Implementation of unemployment and sector wage development in a global CGE model

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1. Introduction

Unemployment is an important and interesting phenomenon in capitalist economies. That is probably an important reason why Joan spent so much of his research time on studying it. One of his inspiring contributions that we remember from the time that we were doing our doctoral research under his supervision was an extensive classification of the various types of unemployment (Muysken, 1989). This is one of the many things that we learned from Joan. (Another one was that we should restrict ourselves enough in our doctoral research, which, however, we only did to a certain extent.) In this paper we analyse the implications of two different types of unemployment in the context of a general equilibrium model.

Unemployment is normally not handled in global CGE (Computable General Equilibrium) models because these models are mainly focused on the long term and because unemployment is primarily a disequilibrium phenomenon. Nevertheless, some global CGE models tackle unemployment, and in most cases (if not all) unemployment is simply created by fixing the wage exogenously (McDonald et al, 2007; Lejour et al, 2006). This is very unsatisfactory because the effects of policies on unemployment play an important role in economic policy. Therefore, it is important that a CGE model can show effects on unemployment beyond those of lowering a fixed wage. For example, such a model may show that the influence of the introduction of a bio-based economy on unemployment will be very small in the long run.

In this paper we develop a module for a general equilibrium model developed at LEI[1], called MAGNET, that is based on the so-called GTAP (Global Trade Analysis Project) model. We add two types of structural unemployment to the model. The first type of unemployment is classical unemployment in the Keynesian sense, i.e. unemployment because on a macroeconomic level wages differ from the equilibrium level. The second type of unemployment is structural in the sense that it is the consequence of different developments of different sectors, where wage negotiations only gradually adjust to changing circumstances. For this last type of unemployment an explicit mobility equation for labour between different sectors has to be created.

In order to investigate some of the features of the new modules, we experiment with a simple "baseline" simulation between 2007 and 2030, with no change except for a

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worldwide change in total factor productivity. By varying these factor productivity changes over time, we can investigate the behaviour of the standard model without unemployment, the model with only classical unemployment, and the model with the above two types of structural unemployment. We incorporate the more sophisticated labour market into the model only for the Netherlands, to simplify the analysis of differences in developments.

In the rest of this paper, we first shortly discuss in Section 2 the literature on unemployment and labour mobility in CGE models. Then, Section 3 briefly explains the general characteristics of MAGNET and specifically the GTAP model that is included in this. In Section 4 we discuss the implementation of the two variants of the labour market with unemployment, while Section 5 analyses the simulation experiments. Finally, in Section 6 the general lessons from this exercise are drawn, and challenges for further extension of this exercise towards more empirically valid implementation are discussed.

2. Unemployment and labour mobility in global CGE models

In most CGE models unemployment is not considered at all. As far as it is considered, unemployment is generated by fixing nominal wages, or bringing unemployment exogenously into the model. For example, in the WorldScan model of the Dutch CPB the following assumptions about the labour market are made:

"Consumers supply labour and firms demand it. Two types of labour are distinguished: high-skilled and low-skilled. We assume that labour markets are cleared at the national level and that the prices of both types of labour (the wage rates) are flexible. For each labour type, supply and demand will become equal at the market-clearing wage. Unemployment is projected exogenously. Part of labour supply is then unemployed and labour supply minus the unemployed will equal labour demand in equilibrium." (Lejour et al, 2006, p. 13)

In contrast to this, the LINKAGE model from FAO (Mensbrugghe, 2005) allows for migration from rural to urban areas and has the possibility of a minimum wage that generates unemployment. The minimum wage depends on unemployment, inflation and other factors. Recently, Shutes (2012) implemented a labour supply curve into a CGE model that may be partly interpreted as modelling voluntary unemployment as a consequence of reservation wages. Also the MIRAGE model (MIRAGE-WIKI, 2013) has a possibility for some unemployment in the context of a dual labour market in developing countries.

In most CGE models it is assumed that there is perfect mobility of labour between different sectors. For example, in the standard GTAP model a differentiation is made between skilled and unskilled labour, but for both skilled and unskilled labour the percentage wage changes in all sectors are the same. In a somewhat more advanced variety of the model with a focus on agriculture, GTAP-AGG (Keeney and Hertel, 2005), imperfect labour mobility between agricultural and non-agricultural sectors has been introduced. Substitution of labour and capital between agricultural and non-agricultural sectors follows a CET (constant-elasticity-of-transformation) function, implying that the relative wage in agriculture declines when the share of agricultural labour in total labour in all sectors declines. For the short and medium term this may be plausible, but in the long term the people that leave the agricultural sector will not influence wages anymore. For this reason Woltjer (2010) introduced a dynamic function that has a very low elasticity of transformation in the short term and is infinitely elastic in the long term.

The modelling of labour mobility is more advanced in national CGE models. For example, McDonald and Thierfelder (2009) model a highly differentiated labour market, where labour mobility is determined by a type of "migration" function, i.e. the flow of labour from one sector to another depends on relative wages. Because, in contrast with models like GTAP that use efficiency units of labour that flow from one sector to another, they use human beings that flow from one sector to another, they must assume something on the relative productivity of the people that come into a sector relative to the average productivity of people in the sector. They assume that the productivity level in the new sector remains the same as in the old sector, and compensate wage in the new sector for this (Flaig, Grethe, and McDonald, 2013).

In summary, modelling of unemployment is underdeveloped in global CGE models, as is the modelling of imperfect labour mobility between sectors. In this paper we will make a first step to improve on this. The next section discusses the model in which we will implement this new labour market structure.

