)
(1.00, 1.00), (1.04, 1.00), (1.08, 1.01), (1.12, 1.01), (1.16, 1.03), (1.20, 1.04), (1.24, 1.06), (1.28, 1.08), (1.32,
1.09), (1.36, 1.10), (1.40, 1.10)
effect_wages__on_the_job_search[sector] =
LOOKUP(graphical_function_effect_wages_on_on_the_job_search,relative_wage_ratio)
emigration__households = emigration__of_workers*households_per__migrant_worker

```

emigration__of_workers =
 hiring_rate_of_ND_workers_out_of_state*fraction_workers_hired_in_other_states_desire_to_migrate
 employed_in_North_Dakota = employed_labor_force+out_of_state_commuters_employed_in_ND
 employed_job_seekers_available_for_selection[sector] =
 init(desired_hiring_rate_of_employed_job_seekers)/normal_standard_for_qualified_fraction_of_employed_applicants
 employed_labor_force = local_employed_labor_force+temporary__employment_in_ND
 employed_labor_force_DATA = GRAPH(TIME)
 (1995, 327896), (1996, 336411), (1997, 341605), (1998, 340726), (1999, 332111), (2000, 331939), (2001, 333328), (2002, 327911), (2003, 329847), (2004, 339925), (2005, 342420), (2006, 348589), (2007, 355496), (2008, 360598), (2009, 352387), (2010, 363297), (2011, 373385), (2012, 384435), (2013, 393999), (2014, 403539)
 employed_job_seekers_INIT[sector] = employed_job_seekers_available_for_selection*des_time__to_recruit
 employee_tenure[sector] = employment_in_jobs/attrition_rate
 employee__tenure_DATA[AG] = 3.7
 employee__tenure_DATA[CO] = 3
 employee__tenure_DATA[MA] = 5.8
 employee__tenure_DATA[MI] = 5.2
 employee__tenure_DATA[OS] = 4
 employee__tenure_DATA[RFL] = 2.4
 employee__tenure_DATA[U] = 13.3-5
 employee__tenure_DATA[WTT] = 4.5
 employment__DATA[AG] = GRAPH(TIME)
 (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), (2014, 4373)
 employment__DATA[CO] = GRAPH(TIME)
 (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), (2014, 35887)
 employment__DATA[MA] = GRAPH(TIME)
 (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), (2014, 26189)
 employment__DATA[MI] = GRAPH(TIME)
 (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), (2014, 29875)
 employment__DATA[OS] = GRAPH(TIME)
 (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), (2014, 191205)
 employment__DATA[RFL] = GRAPH(TIME)
 (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), (2014, 87137)
 employment__DATA[U] = GRAPH(TIME)
 (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), (2014, 18666)
 employment__DATA[WTT] = GRAPH(TIME)
 (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), (2014, 51326)
 employment__DATA_1[AG] = GRAPH(TIME)
 (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), (2014, 4373)
 employment__DATA_1[CO] = GRAPH(TIME)
 (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), (2014, 35887)
 employment__DATA_1[MA] = GRAPH(TIME)

(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), (2014, 26189)

employment__DATA_1[MI] = GRAPH(TIME)
(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), (2014, 29875)

employment__DATA_1[OS] = GRAPH(TIME)
(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), (2014, 191205)

employment__DATA_1[RFL] = GRAPH(TIME)
(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), (2014, 87137)

employment__DATA_1[U] = GRAPH(TIME)
(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), (2014, 18666)

employment__DATA_1[WTT] = GRAPH(TIME)
(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), (2014, 51326)

employment__distribution[sector] = employment_in_jobs/SUM(employment_in_jobs)
employment__distribution_INIT[sector] = init(employment__DATA)/init(total__employment_DATA)
equilibrium_switch = 0
EQ_average_weeks_unemployed_US = init(perceived_time__to_find_a_job_for_unemployed)
EQ_fractional_birth_rate_20_to_39 =
SUM(EQ_population_by__single_year_and_sex[*])/EQ_woman_20_to_39
EQ_life__expectancy = 85
EQ_life__expectancy_at_65 = EQ_life__expectancy-age_65
EQ_population_by__single_year_and_sex[sex] =
population__2000_DATA/EQ_life__expectancy*fraction_births__per_sex
EQ_switch_for_population = equilibrium_switch
EQ_time__to_recruit[sector] = init(vacant_jobs_DATA)/init(vacancies_to_fill_EQ)
EQ_woman_20_to_39 = EQ_population_by__single_year_and_sex[Female]*amount_of_single_years
excess_capacity_for_housing_population = capacity_for__households-households_in_ND
expected_relative_time_to_find_a_job_in_ND_2000 = init(expected_relative_time_to_find_a_job_ratio)
exp_relative_time_to_find_a_job_ratio_compared_to_2000 =
expected_relative_time_to_find_a_job_ratio/expected_relative_time_to_find_a_job_in_ND_2000
