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Juha Honkatukia, Jere Lehtomaa, Naufal Alimov,
Janne Huovari ja Olli-Pekka Ruuskanen

Alueellisen taloustiedon tietokanta

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Juha Honkatukia, THL, Jere Lehtomaa, ETH Zürich, Naufal Alimov, Janne Huovari, Olli-Pekka Ruuskanen, Pellervon taloustutkimus PTT ry

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Tiivistelmä

Tutkimushankkeessa täydennettiin kansantalouden tilinpidon aluetilinpitoa tuottamalla päivitetyt, alueelliset kysyntä- ja tarjontataulukot, kehittämällä alueelliset tilinpidon matriisit ja kuvaamalla sektoreiden väliset tulonsiirrot. Tavoitteena oli, että hanke tukisi talouspoliittista suunnittelua ja vaikutusarviointia läpinäkyvällä tavalla sekä aineistojen että niitä hyödyntävien mallien avulla. Hankkeessa tuotettiin alueelliset panos-tuotosaineistot Tilastokeskuksen (TK) aluetilinpidon julkaisutasolla.

Tämän projektin pohjalta tapahtunut aluetilinpidon tietopohjan parantaminen tukee tulevaisuudessa julkisten sektorien kestävyyden ja maakuntien tarpeiden arviointia, ennakointia ja yhteensovittamista. Hankkeessa sovellettiin uusia aineistoja vuosien 2008 – 2014 laman aikana tapahtuneen rakennemuutoksen kuvaamiseen ja aluetalouden kehityksen ennakointiin. Tutkimuksessa myös julkaistiin tuotetuista aineistoista koottu tietokanta, joka soveltuu alueellisella tasapainomallilla tehtävään analyysiin. Tietokanta esitettiin REFINAGE-tasapainomallin käyttämässä muodossa, ja hankkeen yhteydessä julkaistiin lisäksi FINAGE/REFINAGE-mallin kuvaus mallikoodeineen. Hankkeessa kehitettiin sähköisiä tietosisältöjä, joten hankkeen päätulokset löytyvät PTT ry:n ylläpitämällä sivustolla osoitteessa: http://www.ptt.fi/julkaisut-ja-hankkeet/kaikki-hankkeet/alueellisen-taloustilastojen-tietokanta-alta.html

Tämä julkaisu on toteutettu osana valtioneuvoston selvitys- ja tutkimussuunnitelman toimeenpanoa. (tietokayttoon.fi)
Julkaisun sisällöstä vastaavat tiedon tuottajat, eikä tekstisisältö välttämättä edusta valtioneuvoston näkemystä.

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Studieprojektet resulterade i uppdaterade regionala tabeller för efterfrågan och utbud, förbättrade regionala matriser för socialräkenskaperna och en beskrivning av inkomstöverföringarna mellan de olika sektorerna i syfte att komplettera de regionala räkenskaperna i anslutning till nationalräkenskaperna.

Syftet var att projektet ska stödja ekonomipolitisk planering och konsekvensbedömning på ett transparent sätt med hjälp av såväl materialet som modeller där materialet utnyttjas. I projektet skapades regionalt input-outputmaterial för Statistikcentralens publicering av regionalräkenskaper.

I framtiden kommer det förbättrade informationsunderlag för de regionala räkenskaperna som projektet bidrog med att utgöra stöd för bedömningen, prognostiseringen och sammanjämkningen av hållbarheten inom de offentliga sektorerna och landskapens behov.I projektet tillämpades ny data för att beskriva omstruktureringen av ekonomin under resessionen 2008-2014 samt för att förutsäga den regionalekonomiska utväcklingen.I studien publicerades även en databas med det material som togs fram. Den lämpar sig för analyser med den regionala jämviktsmodellen och presenterades i den form som används i jämviktsmodellen REFINAGE. Dessutom publicerades en beskrivning av modellen FINAGE/REFINAGE inbegripet modellkoderna. Informationsinnehållet från projektet är i elektroniskt form, varför de huvudsakliga resultaten finns tillgängliga på http://www.ptt.fi/julkaisut-ja-hankkeet/kaikki-hankkeet/alueellisen-taloustilastojen-tietokanta-alta.html som administreras av Pellervo ekonomiska forskningsinstitut PTT.