3. MAGNET and GTAP

MAGNET, Modular Applied General Equilibrium Tool (Woltjer et al, 2013), is a general equilibrium model based on GTAP (Hertel et al, 1999) and following a modular approach in adding systematically independent modules to the GTAP model and thus creating a much more advanced model. In this paper we use the simplest form, i.e. standard GTAP, and enrich it with the newly developed labour market module.

The world economy is interlinked. If something happens in one country, this may influence the rest of the world. Thus, the state of the economy in a country like the Netherlands depends on what happens in other countries. Computable General Equilibrium (CGE) models are meant to highlight these interrelationships. The GTAP model is one of the best-known models of this type, especially because it is linked to a consistent international database for CGE models that is the foundation of most global CGE models. The Global Trade Analysis Project (GTAP) is a global network of researchers and policy makers conducting quantitative analysis of international policy issues, and has the GTAP database as one of its main outputs.

At LEI MAGNET has been developed that uses the GTAP model and database as a starting point. The basic idea of the system is its modular character. Each user can build his own database and model based on the GTAP model and database by including modules with program code and databases. In this manner the GTAP database can be enriched with extra sectors, regions, production factors, specific country information, information from international databases like FAO and World Bank, and with adjustments designed by specialists. Each adjustment and addition is a separate module, and these modules can be called by a software interface called Dynamic Steering System (DSS) that has been developed specifically for this purpose at LEI. The choices made by a user for a project are stored in a so-called answer file that enables the user to document and replicate her choices and also provides the possibility to do the same adjustments for a new release of the GTAP database. The basic philosophy of the system is that all procedures are coded in the programming language, and that all procedures start with the data as supplied by the data supplier, making sure that everything can be traced and replicated.

The same principle for the database is also used for the aggregation of the database and the generation of data for scenarios. Everything is modular and stored by the user, and should be as independent as possible of the level of aggregation chosen by the user. Finally, the model code itself is organized in a modular fashion, where each module can be included by the user through the DSS interface and is stored in a separate file. In this manner, a library of modules can be developed, where a user can decide which module is most suitable for the purpose of the analysis, and where a user can also develop some additional modules for the specific purpose of a project. A specific software interface, called GTREE, has been developed that shows the model code in a structured manner, where you can see the separate modules, and where the different steps in the model code are structured according to a hierarchical tree structure. The program GTREE generates the code for the programming language automatically.

One of the challenges in analysing results is that, in many cases, one likes to present results at a higher aggregation level than at which the model is running, and that one can compare different scenarios in an easy manner. For this purpose a presentation tool has been developed, called GEMSE_Analist, that aggregates model outcomes in a systematic manner, and has a lot of features to show results in different formats, like as a percentage of a reference scenario, in percentage or absolute changes, in levels, etc.

In summary, the MAGNET modelling system provides a systematic way to process data, organize model code and analyse results, where the GTAP database and GTAP model are the starting point. In the remainder of this section we will shortly discuss the GTAP database and model.

3.1 The GTAP database

The most recent GTAP database describes the global economy in millions of dollars of 2007. The GTAP database is released at three year intervals, the most recent ones being those for 1998, 2001, 2004 and 2007, where more recent releases have more differentiation in regions and where sometimes also the number of sectors changes. The global economy in the GTAP version 8 database for 2007 has been divided in 129 regions, 5 production factors and 57 sectors (of which 12 primary agricultural sectors), forestry, and 8 food-processing sectors. Each sector in the GTAP database produces one commodity by using production factors and intermediate inputs. Total value added generated in a sector is allocated to the production factors land, skilled and unskilled labour, capital and natural resources,[2] and a small part is transferred directly as indirect taxes to government. A so-called input-output table describes which sectors use which commodities and production factors as inputs.

National income in GTAP, i.e. the sum of all value added generated in the different sectors, is earned by one regional household. This regional household distributes this income over private consumption, government expenditures and savings, where the sum of all savings in the world equals investment in the world. Consumption and government expenditures are distributed over expenditures on different commodities, where a differentiation is made between imported and domestically produced commodities.

The international interdependence in the GTAP database is through bilateral trade. The GTAP database describes bilateral trade flows of all commodities. A lot of effort is made to make the international trade database consistent. It is not obvious that the Dutch statistical office reports the same export flows to India as the Indian statistical office reports as imports from the Netherlands. Creating a reliable and consistent database for world trade flows is therefore not an easy task.

In order to transport commodities from one region to another, transport and other handling costs are involved. These transport costs for shipping commodities between India and the Netherlands equal the difference between the import value for India and the export value for the Netherlands (corrected for inconsistencies in prices). The production of these transport commodities is allocated to the countries that supply the transport services.

The GTAP database gives a lot of attention to taxes and subsidies. For this purpose it differentiates between values at market prices and values at agent or world prices. For example, an import tariff on wheat in India is the difference between the import value of wheat at market prices and the import value at world prices. In this manner import and export tariffs, taxes on the use of production factors or intermediate inputs (differentiated between imported and domestically produced commodities), export subsidies, taxes on consumption, taxes on output, and taxes on income are distinguished. Subsidies in this system are just negative taxes. This detailed accounting system in the GTAP database allows for a very sophisticated analysis of the effect of changes in subsidies and taxes.