factor_employed[Unemployed] = 0
factor_employed[Employed] = 1
factor_employed[Out_of_state] = 0
factor_local_unemployed[Unemployed] = 1
factor_local_unemployed[Employed] = 0
factor_local_unemployed[Out_of_state] = 0
factor__out_of_state[Unemployed] = 0
factor__out_of_state[Employed] = 0
factor__out_of_state[Out_of_state] = 1
fractional_birth_rate_female_20_to_39 = 0.095638951
fractional_death_rate_16_to_65[From_16_to_19] = 0.000701

fractional_death_rate_16_to_65[From_20_to_24] = 0.000701

fractional_death_rate_16_to_65[From_25_to_29] = 0.000741

fractional_death_rate_16_to_65[From_30_to_34] = 0.000741

fractional_death_rate_16_to_65[From_35_to_39] = 0.001616

fractional_death_rate_16_to_65[From_40_to_44] = 0.001616

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fractional_death_rate_16_to_65[From_45_to_49] = 0.00305

fractional_death_rate_16_to_65[From_50_to_54] = 0.00305

fractional_death_rate_16_to_65[From_55_to_59] = 0.008118

fractional_death_rate_16_to_65[From_60_to_64] = 0.008118

fractional_death_rate__65_plus = 0.040855362

fractional__death_rate_below_16 = 0.000229
fraction_births__per_sex[Male] = 0.51
fraction_births__per_sex[Female] = 0.49
fraction_civilian_non_institutional_population_DATA = 0.967908474
fraction_housing_units_available_for_occupation_population = 0.951
fraction_multiple__job_holders_of__employed_labor_force_DATA = 0.094631579
fraction_ND_jobs_filled_by_out_of_state_workers =
out_of_state_commuters_employed_in_ND/persons_per_job/SUM(employment_in_jobs[*])
fraction_ND_jobs_filled_by_out_of_state_workers_DATA = GRAPH(TIME)
(2002, 0.1), (2003, 0.1), (2004, 0.0857), (2005, 0.0847), (2006, 0.0874), (2007, 0.0943), (2008, 0.0997), (2009,
0.101), (2010, 0.106), (2011, 0.117), (2012, 0.135)
fraction_ND_workers_employed_in_other_states =
ND_commuters_employed_out_of_state/employed_labor_force
fraction_ND_workers_employed_in_other_states_DATA = GRAPH(TIME)
(2002, 0.038), (2003, 0.039), (2004, 0.044), (2005, 0.043), (2006, 0.041), (2007, 0.047), (2008, 0.044), (2009,
0.044), (2010, 0.043), (2011, 0.043), (2012, 0.042)
fraction_of_ND_job_search_out_of_state =
normal_fraction_of_ND_job_search_in_other_states*effect_of_time_to_find_a_job_on_ND_job_search_out_of
_state
fraction_on_the_job_search[sector] =
normal_fraction_job_seekers_per_job*effect_of_on_the_job_search*effect_wages__on_the_job_search
fraction_out_of_state_applications_accepted_of_total = SUM(job_seekers__hired[*],
Out_of_state))/SUM(job_seekers__hired[*], *)
fraction_out_of_state_resumes_as_total_resumes_online_DATA = GRAPH(TIME)
(2008, 0.0837), (2009, 0.0858), (2009, 0.0923), (2009, 0.0861), (2009, 0.094), (2009, 0.0895), (2009, 0.0963),
(2009, 0.0929), (2009, 0.126), (2009, 0.108), (2009, 0.0986), (2009, 0.0963), (2009, 0.111), (2010, 0.109),
(2010, 0.109), (2010, 0.107), (2010, 0.103), (2010, 0.109), (2010, 0.115), (2010, 0.117), (2010, 0.124), (2010,
0.118), (2010, 0.116), (2010, 0.128), (2010, 0.131), (2011, 0.146), (2011, 0.145), (2011, 0.132), (2011, 0.148),
(2011, 0.139), (2011, 0.155), (2011, 0.162), (2011, 0.172), (2011, 0.173), (2011, 0.2), (2011, 0.212), (2011,
0.187), (2012, 0.244), (2012, 0.209), (2012, 0.223), (2012, 0.22), (2012, 0.289), (2012, 0.333), (2012, 0.342),
(2012, 0.282), (2012, 0.264), (2012, 0.266), (2012, 0.263), (2012, 0.262), (2012, 0.258), (2013, 0.252), (2013,
0.243), (2013, 0.236), (2013, 0.226), (2013, 0.216), (2013, 0.206), (2013, 0.202), (2013, 0.204), (2013, 0.201),
(2013, 0.193), (2013, 0.177), (2013, 0.197), (2014, 0.202), (2014, 0.209), (2014, 0.204), (2014, 0.182), (2014,
0.174), (2014, 0.172), (2014, 0.171), (2014, 0.178), (2014, 0.202), (2014, 0.212), (2014, 0.204), (2014, 0.188),
(2015, 0.18), (2015, 0.176), (2015, 0.162), (2015, 0.162), (2015, 0.159), (2015, 0.156), (2015, 0.148), (2015,
0.153), (2015, 0.149), (2015, 0.153)
fraction_out_of_state_workers_desire_to_migrate =
normal_fraction_out_of_state_workers_desire_to_migrate_normal
fraction_selection_procedures_completed[sector] = SUM(job_seekers__hired[sector, *])/desired__hiring_rate
fraction_time_spend_in_state_of_work = 0.5
fraction_workers_hired_from_other_industries[sector] =
hiring_rate_of__other_sectors/hiring_rate_of_employed_job_seekers
fraction_workers_hired_in_other_states_desire_to_migrate =
normal_fraction_workers_hired_outside_ND_desire_to_migrate
gap_in_jobs[sector] = (desired_jobs-total_vacant__and_filled_jobs)