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Abstract

The project augmented regional accounts of the national economy by updating regional demand and supply tables, developing regional accounting matrices, and describing cross-sector income transfers. The project was designed to support economic policy planning and impact assessment in a transparent manner, using datasets as well as models utilising them. The project also produced regional input-output datasets at the regional accounts level as defined by Statistics Finland.

The improvement of the knowledge base of regional accounting achieved in this project will support future assessment, forecasting and coordination of public-sector sustainability and regional needs. The datasets that were derived in the project was used to illustrate the changes in the regional production structures between 2008-2014 and also to forecast future developments. A database consisting of the data collected in the project was also published and is suited to analyses conducted with the regional equilibrium model. The database was published in the format used by the REFINAGE equilibrium model; a description of the FINAGE/REFINAGE model with model codes was also published. Because the project also developed data in digital format, the main results of the project can be found on a website maintained by PTT: http://www.ptt.fi/julkaisut-ja-hankkeet/kaikki-hankkeet/alueellisen-taloustilastojen-tietokanta-alta.html

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Sisältö

1 Johdanto

1.1 Tausta

Suomen alueellinen väestö- ja talouskehitys on epätasaista. Kansantalouteen on kohdistunut suuria rakenteellisia muutospaineita tällä vuosituhannella. Monet toimialat ovat käyneet läpi ennennäkemättömän kasvun ja sitä seuraavan kuihtumisen syklin, jonka vaikutukset heijastuvat aluetalouteen hyvin selvinä. Suomen talous on myös keskittynyt entistä selvemmin muutaman kasvukeskuksen ympärille. Tämä kehitys muuttaa hyvin syvällisesti koko maata ja heijastuu kansalaisten elämään ja julkisen sektorin toimintaan. Selvimmin kehitys koskettaa julkista sektoria väestön nopean vanhenemisen ja työikäisen väestön alueellisen keskittymisen kautta. Tämän kehityksen myötä suuressa osassa Suomea aluetalouden kasvuedellytykset ovat heikkenemässä samanaikaisesti kun julkispalvelujen tarve kasvaa. Alueellisten kasvuedellytysten turvaaminen on jäämässä entistä enemmän julkisen sektorin varaan yksityisen elinkeinoelämän alueellisten toimintaedellytysten muuttuessa. Kuitenkin myös julkisen sektorin alueelliset toimintaedellytykset ovat heikkenemässä, kun veropohja kapenee useimmissa maakunnissa.

Aluerakenteen murros asettaa haasteita talouspolitiikalle ja julkisten palvelujen pitkäjänteiselle suunnittelulle ja korostaa alueellisen taloustiedon tarvetta. Julkisen palvelutuotannon uudistaminen kuitenkin edellyttää alueellisen talouskehityksen monilta osin aiempaa syvällisempää seurantaa ja ennakointia. Tulevat uudistukset ovat myös muuttamassa julkisten sektorien roolia ja vaikuttavat niiden tuloihin ja menoihin sekä niiden vastuulla oleviin ja niiden välisiin tulonsiirtoihin. Myös muuttoliike asettaa uusia haasteita aluekehitykselle.

Alueellisten taloustilastojen tarve on siten lisääntynyt. Kun Tilastokeskus on karsinut monien aluetaloutta kuvaavien tilastojen tuotantoa jo pidemmän aikaaei uudistusten arviointiin ole kaikin osin ollut kattavaa, julkista tietopohjaa.

Alueellisen tilinpitojärjestelmän erityisenä puutteena on ollut alueellista tuotantorakennetta kuvaavan tiedon puutteelisuusTietoa tuotantorakenteesta on ollut ajantasaisena käytössä vain arvonlisän osalta panos-tuotosrakenteen jäädessä jo vanhentuneen tiedon varaan. Viimeisimmät panos-tuotostaulukot ovat vuodelta 2002.