The GTAP consortium has a lot of other data available that is made consistent with the GTAP database; this is issued at irregular intervals. For example, energy volumes are delivered as well as CO2 emissions, split into the same demand categories as in the GTAP database. A GTAP land use database is available that registers land cover, land use per crop sector, and the volume of production for these sectors. A forestry

2 Land and natural resources are interpreted as kinds of physical capital.

database shows the areas of forest and its related carbon stock per agro-ecological zone, management intensity and age. There is also a database on non-CO2 greenhouse gas emissions available. In summary, the GTAP consortium delivers a lot of relevant information for global analyses.

In MAGNET the GTAP database is used as a starting point. Additional information comes from, for example, FAO, the World Bank, and International Energy Agency, while the additional databases delivered by GTAP are processed automatically into an integrated MAGNET database. Additional information like cost structures of specific sectors can also be easily processed into the MAGNET database.

In summary, the GTAP database offers a consistent description of the global world economy with a lot of attention to taxes and subsidies. The GTAP consortium also offers a lot of related databases that can be automatically processed into the MAGNET database. Also information from other databases and sources is used and can be processed into the MAGNET database.

3.2 The GTAP model

In MAGNET the GTAP code forms the starting point of the other modules and is kept in its original state as much as possible. In order to make the code easier to read, the code has been reorganized. For example, all parts of the code on firms have been put into one chapter on firms, and the same holds for trade, households, etc. This section discusses the most important elements of the standard GTAP model.

Regional household

The regional household collects all income and distributes income over private consumption, savings and government expenditures. It uses a very simple, Cobb Douglass type of utility function for this. Savings are supplied to the banking sector and will be discussed later. Government consumption is distributed over different sectors with a simple Cobb Douglass type of utility function. Only private consumption is distributed over different sectors using a more sophisticated function, the Constant Difference of Elasticity (CDE) utility function. This function has the property that it allows for different income elasticities, in contrast with CES or Cobb Douglass utility functions, where it is always assumed that a one per cent increase in income generates a one per cent increase in demand for all commodities if all relative prices remain the same. This property of non-homotheticity is important, especially if there are experiments that increase income. The CDE utility function has two parameters, one that is usually calibrated to determine the own price elasticities of consumption, and one that is calibrated to determine the income elasticities of consumption. The disadvantage of this utility function is that the cross price elasticities of consumption cannot be calibrated independently of the own price and income elasticities, and are usually around zero. Another disadvantage is that the income elasticities do not change when income increases.

Imports and exports

Imports in GTAP are determined by a two-level Armington production or utility function applied for each expenditure category, i.e. intermediate inputs for firms, private consumption, investment and government consumption. An Armington function is like a CES function, but applied to imports and domestic commodities instead of inputs of production and consumption. For each agent that demands a commodity, first the decision is taken either to import the commodity or to buy it from a domestic producer. When a decision to import is taken, subsequently a choice is made from which region to import the commodities. All the potentially supplying regions are in one function with the same elasticity of substitution.

The line of argument behind the Armington import function is that imported commodities are heterogeneous at the aggregation level used by GTAP. For example, you cannot perfectly substitute fruits imported from southern countries that produce oranges for fruits imported from northern countries that produce apples. For this reason, the users have a preference for a mix of the commodities, and therefore the utility of an extra unit of imports from one country decreases when more is imported from that country. This principle is included in the Armington function.

The Armington function has the advantage that it allows for bilateral trade. Exports of countries are completely determined by the import decisions of the importing countries, given the price of the commodities in the different regions of the world.

Trade requires transport. This implies that the price an exporting country gets is lower than what the importing country has to pay. The difference is paid to the transport sectors in GTAP. The payments for international transports are distributed over supplying countries where regions with rising relative transport supply prices get a smaller transport share according to an Armington demand function for international transport services. When relative prices of supply of international transport services remain the same, the supply of transport services increases with the same percentage in all regions.

Firms and factor markets

Sectors are called firms in GTAP. Firms in GTAP sell one commodity with the same name as the sector. Because of the substitution possibilities in the consumption function, domestic commodity demand displays a negative relationship between quantity and price demanded. Exports are determined by the import decision of importing firms, and the Armington function guarantees again that the export demand depends negatively on price. Given this negative demand curve, the firm has a constant returns to scale production function.

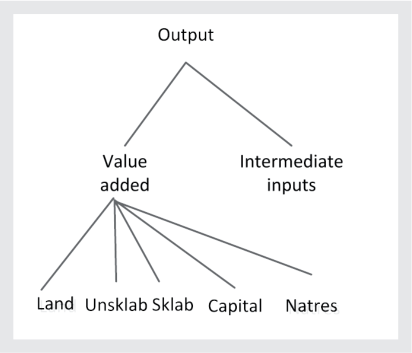

Figure 1: GTAP production structure
(Unsklab = unskilled labour, Sklab = skilled labour, Natres = natural resources)

The production function is a Constant Elasticity of Substitution function with two nests: one with value added as a whole and intermediate inputs, that usually has a substitution elasticity of zero, and a value- added nest (Figure 1). This implies that demand for intermediate inputs usually grows with the same rate as production, as does value added as a whole. When relative prices of production factors change, more or less production factors may be used. In this manner demand for production factors adjusts to relative availability of these production factors.

Usually total supply of production factors is fixed, or in case of scenarios, changes exogenously. This implies that the availability of production factors is determined outside the model. For the modelling of the production factors there are basically two mechanisms. For the first type of production factors, called mobile endowments (endowments is just production factors), price is adjusted till total demand for production factors (through adjustments made possible by the CES production function) equals supply. Labour and capital are considered to be mobile production factors and therefore the changes in wages and the prices of capital change with the same percentage for all sectors in one region.