goal_for_qualified_fraction_out_of_state[sector] = IF required_qualified_fraction_out_of_state>0 THEN(IF
required_qualified_fraction_out_of_state>max_qualified_fraction_out_of_state THEN
max_qualified_fraction_out_of_state ELSE required_qualified_fraction_out_of_state) ELSE 0

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goal_for_qualified_fraction_unemployed[sector] = IF
required_qualified_fraction_unemployed>max_qualified_fraction_unemployed_in_use THEN
max_qualified_fraction_unemployed_in_use ELSE required_qualified_fraction_unemployed
goal_for_qualified_fraction__employed[sector] = IF
required_employed_qualification_fraction>max_qualified__fraction_employed THEN
max_qualified__fraction_employed ELSE required_employed_qualification_fraction
goal_local_labor_force_participation_rate = MIN(desired_labor_force_participation_rate,
max_local_labor_force_participation_rate_in_use)
graphical_function_effect_wages_on_on_the_job_search = GRAPH(relative_wage_ratio[AG])
(0.5, 1.20), (0.6, 1.20), (0.7, 1.19), (0.8, 1.16), (0.9, 1.11), (1.00, 1.00), (1.10, 0.917), (1.20, 0.87), (1.30, 0.838),
(1.40, 0.813), (1.50, 0.8)
graphical_function_time_to_find_a_job_on_job_search =
GRAPH(time_to_find__a_job_for_employed_ratio[AG])
(0.5, 1.20), (0.583, 1.19), (0.667, 1.17), (0.75, 1.15), (0.833, 1.12), (0.917, 1.08), (1.00, 1.00), (1.08, 0.941),
(1.17, 0.877), (1.25, 0.84), (1.33, 0.817), (1.42, 0.801), (1.50, 0.8)
hired_by__other_sectors[sector] = SUM(hiring_rate_of__other_sectors)*distribution_residual_job_seekers
hired_by__own_sector[AG] = MIN(max_hiring__own_sector[AG], hiring_rate_of_employed_job_seekers[AG])
hired_by__own_sector[CO] = MIN(max_hiring__own_sector[CO], hiring_rate_of_employed_job_seekers[CO])
hired_by__own_sector[MA] = MIN(max_hiring__own_sector[MA],
hiring_rate_of_employed_job_seekers[MA])
hired_by__own_sector[MI] = MIN(max_hiring__own_sector[MI], hiring_rate_of_employed_job_seekers[MI])
hired_by__own_sector[OS] = MIN(max_hiring__own_sector[OS], hiring_rate_of_employed_job_seekers[OS])
hired_by__own_sector[RFL] = MIN(max_hiring__own_sector[RFL],
hiring_rate_of_employed_job_seekers[RFL])
hired_by__own_sector[U] = MIN(max_hiring__own_sector[U], hiring_rate_of_employed_job_seekers[U])
hired_by__own_sector[WTT] = MIN(max_hiring__own_sector[WTT],
hiring_rate_of_employed_job_seekers[WTT])
hiring_of_ND_workers_in_other_states_EQ = init(hiring_of_out_of_state_workers_INIT)
hiring_of_ND__workers_in_other_states_INIT =
outmigration_of__workers_EST+additions_to_commuters_from_ND_to_other_states
hiring_of_out_of_state_workers_INIT =
init(inmigration_of__workers_INIT_EST)+init(additions_to_out_of_state_workers_employed_in_ND)
hiring_of_unemployed_and_out_of_state_EQ[sector] =
init(quit_rate_of__local_employed)+init(quit_rate_of__out_of_state_workers_employed_in_ND)
hiring_rate_of_employed_job_seekers[sector] = IF
desired_hiring_rate_of_employed_job_seekers>qualified_employed__job_seekers THEN
qualified_employed__job_seekers ELSE desired_hiring_rate_of_employed_job_seekers
hiring_rate_of_out_of_state_job_seekers[sector] = IF
desired_hiring_rate_of_out_of_state_job_seekers>qualified_out_of_state_job_seekers THEN
qualified_out_of_state_job_seekers ELSE desired_hiring_rate_of_out_of_state_job_seekers
hiring_rate_of_unemployed_job_seekers[sector] = IF
desired_hiring_of_unemployed_job_seekers>qualified_unemployed__job_seekers THEN
qualified_unemployed__job_seekers ELSE desired_hiring_of_unemployed_job_seekers
hiring_rate_of__other_sectors[sector] = hiring_rate_of_employed_job_seekers-hired_by__own_sector
households_in_ND = total_population/average__household_size
households_per__migrant_worker = 1
households__per_house = 1
housing_units_available_for_households =
housing__units_DATA_til_2013*fraction_housing_units_available_for_occupation_population
housing__units_DATA_til_2013 = GRAPH(TIME)
(2000, 289677), (2001, 292002), (2002, 294165), (2003, 296959), (2004, 300815), (2005, 304458), (2006,
306982), (2007, 310438), (2008, 313018), (2009, 315625), (2010, 318099), (2011, 320888), (2012, 329249),
(2013, 339293), (2014, 343444), (2015, 347647), (2016, 351900), (2017, 356206), (2018, 360564), (2019,
364976), (2020, 369442)
immigration__of_households = immigration_of_workers*households_per__migrant_worker
immigration_16_to_65 = Inmigration_DATA*SUM(distribution_migration__16_to_65_DATA[*])
immigration_all_ages = SUM(immigration__below_16[*],
*)+SUM(immigration__65_plus[*])+SUM(immigration__16_to_65[*], *)