Aluetaloutta koskevalle tiedolle on kuitenkin ollut jatkuva tarve rakennemuutoksen, työvoiman ja koulutustarpeen ennakoinnin näkökulmista. Tähän tarpeeseen on useiden vuosien ajan vastattu tuottamalla puuttuva tietoa yksittäisissä tutkimushankkeissa. Esimerkiksi alueellisten panostuotosaineistojen päivittämiseen on viimeisen kymmenen vuoden aikana panostettu useassa tutkimushankkeessa.

Valtiovarainministeriö (VM) ja Työ- ja elinkeinoministeriö (TEM) ovat rahoittaneet alueellisen panostuotosaineiston ja alueellisen tasapainomallin kehitystä erinäisissä hankkeissa (muun muassa Honkatukia ym. 2007). Myös ympäristöministeriö (YM) on rahoittanut alueellisten aineistojen kehittämistä esimerkiksi rakentamiseen liittyvien kysymysten tarkastelun mahdollistamiseksi (Honkatukia ym. 2015). Muita laajoja hankkeita on ollut Suomen Akatemian (SA) rahoittama alueellisen tasapainomallin ja sen tietokantojen päivittäminen (REFINAGE-malli) vuonna 2016 käynnistyneessä BeMine Strategisen tutkimuksen neuvoston (STN) hankkeessa, jossa kehitettiin etenkin alueellisen väestöennusteen ja muuttoliikkeen mallintamista uudella tavalla, samalla kun päivitettiin alueellisen tasapainomallin perusaineistoa sekä panostuotosaineiston että julkisten sektorien alueellisten tulojen ja menojen sekä sektorien välisten tulonsiirtojen osalta.

Nykyinen hanke voidaan siten nähdä jatkumona sarjassa tutkimushankkeita, joilla on pyritty parantamaan politiikkatoimenpiteiden tietopohjaa ja arvioimaan aluetalouden rakenteellista kehitystä. Aineistojen lisäkehityksen lisäksi hankkeen uutena elementtinä on aineistojen avoimuuden ja laajan saatavuuden lisääminen.

1.2 Tavoitteet

Tämän hankkeen päätavoitteena oli täydentää aluetilinpitoa tuottamalla päivitetyt, alueelliset kysyntä- ja tarjontataulukot , kehittämällä alueelliset sosiaalitilinpidon matriisit ja kuvaamalla sektoreiden väliset tulonsiirrot. Kokonaistuotannon kuvaus rakentuu alueellisten tasapainomallien metodologiaan, jolla aluetilinpitoa on täydennetty vastaavasti monissa maissa niin Pohjois- ja Etelä-Amerikassa kuin Aasiassakin (esim. Wittwer, 2017).

Aluetilinpidon täydentämisen ja ajantasaistamisen tavoitteena oli:

1. Tilastokeskuksen aluetilinpidon julkaisutasoisen alueellisen panos-tuotosaineiston tuottaminen.
2. Julkisten menojen ja tulonsiirtojen kuvaus hyödyntäen THL:n tietoaineistoja terveys- ja hoivapalvelujen tuotannosta ja kustannuksista ja uudistumassa olevasta VOS-kriteeristöstä ja maakuntakriteeristöstä.
3. Tutkimusta palvelevien, julkisten tietoaineistojen muodostaminen.
4. Tutkimusta palvelevan, alueellisen tasapainomallin tietokannan ja mallin kuvauksen julkaiseminen (REFINAGE-malli, Liite C.).

Tutkimuksessa kehitetyt tietoaineistot tukevat aluetalouden tutkimusta monella tapaa. Tässä hankkeessa arvioitiin tuoreeltaan aluetalouden rakenteen muutosta vuonna 2008 alkaneen laman aikana vuoteen 2014 saakka.Tietiokannan perusteellanäytettiin, kuinka erityisesti vientiteollisuuden suuret muutokset näkyvät useiden maakuntien aluetalouden rakenteessa. Lisäksi hankkeessa näytettiin, kuinka rakennetiedon perusteella voidaan arvioida aluetalouden kehitystä tulevaisuudessa.