The second type of production factors is called sluggish endowments, and in this case the percentage change of the price depends on the sector which is demanding this endowment. The supply of sluggish endowments is distributed according to a Constant Elasticity of Transformation (CET) function that functions more or less in the same manner as a CES function, but then for the supply side. The argumentation behind the use of this CET function is that the endowment is not homogeneous, and therefore not suitable to the same extent for all sectors. For example, very wet land may be very useful for rice production, but not for wheat production. It is assumed that each sector uses the land that is best suitable, and therefore, when it likes to expand land use, it has to accept land of lower quality for its own purposes, implying that the implicit cost of using this land increases.

Investment

On a global level savings determine investments in a general equilibrium model. In standard GTAP there are two possible closures that distribute global savings over regions. The first is that the growth of net investment is equal in all regions, implying that rates of return may differ a lot between different regions. The other is that the expected rate of return is equalized in all regions. This condition is a little bit complicated in the sense that the expected rate of return is determined by the current rate of return and the difference between the growth of capital stock as determined by the exogenous shocks to the model, and the growth of capital stock that would emerge if the capital stock would grow according to the net investments made in the region. This last mechanism generates a faster increase in investment when the assumed growth of capital stock is higher, and therefore tries to enforce a little bit of consistency between short term investment and long term growth of capital stock.

Taxes and subsidies

As discussed when introducing the database, almost everywhere in the model taxes can be implemented. In GTAP all these taxes are considered to be ad valorem taxes, implying that the tax revenues grow proportionally with the value of the tax base. For example, if the price of crude oil increases, the taxes increase with the same percentage as the petrol price. This may be correct for a country like the USA, but for Europe taxes on petrol are mainly specific duties.

Conclusion

The GTAP model is a simple and, for a large number of issues, straightforward general equilibrium model of the world. In combination with its database it is a powerful tool to investigate interdependencies in the world economy. However, it is also obvious that the model focuses on general principles and is over-simplified for most real world analysis. For this reason, the model can only be seen as a starting point. In the MAGNET system the GTAP model is presented in a lucid manner, and there is an easy way to extend the model to make it more suitable for real world analyses.

4. Implementation of a structural unemployment module in MAGNET

The simplest adjustment of the labour market allowing for neoclassical unemployment, i.e. unemployment as a consequence of wages higher than the equilibrium level, is the introduction of a lagged wage adjustment function on a macro-level, where mobility of labour between sectors remains perfect, i.e. in all sectors the same wage holds. This is the first module we build.

The second module is a module where the labour market is segmented by sector, implying that mobility of labour between sectors is imperfect. For each sector there is a reservoir of unemployed people that may also be employed in other sectors. A wage adjustment function determines the sector-specific wages, while a labour migration function determines the flow of labour from one sector to another.

4.1 The macroeconomic wage adjustment module

We define employment of labour type i (skilled, unskilled) in sector j in region r as $E_j(i,r)$, and define labour demand for labour type i in region r as the sum of employment per sector:

$$E(i,r) = \sum E_j(i,r)\,. \qquad (1)$$

We assume that frictional or natural employment is a fraction γ of total employment. This implies that in equilibrium total labour supply $LS(i,r)$ equals

$$LS(i,r) = (1+\gamma)E(i,r). \qquad (2)$$

In order to generate a memory of past increases in wages, a wage history variable has been created that is given by

$$\Delta \log\big(wh(i,r)\big)_t = \kappa \Delta \log\big(w(i,r)\big)_t + (1-\kappa)\Delta \log\big(wh(i,r)\big)_{t-\Delta t}, \qquad (3)$$

where wh is the wage history, w is the current wage, and is the length of the period of the update (e.g. a month).

The current wage increase is determined by the wage history and the tension between equilibrium labour supply $(1+\gamma)E(i,r)$ and current labour supply. So, the current wage increase depends on the wage increases in the past, and the current tension on the labour market:

$$\Delta \log\big(w(i,r)\big) = \Delta \log\big(wh(i,r)\big) + \alpha\left(\frac{(1+\gamma)E(i,r) - LS(i,r)}{LS(i,r)}\right) \qquad (4)$$

This is basically the whole system. Employment $E_j(i,r)$ in all sectors is determined automatically by setting labour in the CES function in such a manner that the marginal revenue of labour equals the wage rate.

In summary, in the simple neoclassical unemployment formulation of the labour market, wages tend to rise with the same rate as in the past, but also adjust gradually towards their long term equilibrium rate by reacting to the difference between equilibrium labour supply and current labour supply, as shown in Figure 2.