Inmigration_DATA = GRAPH(TIME)

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(2000, 18594), (2001, 18594), (2002, 18594), (2003, 18594), (2004, 18594), (2005, 18594), (2006, 26260),
 (2007, 22399), (2008, 26746), (2009, 29970), (2010, 30100), (2011, 32510), (2012, 38213), (2013, 38908)
 immigration_of_NIL_INIT = immigration_16_to_65-immigration_of__workers_INIT_EST
 immigration_of__workers_INIT_EST = immigration__households_EST/households_per__migrant_worker
 immigration__households_EST = Immigration_DATA/average__household_size
 labor_force = local_unemployed__labor_force+employed__labor_force
 labor_force_DATA = unemployed__labor_force_DATA+employed__labor_force_DATA
 labor_force_participation_rate_DATA = GRAPH(TIME)
 (2000, 0.704), (2001, 0.71), (2002, 0.701), (2003, 0.703), (2004, 0.717), (2005, 0.722), (2006, 0.726), (2007,
 0.74), (2008, 0.743), (2009, 0.738), (2010, 0.734), (2011, 0.725), (2012, 0.73), (2013, 0.73), (2014, 0.724),
 (2015, 0.73)
 labor_force_participation_rate_DATA_EST_16_to_65 = GRAPH(TIME)
 (2000, 0.875), (2001, 0.882), (2002, 0.875), (2003, 0.879), (2004, 0.894), (2005, 0.897), (2006, 0.906), (2007,
 0.92), (2008, 0.926), (2009, 0.909), (2010, 0.885), (2011, 0.891), (2012, 0.892), (2013, 0.885), (2014, 0.879),
 (2015, 0.871)
 labor_force__participation_rate =
 labor_force/(fraction_civilian_non_institutional_population_DATA*(SUM(population__65_plus[*])+SUM(pop
 ulation__16_to_65[*,*])))
 labor_force__participation_rate_16_to_65 = labor_force/civ_population__16_to_65
 local_emigration__excl_workers = total_outmigration__16_to_65-emigration__of_workers-
 return_migration__not_employed
 local_exit_rate_employed__labor_force =
 local_exit_rate_working_age_population*local_labor_force__participation__rate
 local_exit_rate_NIL = local_exit_rate_working_age_population*(1-local_labor_force__participation__rate)
 local_exit_rate_working_age_population =
 total_aging_65*fraction_civilian_non_institutional_population_DATA+local_emigration__excl_workers
 local_hiring__rate_unemployed = SUM(hiring_rate_of_unemployed_job_seekers[*])
 local_labor_force = local_unemployed__labor_force+local_employed__labor_force
 local_labor_force__participation__rate = local_labor_force/total_local_civ_population__16_to_65
 local_net_growth__of_households = (total_births-total_deaths)/average__household_size
 local__labor_force__adjustment = (desired__local_labor_force-local_labor_force)/time_to_adjust__labor_force
 max_hiring__own_sector[sector] =
 (SUM(qualified_employed__job_seekers)*distrbution_employed__job_seekers*(1-
 EQ_switch__for_population)+EQ_switch__for_population*hiring_rate_of_employed_job_seekers)
 max_inmigration__of_households =
 excess_capacity_for_housing_population/time_to_fill__excess_capacity+outmigration__of_households-
 local_net_growth__of_households
 max_labor_force_participation_rate_EQ = 1
 max_lf_participation =
 (potential__unemployed_DATA+local_employed__labor_force+local_unemployed__labor_force)/total_local_ci
 v_population__16_to_65
 max_local_labor_force_participation_rate = 0.96
 max_local_labor_force_participation_rate_in_use =
 max_labor_force_participation_rate_EQ*EQ_switch__for_population+max_local_labor_force_participation_rat
 e*(1-EQ_switch__for_population)
 max_qualified__fraction_unemployed = 0.25
 max_qualified_fraction_out_of_state = 0.75
 max_qualified_fraction_unemployed_in_use = 1*(1-
 switch_for_growth_in_labor_demand)+switch_for_growth_in_labor_demand*max_qualified__fraction_unemplo
 yed
 max_qualified__fraction_employed = 0.75
 multiple_job_holders_DATA = GRAPH(TIME)
 (1995, 9.60), (1996, 9.40), (1997, 10.5), (1998, 10.8), (1999, 10.3), (2000, 10.0), (2001, 9.90), (2002, 9.20),
 (2003, 9.70), (2004, 10.1), (2005, 9.90), (2006, 8.40), (2007, 8.70), (2008, 9.70), (2009, 9.80), (2010, 8.90),
 (2011, 9.00), (2012, 8.00), (2013, 7.90)
 ND_commuters_employed_in_other_states_DATA_EST =
 employed__labor_force_DATA*fraction_ND_workers_employed_in_other_states_DATA
 ND_job_seekers_in_other_others_INIT =
 hiring_of_ND__workers_in_other_states_INIT*time_to__find_job_in_US*(1-

EQ_switch__for_population)+hiring_of_ND_workers_in_other_states_EQ*time_to__find_job_in_US*(EQ_sw
 tch__for_population)
 net_additions__to_unemployed_job_seekers = additions_to__labor_force+firing_rate-
 exit_rate_of_local__unemployed-new_ND_commuters__out_of_state
 net_migration = immigration_all_ages-outmigration_all_ages