1.3 Toteutus

Tutkimuksen toteutuksen perusajatus on ollut hyödyntää kansallisten tarjonta- ja käyttötaulujen ja aluetilinpidon tietojen luomia edellytyksiä tarjonta- ja käyttötaulujen alueellistamiseen käyttäen talouden rakenteiden kehitystä ja talouspolitiikkaa arvioivan yleisen tasapainon malleihin perustuvassa lähestymistavassa kehitettyjä, laajassa käytössä olevia menetelmiä ja ohjelmistoja. Näitä ratkaisuja on sovellettu kymmeniin maihin, mukaan lukien Suomi (esim. Honkatukia 2013). Tämä lähtökohta on sanellut hankkeen työvaiheiden ajoituksen ja linkityksen toisiinsa, siten, että viimeinen vaihe, alueellisten panos-tuotosaineistojen tuottaminen, on perustunut tasapainomalleille tuotettuihin tietokantoihin, joiden käyttämä aineisto on monin osin huomattavasti panos-tuotosaineistoja laajempi.

Tutkimuksessa hyödynnettiin Tilastokeskuksen aluetilinpidon tietoja niiden koko laajuudessa. Aluetilinpito kerää yhteen aluetason arvonlisää, pääomanmuodostusta ja työllisyyttä koskevaa tietoa ja kattaa siten kokonaistuotannon tarjontaerät varsin hyvin. Käyttöerien suhteen aluetilinpito ei ole yhtä kattava – se kuvaa yksityisen ja julkisten sektorien taloustoimet mukaan lukien verotuksen ja tulonsiirrot julkisten sektoreiden välillä ja julkisilta sektoreilta kotitalouksille. Lisäksi se kattaa pääomanmuodostuksen. Aluetilinpito sisältää myös toimialojen välituotekäytön summan, mutta ei välituotteita tarjontatoimialoittain eikä alueiden välisiä kauppavirtoja.

Hankkeessa täydennettiin nimenomaan tiedollisia aukkoja tutkimuksellisin keinoin, mutta hyödyntäen kaikkea sitä rakennetietoa, joita aluetilinpitoon oli jo koottu. Tämä toteutettiin koko maan tasoisen panos-tuotosaineiston pohjalta, joka alueellistettiin aluetilipidon alueellisesta arvonlisästä jo tuottamien aineistojen avulla. Alueellisten kauppavirtojen osalta sovellettiin painovoima-menetelmää, jota on käytetty TEM:n ja VM:n rahoittaman alueellisen tasapainomallin tietokantojen tuottamisessa ja monissa tutkimushankkeissa (esimerkiksi Honkatukia ym. 2007, 2013); Myös Suomen Akatemian rahoittamassa BeMine-hankkeessa on päivitetty panos-tuotosaineistoja julkaisutasolta alkaen samalla menetelmällä. BeMine-hankkeessa on myös koottu julkissektorien nykyrakenteisista tulonsiirroista ajantasainen tietokanta, joita molempia tässä hankkeessa hyödynnettiin.

Hankkeessa varauduttiin tulonsiirtojen rakenteen muutokseen maakunta- ja sote-uudistuksen edetessä ja luotiin edellytys julkisten menojen ja maakunta- ja kuntasektorien rahoitusaseman ja tulonsiirtojen kehityksen arvioinnille. Hankkeen alkuperäisenä tarkoituksena oli myös tukea hankkeen alkaessa tekeillä olevia maakunta- ja sote-uudistuksia. Uudistusten kariutuminen on vaikuttanut hankkeen toteutukseen eräiltä osin.

Kun alkuperäinen tavoite oli soveltaa Terveyden ja hyvinvoinnin laitoksessa (THL) käynnissä olevan menopaineen arvioinnin päivityksen ja tulonsiirtojen määräytymisperusteiden, erityisesti VOS-kriteerien viimeistä tietoa hyödyntäen, on uudistuksen kariutuminen tehnyt osan näistä tavoitteista mahdottomiksi saavuttaa aiotun aikataulun puitteissa. Menopaineen osalta tavoite kylläkin saavutettiin, mutta SOTE-uudistuksen kariutumisen myötä VOS-kriteeristön päivitys on siirtynyt tulevaisuuteen. Koska on selvää, että uudistus tulee muuttamaan nykykriteerejä mahdollisesti paljonkin, on hankkeessa tyydytty kuvaamaan muuttumassa olevia julkisten sektoreiden välisiä tulonsiirtoja aiottua yksinkertaisemmin.