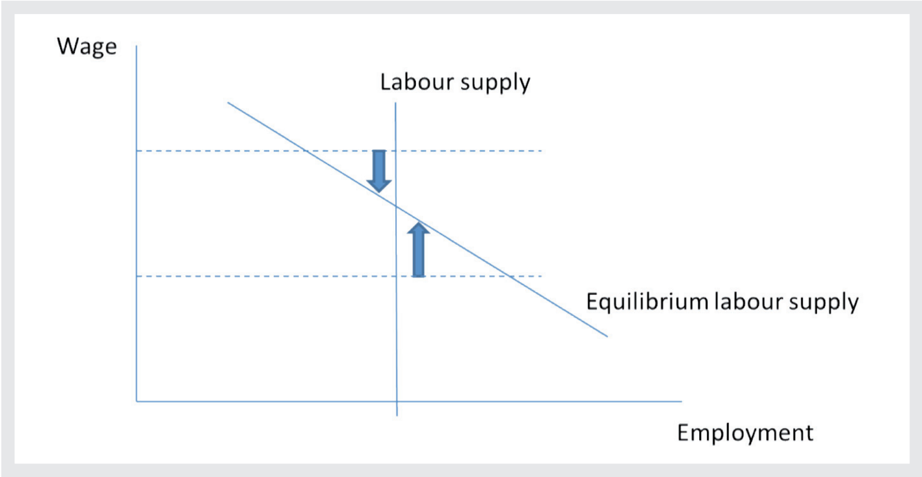

Figure 2: Wage adjustment with surplus or shortage of labour supply

4.2 The sector wage adjustment and migration module

Introducing imperfect mobility between sectors complicates the model a lot. A separate module has been introduced to tackle the idea. The module is based on the same idea of sector wage adjustment as in the module for imperfect labour mobility between agriculture and non-agricultural sectors (Woltjer, 2010), while the migration function is modelled in the same way as the land transition in the land transition approach to land allocation (Woltjer, 2013), and is roughly consistent with the approach of McDonald and Thierfelder (2009). A specific feature is added that allows for gradual wage adjustment in the same manner as in the macroeconomic wage adjustment module described above and that implies sector- specific unemployment.

First a sector-specific wage, $w_j(i,r)$, must be defined, where the wage history can be calculated in the same manner as for the national module:

$$\Delta \log\left(wh_j(i,r)\right)_t = \kappa \Delta \log\left(w_j(i,r)\right)_t + (1-\kappa)\Delta \log\left(wh_j(i,r)\right)_{t-\Delta t}. \qquad (5)$$

Also the wage adjustment equation can be specified analogously to the equation in the national module:

$$\Delta \log\left(w_j(i,r)\right) = \Delta \log\left(wh_j(i,r)\right) + \alpha\left(\frac{(1+\gamma)E_j(i,r) - LS_j(i,r)}{LS_j(i,r)}\right). \qquad (6)$$

The new part for the sector-specific module is the equation that determines labour supply per sector. For this we define a migration variable, M(j,k;i,r), i.e. migration from sector j to sector k of labour type i in region r, and a sector-specific unemployment rate $U_j(i,r)$ that is defined as:

$$U_j(i,r) = \frac{LS_j(i,r) - E_j(i,r)}{LS_j(i,r)}, \tag{7}$$

where labour supply is determined by the national growth of labour supply and the net migration inflow:

$$\Delta LS_j(i,r) = LS_j(i,r)_{t-\Delta t}\Delta \log(LS(i,r)) + \sum_{k \neq j} M(j,k;i,r) - \sum_{k \neq j} M(k,j;i,r). \tag{8}$$

The percentage change in migration of labour from region j to region k is determined by the percentage change in the relative unemployment rate and the percentage change in the relative wage in the two sectors:

$$dlog(M(j,k;i,r)) = S_j(i,r) + \beta_U dlog\left(\frac{U_j(i,r)}{U_k(i,r)}\right) + \beta_W dlog\left(\frac{w_k(i,r)}{w_j(i,r)}\right), \tag{9}$$

where $S_j(i,r)$ is a shifter that is set in such a manner that all labour of sector j goes to some sector.

This completes the modelling of dynamic sector-specific labour supply. The model implies that when labour demand in one sector grows faster than in other sectors, relative wage will be higher and unemployment will be reduced, increasing the migration flows to the sector till equilibrium is reached. So, sectors that grow in general faster will have to pay higher wages. It is obvious that the basic system developed here can be easily extended with more complicated equations.

5. Some simulation experiments

In this section we analyse the behaviour of the new module for the Netherlands. We do simulation experiments for the Netherlands starting from the GTAP database version 8.1, with the rest of the world aggregated to six regions (Europe, North America, South and Middle America, Oceania, Africa and Asia). For all regions except the Netherlands we use the standard GTAP labour market formulation while using the new labour market modules only for the Netherlands. We just take a more or less random sector aggregation, because the focus is on the mechanisms involved, not on the empirical validity. We simulate into the future while making very simple assumptions on the development of the economy in order to investigate the mechanisms that work in the model.

In order to focus on the basic mechanisms, we use a standardized simple baseline, where exogenous value-added productivity growth (i.e. the multiplicative factor for the value-added CES function) in all regions and sectors is the same, i.e. 2% per year between 2007 and 2019, and 1% per year starting from 2020. We first compare a scenario with

the standard flexible-wage GTAP model and the same scenario with the macroeconomic wage adjustment model.

The essence of the macroeconomic wage adjustment model is its wage adjustment. Roughly, you would expect a possibility for wage growth of 2% per year till 2019, and 1% afterwards. This is what we see in Figure 3 for the flexible-wage simulation, although the wage increase is a little bit above 2% at the start of the simulation. The reason is that the equilibrium wage is not only determined by productivity growth, but also by substitution between labour and other production factors.