 net_migration_DATA = Immigration_DATA-Outmigration_DATA
 new_job_seekers_outside_ND_from_temp_population = temporary_employment_for_return_migration
 new_ND_job_seekers_in_other_states = init(labor_force)*fraction_of_ND_job_search_out_of_state
 normal_additions_to_out_of_state_job_seekers = init(hiring_of_out_of_state_workers_INIT)
 normal_fractional_return__migration = 0.3
 normal_fraction_hiring_of_unemployed_of_residual_vacancies[sector] =
 init(normal_hiring_of_local_unemployed_per_sector)/init(hiring_of_unemployed_and_out_of_state_EQ)
 normal_fraction_job_seekers_per_job[sector] = init(employed__job_seekers_INIT)/init(employment_DATA)
 normal_fraction_of_ND_job_search_in_other_states = (init(hiring_of_ND_workers_in_other_states_EQ)-
 init(temporary_employment_for_return_migration))/init(labor_force)*EQ_switch__for_population+(init(hiring_
 of_ND__workers_in_other_states_INIT)-
 init(temporary_employment_for_return_migration))/init(labor_force)*(1-EQ_switch__for_population)
 normal_fraction_out_of_state_workers_desire_to_migrate_normal =
 init(inmigration_of__workers_INIT_EST)/init(hiring_of_out_of_state_workers_INIT)
 normal_fraction_workers_hired_outside_ND_desire_to_migrate =
 init(outmigration_of__workers_EST)/init(hiring_of_ND__workers_in_other_states_INIT)*(1-
 EQ_switch__for_population)+normal_fraction_out_of_state_workers_desire_to_migrate_normal*EQ_switch__f
 or_population
 normal_hiring_of_local_unemployed_per_sector[sector] = hiring_of_unemployed_and_out_of_state_EQ-
 normal_out_of_state_hiring_per_sector
 normal_local_labor_force_participation_rate = init(local_labor_force__participation__rate)
 normal_out_of_state_hiring_per_sector[sector] =
 init(hiring_of_out_of_state_workers_INIT)*distribution_hiring_of_unemploye_and_out_of_state_INIT
 normal_standard_for_qualified_fraction_of_employed_applicants[sector] = 0.5
 normal_standard_for_qualified_fraction_of_out_of_state_applicants[sector] = 0.5
 normal_standard_for_qualified_fraction_of_unemployed_applicants[sector] =
 normal_hiring_of_local_unemployed_per_sector/(unemployed__job_seekers_INIT/des_time__to_recruit)
 normal_time_to__recruit_in_US_DATA[sector] =
 (normal_time__to_recruit_in_weeks_in_US_DATA*1.25)/weeks_per_year
 normal_time__to_recruit_in_weeks_in_US_DATA[AG] = 2.4
 normal_time__to_recruit_in_weeks_in_US_DATA[CO] = 1.56
 normal_time__to_recruit_in_weeks_in_US_DATA[MA] = 3.48
 normal_time__to_recruit_in_weeks_in_US_DATA[MI] = 1.56
 normal_time__to_recruit_in_weeks_in_US_DATA[OS] = 5.36
 normal_time__to_recruit_in_weeks_in_US_DATA[RFL] = 2.8
 normal_time__to_recruit_in_weeks_in_US_DATA[U] = 3.7
 normal_time__to_recruit_in_weeks_in_US_DATA[WTT] = 3.27
 North_Dakata's_labor_supply = labor_force+out_of_state_commuters_employed_in_ND-
 ND_commuters_employed_out_of_state+out_of_state__job_seekers-ND_job_seekers__out_of_state
 not_in_the_labor_force = local_not_in_the__labor_force+temporary_population_not_employed
 outmigration_all_ages = SUM(emigration__65_plus[*])+SUM(emigration__16_to_65[*],
)+SUM(emigration__below_16[], *)
 outmigration_of__workers_EST = outmigration__household_EST/households_per__migrant_worker
 outmigration__16_to_65_DATA = Outmigration_DATA*SUM(distribution_migration__16_to_65_DATA[*])
 Outmigration_DATA = GRAPH(TIME)
 (2000, 22594), (2001, 22594), (2002, 22594), (2003, 22594), (2004, 22594), (2005, 21147), (2006, 25155),
 (2007, 21057), (2008, 24344), (2009, 21343), (2010, 24450), (2011, 26563), (2012, 23959), (2013, 29808)
 outmigration__household_EST = Outmigration_DATA/average__household_size
 outmigration__of_households = emigration__of_workers*households_per__migrant_worker
 out_of_state_commuters_employed_in_ND_DATA_EST =
 SUM(employment_DATA_1[*])*fraction_ND_jobs_filled_by_out_of_state_workers_DATA
 out_of_state__job_seekers_INIT[sector] =
 normal_out_of_state_hiring_per_sector/normal_standard_for_qualified_fraction_of_out_of_state_applicants*des
 _time__to_recruit
 perceived_time_to_find_a_job_unemployed_2000 = init(perceived_time__to_find_a_job_for_unemployed)

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perceived_time_to_find_a_job__2000[sector] = init(perceived_time__to_find_a_job_for_employed)
persons_per_job = 1
population_DATA = GRAPH(TIME)
(1995, 647832), (1996, 650382), (1997, 649716), (1998, 647532), (1999, 644259), (2000, 642023), (2001,
639062), (2002, 638168), (2003, 638817), (2004, 644705), (2005, 646089), (2006, 649422), (2007, 652822),