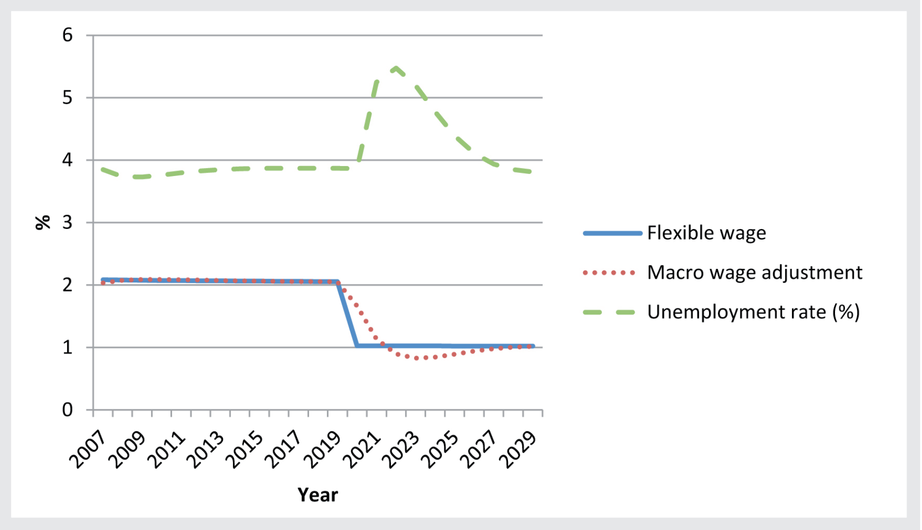

Figure 3: Wage adjustment and unemployment

In the macro wage adjustment simulation the wage develops more or less in the same manner as in the flexible wage model till 2019, but adjusts much slower to the new rate of technological change. This implies that during the first years after the productivity slowdown the wage rate remains too high, what is compensated after 2022 with a slower wage increase than 1% per year. At the end of the simulation period the wage rate is more or less in equilibrium.

The consequences of the wage adjustment process for unemployment are straightforward. Till 2020 unemployment is more or less at its equilibrium level, but then unemployment rises as a consequence of wages being too high. When the growth rate of wages becomes smaller than its equilibrium value, wages return gradually to their equilibrium level and unemployment returns to equilibrium unemployment.

The story above is consistent with the classical view on unemployment as discussed by Keynes(1936) and Hicks(1937). It is a stylized representation of the development of one of the causes of unemployment in the 1970s and 1980s, as discussed in Woltjer (2007).
The second analysis focuses on the sector specific wage adjustment model. On a macroeconomic level, the behaviour of the model is not fundamentally different from

that of the macroeconomic wage adjustment model. However, there are large differences between sectors. Figure 0.4 shows the development of wages in three aggregated sectors (we simulate with much more detail). The model starts in disequilibrium, because we initialize the migration flows symmetrically as one per cent of the minimum of employment in the three sectors involved. Because with growing income the differences in income elasticity of demand generate different growth rates in demand, labour demand for some sectors is structurally rising, while in others it is structurally declining. This explains why at the start of the simulation the rise in wages is less than 2% in agriculture, with a net outflow of labour, and more than 2% with a net inflow of labour (Figure 4).

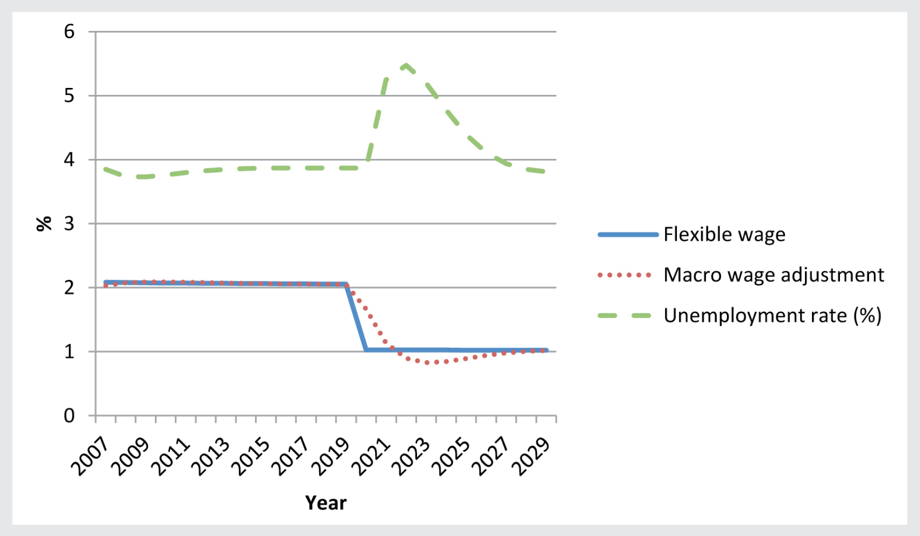

Figure 4: Wage adjustments in the sector wage adjustment model

When productivity decreases, we see for all sectors more or less the same pattern, but we see that agriculture is declining far below 1% of wage growth, while wage growth in services is below 1% for only a short period of time.

This has consequences for unemployment per sector (figure 5). We see that till 2019 unemployment in the labour loosing sector increases a little bit, while it increases in the labour attracting sector. Around 2019 equilibrium is more or less reached.