(2008, 657569), (2009, 664968), (2010, 674345), (2011, 685242), (2012, 701705), (2013, 723857), (2014,
739482)
population__15_to_65 = SUM(population__16_to_65[*,*])
population__2000_DATA = 642200
potential__unemployed_DATA = GRAPH(TIME)
(2003, 6900), (2004, 6500), (2005, 5800), (2006, 4800), (2007, 4900), (2008, 5400), (2009, 7900), (2010, 7000),
(2011, 7300), (2012, 7300), (2013, 6800), (2014, 6900)
qualified_employed__job_seekers[sector] =
total_job_seekers_available_for_selection_procedure_per_year[sector,
Employed]*qualified_fraction__employed
qualified_out_of_state_job_seekers[sector] =
total_job_seekers_available_for_selection_procedure_per_year[sector,
Out_of_state]*qualified_fraction__out_of_state
qualified_unemployed__job_seekers[sector] =
total_job_seekers_available_for_selection_procedure_per_year[sector,
Unemployed]*qualified_fraction__unemployed
quit_rate[sector] = quit_rate_of__local_employed+quit_rate_of__out_of_state_workers_employed_in_ND
quit_rate_ND_workers_in_other_states =
ND_commuters_employed_in_other_states_DATA_EST/desired_years__of_commuting
quit_rate_of__local_employed[sector] = exit_rate_of_local__employed*employment__distribution
quit_rate_of__out_of_state_workers_employed_in_ND[sector] =
quit_rate_of_out_of_state_commuters_in_ND*employment__distribution
quit_rate__out_of_state_workers =
out_of_state_commuters_employed_in_ND_DATA_EST/desired_years__of_commuting
relative_time_to_find_a_job_ratio =
perceived_time__to_find_a_job_for_unemployed/perceived_time_to_find_a_job_in_US
relative_wage[sector] = Wage__determination.annual_wage/average_annual_wage
relative_wage_2000[sector] = init(relative_wage)
relative_wage_ratio[sector] = relative_wage/relative_wage_2000
remaining__desired_hiring_rate[sector] = desired__hiring_rate-hiring_rate_of_employed_job_seekers
required_employed_qualification_fraction[sector] =
desired_hiring_rate_of_employed_job_seekers/total_job_seekers_available_for_selection_procedure_per_year[s
ector, Employed]
required_qualified_fraction_out_of_state[sector] =
desired_hiring_rate_of_out_of_state_job_seekers/total_job_seekers_available_for_selection_procedure_per_yea
r[sector, Out_of_state]
required_qualified_fraction_unemployed[sector] =
desired_hiring_of_unemployed_job_seekers/total_job_seekers_available_for_selection_procedure_per_year[secto
r, Unemployed]
residual_max_hiring_of_employed_job_seekers[sector] = max_hiring__own_sector-hired_by__own_sector
return_migration__not_employed =
exit_rate_of_temporary_population_not_employed*fractional__return_migration
service__population =
total_population+out_of_state_commuters_employed_in_ND*fraction_time_spend_in_state_of_work-
ND_commuters_employed_out_of_state*fraction_time_spend_in_state_of_work
switch_for_growth_in_labor_demand = 1-equilibrium_switch
temporary_employment_for_return_migration =
exit_rate_of__temporary_employment*fractional__return_migration
temporary_employment__in_ND_INIT =
immigration_of__workers_INIT_EST*duration_of_temporary_status_in_use
time_to_adjust_distribution_job_seekers = 6/12
time_to_adjust_distribution_out_of_state_job_seekers = 1/12
time_to_adjust_fractional_return_migration = 1/12
time_to_adjust__expectations = 3/12
time_to_adjust__job_seekers = 1/12

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time_to_adjust_labor_force = 1
time_to_adjust_standards_employed = 6/12
time_to_adjust_standard_out_of_state = 6/12
time_to_adjust_standard_unemployed = 6/12
time_to_adjust_vacant_jobs = 1/12
time_to_decrease_labor_force_participation_rate = 3/12
time_to_fill_excess_capacity = 1
time_to_find_a_job_for_employed_in_weeks[sector] =
employed_job_seekers/hiring_employed_job_seekers*weeks_per_year
time_to_find_a_job_for_unemployed_in_weeks =
local_unemployed_labor_force/hiring_rate_unemployed*weeks_per_year
time_to_find_a_job_for_employed_ratio[sector] =
perceived_time_to_find_a_job_for_employed/perceived_time_to_find_a_job_2000
time_to_find_a_job_for_unemployed_ratio =
perceived_time_to_find_a_job_for_unemployed/perceived_time_to_find_a_job_unemployed_2000
time_to_find_a_job_US = EQ_switch_for_population*EQ_average_weeks_unemployed_US+(1-
EQ_switch_for_population)*average_weeks_unemployed_US_DATA
time_to_increase_labor_force_participation_rate = 1/12
time_to_perceive_labor_market_information = 1/52
time_to_recruit[sector] = vacant_jobs/vacancies_filled
time_to_recruit_in_weeks[sector] = time_to_recruit*weeks_per_year