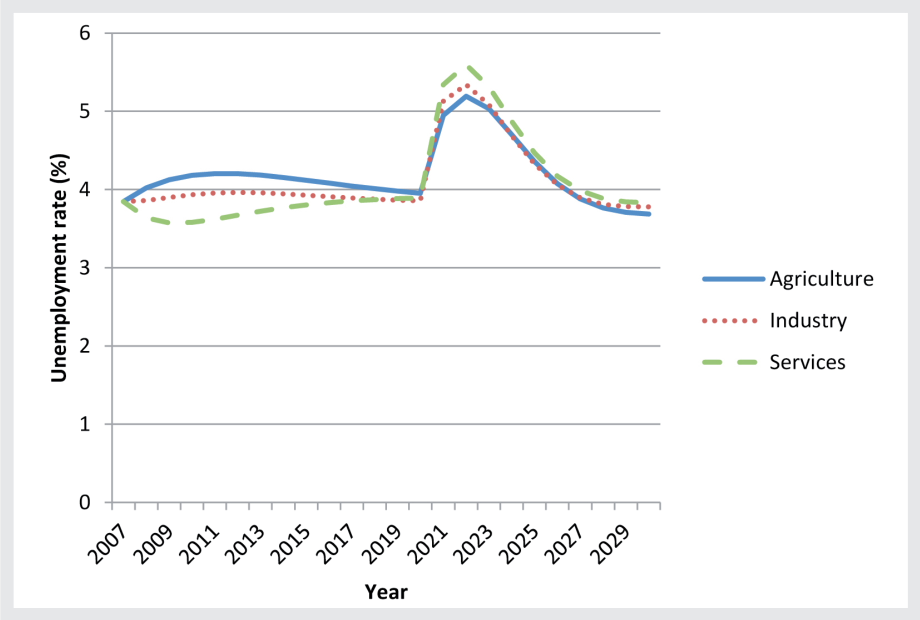

Figure 5: Unemployment in the sector-wage-adjustment model

After 2020 we see again that unemployment rises for some years, and then decreases till the equilibrium level. Agriculture generates less unemployment than industry, and industry less than services. This has to do with the wage history till 2019, where the wages in agriculture are already much lower than in services. Till now the focus was completely on the Netherlands. However, the Netherlands operates in an international context that was implicit in the discussions above. In order to show the importance of the international context, we apply the sectorally different labour market also in the rest of the world, with the rest of the assumptions the same. Figure 6 shows that when the rest of the world has the same institutional setting for wage setting as the Netherlands, that wage growth lags more behind other sectors, while the unemployment rate is higher. The reason is obvious: when also in the rest of the world wages in agriculture become lower, the competitive position of the Netherlands becomes worse and therefore unemployment is higher.

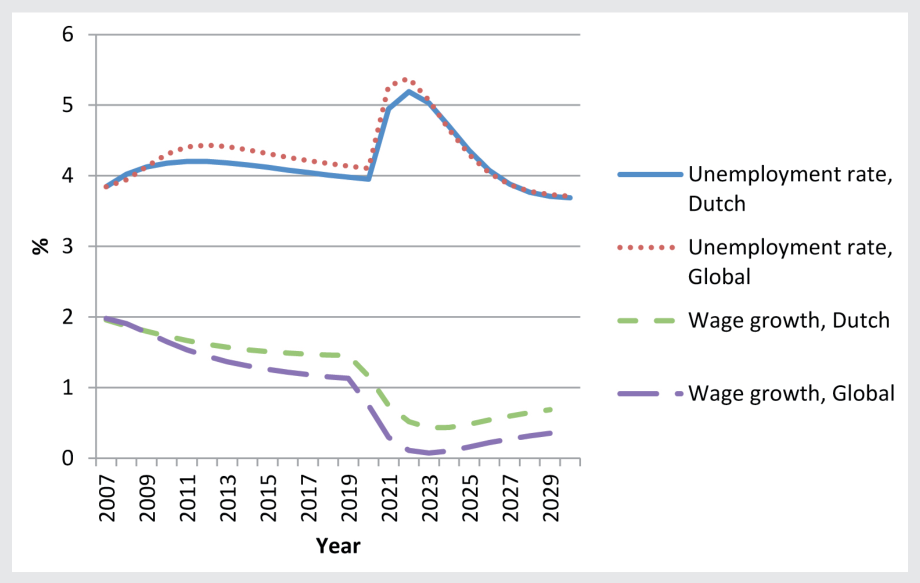

Figure 6: Unemployment and percentage wage change in Dutch agriculture in the model with global sector inflexible wage versus only in the Netherlands

In order to investigate the logic of the model, we also simulate the consequences of a simple sector-specific shock. We reduce the consumer demand for other industry and transport with 30% in 2020 for the whole world in order to see the effects on the Dutch economy. This sector-specific shock could be an example of the type of sector-specific shocks as a consequence of the current crisis, although it is obvious that the essence of the current crisis cannot be captured with the current general equilibrium model.

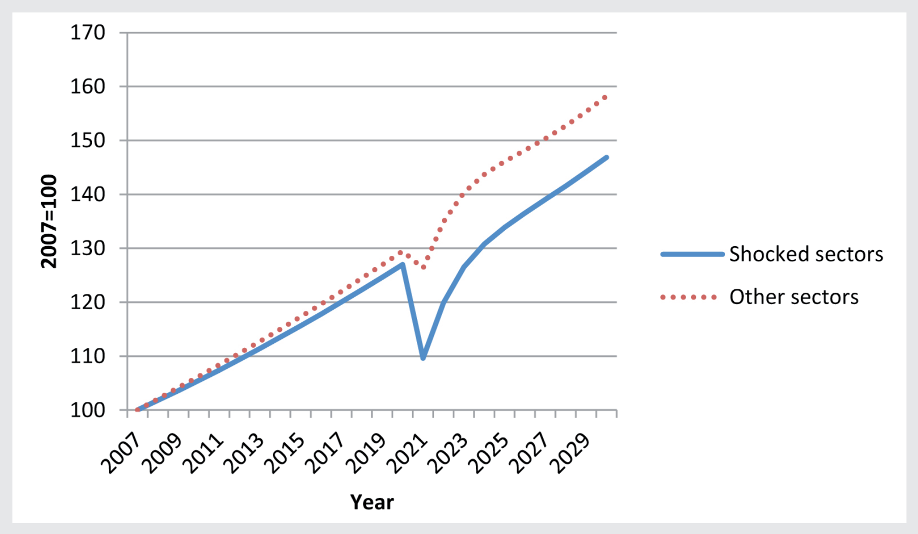

Figure 7: Production development of shocked versus non-shocked sectors

Figure 7 shows that production in the shocked sectors is reduced with about 15% in 2020, but that production in the other sectors is reduced as well. The causes of this are two-fold. First, the increase in unemployment in the shocked sectors reduces income and therefore demand in the whole economy. Second, the shocked sectors will demand less of the other commodities as intermediate inputs. Thus, in this general equilibrium framework, a sector-specific shock can generate an economy-wide reduction in production.

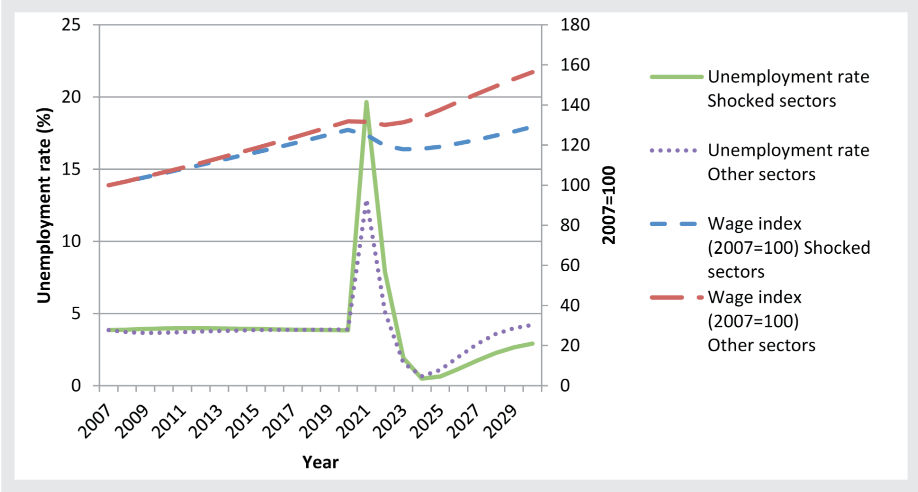

Figure 8 Wage and unemployment development of shocked versus non-shocked sectors

Figure 8 shows the consequence of the reduction in production for unemployment. The shocked sectors experience an increase in the unemployment rate to 20%, but also the non-shocked sectors show a significant increase in unemployment rate. This generates a general decrease in wages that with the current parameters solves the unemployment problem very fast. Because of the role of the wage history in wage setting, the reduction in wages is overshooting its target and a period with a very low unemployment rate starts. Looking at the results, it seems that mobility reacts a little bit too easily to unemployment and wage differences, where it seems that everyone in the shocked sectors finds work outside the problematic sectors easily. The lack of rationing on the demand side through increasing vacancies provides the opportunity to generate a very low unemployment rate in the economy after 2023, that goes back to more or less normal levels at the end of the simulation period.

The interesting conclusion of the demand shock exercise is that the GTAP CGE model in combination with the sector-unemployment mechanism is able to generate macroeconomic unemployment that is not too far from a Keynesian type of unemployment. The productivity slowdown experiment shows that a productivity slowdown generates endogenous unemployment through a lagged wage adjustment.

6. Discussion and conclusion

This paper was focused on the implementation of two types of unemployment in the CGE model MAGNET. The first type is neoclassical unemployment of the macro type, and the second is unemployment as a consequence of sector dynamics. Frictional unemployment is assumed, not explained, while also cyclical unemployment is not explicitly included, because monetary policy and disequilibrium investment are not included in the model.

The setup of the modules has been kept as simple as possible. Even within the current mechanisms a lot of flexibilities are available. For example, by making migration flows within a group of sectors bigger, the ease of substitution within this group can be increased. By changing the parameters for effects of unemployment and wage on the flows, the relative effect sizes for these two variables can be changed. And making the parameter of the wage adjustment curve sector, labour type and region-specific, a lot of differentiation can be incorporated with respect to the dynamics of wages. This flexibility creates the possibility to bring empirical content into the wage and unemployment module.

One of the weak elements of the standard GTAP model is the lack of a sector-specific investment module. Woltjer (2013b) has implemented a module that models international investment allocation dynamically based on average relative profitability in different countries and has an explicit relationship between investment and the growth of capital stock. Because of the importance of investment for sector developments, such a mechanism should also be included on a sector level within countries in order to improve on the dynamics of the labour market (Woltjer, 1995).

In the future it would be interesting to base the parameters of the wage adjustment and migration equations on empirical data. For example, in Tabeau and Woltjer (2010) dynamic migration functions from agricultural to non-agricultural sectors have been estimated for OECD countries that can be directly integrated in a CGE model.

In order to model the dynamics of unemployment more realistically, not only a sector differentiation but also a more detailed skill differentiation is required. Furthermore, in order to be able to model the dynamics of the current crisis it is essential that also a Keynesian type of dynamics is introduced which allows for explicit investment that is not automatically determined by savings, but also allows for causation the other way round.

In summary, two adjustment mechanisms in the labour market have been introduced: delayed wage adjustment and explicit labour migration between sectors. An experiment with a productivity slowdown and an experiment with a sector-specific demand shock have shown the dynamics of the labour market institutions that have been created. The design of the system opens opportunities to fine tune the parameters of the system to empirical information and to implement other institutions within the same framework.

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