time_to_find_job_in_US = SMTH1(average_weeks_unemployed_US_DATA, 6/12,
average_weeks_unemployed_US_DATA)/weeks_per_year
time_to_recruit_in_weeks_EQ[sector] = EQ_time_to_recruit*weeks_per_year
total_aging_16 = SUM(aging_16[*,*])
total_aging_65 = SUM(aging_65[*])
total_births = woman_20_to_39*fractional_birth_rate_female_20_to_39*(1-
EQ_switch_for_population)+EQ_switch_for_population*woman_20_to_39*EQ_fractional_birth_rate_20_to_39
total_deaths = SUM(deaths_65_plus[*])+SUM(deaths_16_to_65[*,*])+SUM(deaths_below_16[*,*])
total_emigration = emigration_households*average_household_size
total_emigration_by_sex[sex] = total_emigration*distribution_by_sex
total_fraction_workers_hired_from_other_industries =
SUM(hiring_rate_of_other_sectors[*])/SUM(hiring_rate_of_employed_job_seekers[*])
total_hiring_of_employed_workers_from_other_industries = SUM(hiring_rate_of_other_sectors[*])
total_immigration = immigration_of_households*average_household_size
total_immigration_16_to_65 = total_immigration*SUM(distribution_migration_16_to_65_DATA[*])
total_immigration_by_sex[sex] = total_immigration*distribution_by_sex
total_inmigration_16_to_65 = SUM(inmigration_16_to_65[*,*])
total_jobs_in_employment = SUM(employment_in_jobs[*])
total_job_seekers_available_for_selection_procedure_per_year[sector, employment_status] =
job_seekers_by_sector/des_time_to_recruit[sector]
total_job_seekers_per_sector_INIT[sector, employment_status] =
employed_job_seekers_INIT[sector]*factor_employed[employment_status]+unemployed_job_seekers_INIT[
sector]*factor_local_unemployed[employment_status]+out_of_state_job_seekers_INIT[sector]*factor_out_o
f_state[employment_status]
total_local_civ_population_16_to_65 = local_not_in_the_labor_force+local_labor_force
total_new_job_seekers[Unemployed] = net_additions_to_unemployed_job_seekers
total_new_job_seekers[Employed] = SUM(new_employed_job_seekers[*])
total_new_job_seekers[Out_of_state] = additions_to_out_of_state_job_seekers
total_outmigration_16_to_65 = SUM(emigration_16_to_65[*,*])
total_population = SUM(total_population_by_sex[*])
total_searching_labor_force =
local_unemployed_labor_force+SUM(employed_job_seekers[*])+out_of_state_job_seekers
total_vacant_and_filled_jobs_DATA[sector] = vacant_jobs_DATA+employment_DATA
total_vacant_jobs = SUM(vacant_jobs[*])
total_vacant_and_filled_jobs[sector] = vacant_jobs+filled_jobs
total_vacant_jobs_DATA = SUM(vacant_jobs_DATA[*])
total_employment_DATA = SUM(employment_DATA[*])

total__population_by_sex[sex] = SUM(population__16_to_65[* , sex])+SUM(population_below_16[* , sex])+population__65_plus
unemployed_labor__force_DATA = GRAPH(TIME)
(1995, 11663), (1996, 10524), (1997, 9842), (1998, 8854), (1999, 11629), (2000, 10496), (2001, 9646), (2002, 11792), (2003, 13123), (2004, 12187), (2005, 12136), (2005, 11537), (2006, 11620), (2007, 11104), (2008, 14441), (2009, 14899), (2010, 13518), (2011, 12373), (2012, 12369), (2013, 11266), (2014, 11945)
unemployed__job_seekers_INIT[sector] =
local_unemployed__labor_force*distribution_hiring_of_unemploye_and_out_of_state_INIT
unemployment_rate = local_unemployed__labor_force/labor_force
vacancies_to_fill_EQ[sector] = attrition_rate_INIT/persons_per_job
vacant_jobs_DATA[AG] = GRAPH(TIME)
(2000, 202), (2001, 211), (2002, 213), (2003, 222), (2004, 230), (2005, 230), (2006, 283), (2007, 364), (2008, 537), (2009, 427), (2010, 294), (2011, 478), (2012, 530), (2013, 614), (2014, 708)
vacant_jobs_DATA[CO] = GRAPH(TIME)
(2000, 426), (2001, 417), (2002, 283), (2003, 272), (2004, 335), (2005, 395), (2006, 506), (2007, 639), (2008, 836), (2009, 417), (2010, 592), (2011, 1108), (2012, 1338), (2013, 1209), (2014, 1474)
vacant_jobs_DATA[MA] = GRAPH(TIME)
(2000, 463), (2001, 465), (2002, 372), (2003, 332), (2004, 458), (2005, 555), (2006, 650), (2007, 758), (2008, 895), (2009, 377), (2010, 607), (2011, 1026), (2012, 1451), (2013, 1423), (2014, 1625)
vacant_jobs_DATA[MI] = GRAPH(TIME)
(2000, 84.0), (2001, 88.0), (2002, 56.0), (2003, 53.0), (2004, 65.0), (2005, 88.0), (2006, 163), (2007, 292), (2008, 648), (2009, 309), (2010, 471), (2011, 898), (2012, 1072), (2013, 970), (2014, 1174)
vacant_jobs_DATA[OS] = GRAPH(TIME)
(2000, 4796), (2001, 4841), (2002, 3842), (2003, 3669), (2004, 3898), (2005, 4402), (2006, 4774), (2007, 5149), (2008, 5570), (2009, 3735), (2010, 3707), (2011, 5533), (2012, 8295), (2013, 7794), (2014, 9419)
vacant_jobs_DATA[RFL] = GRAPH(TIME)
(2000, 2526), (2001, 2518), (2002, 1878), (2003, 1858), (2004, 2123), (2005, 2422), (2006, 2361), (2007, 2284), (2008, 2196), (2009, 1441), (2010, 1783), (2011, 2536), (2012, 3400), (2013, 3119), (2014, 3452)
vacant_jobs_DATA[U] = GRAPH(TIME)
(2000, 491), (2001, 524), (2002, 403), (2003, 355), (2004, 380), (2005, 445), (2006, 453), (2007, 464), (2008, 464), (2009, 256), (2010, 333), (2011, 557), (2012, 802), (2013, 744), (2014, 851)
vacant_jobs_DATA[WTT] = GRAPH(TIME)
(2000, 745), (2001, 749), (2002, 600), (2003, 596), (2004, 701), (2005, 794), (2006, 908), (2007, 1039), (2008, 1218), (2009, 712), (2010, 1076), (2011, 1896), (2012, 2477), (2013, 2419), (2014, 2823)
weeks_per_year = 52
woman_20_to_39 = population__16_to_65[From_20_to_24, Female]+population__16_to_65[From_25_to_29, Female]+population__16_to_65[From_30_to_34, Female]+population__16_to_65[From_35_to_39, Female]
years_per_age__group_20_to_64 = 5
years_per_age__group_below_19 = 4

Wage determination:

hourly_wage[AG](t) = hourly_wage[AG](t - dt) + (hourly_wage__adjustment[sector]) * dt
INIT hourly_wage[AG] = 13
hourly_wage[CO](t) = hourly_wage[CO](t - dt) + (hourly_wage__adjustment[sector]) * dt
INIT hourly_wage[CO] = 14
hourly_wage[MA](t) = hourly_wage[MA](t - dt) + (hourly_wage__adjustment[sector]) * dt
INIT hourly_wage[MA] = 11
hourly_wage[MI](t) = hourly_wage[MI](t - dt) + (hourly_wage__adjustment[sector]) * dt
INIT hourly_wage[MI] = 13
hourly_wage[OS](t) = hourly_wage[OS](t - dt) + (hourly_wage__adjustment[sector]) * dt
INIT hourly_wage[OS] = 11
hourly_wage[RFL](t) = hourly_wage[RFL](t - dt) + (hourly_wage__adjustment[sector]) * dt
INIT hourly_wage[RFL] = 9
hourly_wage[U](t) = hourly_wage[U](t - dt) + (hourly_wage__adjustment[sector]) * dt
INIT hourly_wage[U] = 13
hourly_wage[WTT](t) = hourly_wage[WTT](t - dt) + (hourly_wage__adjustment[sector]) * dt
INIT hourly_wage[WTT] = 12

INFLOWS:

hourly_wage__adjustment[sector] = hourly_wage*hourly_wage__growth_rate
annual_wage[sector] = total_working_hours_per_week*hourly_wage*weeks_per_year

```

average_qualified_fraction[sector] =
(.qualified_fraction__employed+.qualified_fraction__out_of_state+.qualified_fraction__unemployed)/3
average_qualified__fraction_2000[sector] = init(average_qualified_fraction)
average_qualified__fraction_ratio[sector] = average_qualified_fraction/average_qualified__fraction_2000
effect_of_qualified_fraction_on_wage[sector] =
LOOKUP(graphical_function_effect_of_qualified_fraction_on_wage, average_qualified__fraction_ratio)
effect_of_selection_proces_completed_on_wages[sector] =
LOOKUP(graphical_function_effect_of_selection_process_completed_on_wage,
.fraction_selection_procedures_completed)
fraction_labor_shortage = SUM(total_shortage__in_working_hours[*])/SUM(total_working_hours[*])
fraction__vacant_jobs_INIT[sector] = INIT(.vacant__jobs)/INIT(.filled__jobs)
graphical_function_effect_of_qualified_fraction_on_wage = GRAPH(average_qualified__fraction_ratio[AG])
(0.5, 0.8), (0.6, 0.803), (0.7, 0.827), (0.8, 0.849), (0.9, 0.889), (1.00, 1.00), (1.10, 1.11), (1.20, 1.15), (1.30, 1.18),
(1.40, 1.20), (1.50, 1.20)
graphical_function_effect_of_selection_process_completed_on_wage =
GRAPH(.fraction_selection_procedures_completed[AG])
(0.00, 1.10), (0.1, 1.06), (0.2, 1.04), (0.3, 1.03), (0.4, 1.03), (0.5, 1.02), (0.6, 1.02), (0.7, 1.01), (0.8, 1.01), (0.9,
1.00), (1.00, 1.00)
hourly_wage__growth_rate[sector] =
normal_hourly__wage_growth_rate*effect_of_selection_proces_completed_on_wages*effect_of_qualified_fract
ion_on_wage*(1-.equilibrium_switch)
normal_hourly__wage_growth_rate[sector] = 0.02
normal_working__hours_per_week_DATA[AG] = 40
normal_working__hours_per_week_DATA[CO] = 40
normal_working__hours_per_week_DATA[MA] = 40
normal_working__hours_per_week_DATA[MI] = 46
normal_working__hours_per_week_DATA[OS] = 33
normal_working__hours_per_week_DATA[RFL] = 29
normal_working__hours_per_week_DATA[U] = 34
normal_working__hours_per_week_DATA[WTT] = 34
normal__vacant_jobs[sector] = .filled__jobs*fraction__vacant_jobs_INIT
total_shortage__in_working_hours[sector] = .vacant__jobs*normal_working__hours_per_week_DATA-
normal__vacant_jobs*normal_working__hours_per_week_DATA
total_working_hours[sector] = .filled__jobs*normal_working__hours_per_week_DATA
total_working__hours_per_week[sector] =
normal_working__hours_per_week_DATA+working_hour_adjustment__per_job
weeks_per_year = 52
working_hour_adjustment__per_job[sector] = total_shortage__in_working_hours/.filled__jobs

```