Hankkeessa tuotettiin paitsi panos-tuotostietokanta, myös FINAGE/REFINAGE-tasapainomallien (ent. VATTAGE/VERM) tietokantojen päivitys uudelle aineistolle. Samalla mallien koodista tuotettiin ajantasainen kuvaus, joka löytyy englanninkielisenä liitteestä C.

Tietokantojen kerääminen toteutettiin Python/Anaconda-ratkaisulla, jonka etuna on aineistotuotannon läpinäkyvyys – tietokantakoodit dokumentoivat jo itsessään aineiston lähteet ja käsittelyn. Vaikka aineisto on yhteensopivaa aluetilinpidon kanssa, on se rakennettu tutkimuksellisin menetelmin eikä siltä osin rinnastu tavanomaisiin tilastoihin. Se edustaa kuitenkin parasta saatavissa olevaa tietoa aluetalouden rakenteesta ja sen kehityksestä. Raja tilaston ja tutkimustuloksen välillä on myös häilyvä: alueellisten panos-tuotosaineistojen tuottamisessa hyödynnetään käytettyjä vastaavia menetelmiä muissa EU-maissakin, eikä esimerkiksi Eurostat ole ohjeistanut alueellisten panos-tuotosaineistojen tuottamista koko maan tasoisten tapaan.

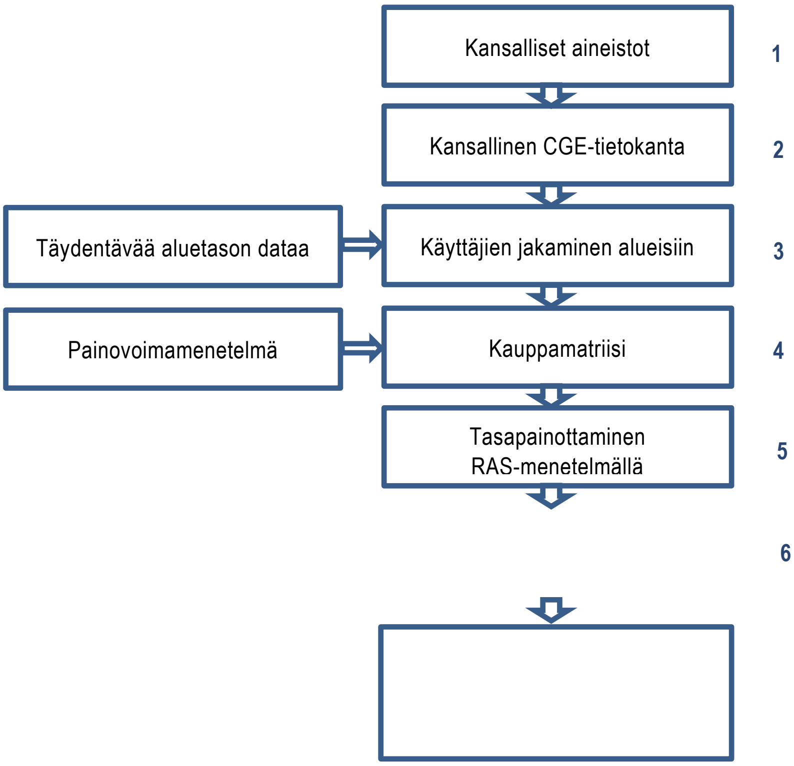
Sen sijaan EU:ssa on kylläkin arvioitu esimerkiksi EU-maiden välisiä kauppavirtoja tässä tutkimuksessa käytetyillä vastaavilla menetelmillä. Esimerkkeinä käy muun muassa EU:n koheesiopolitiikan arvioinnissa käytettävän laskennallisen tasapainomalli (RHOMOLO-malli), minkä lisäksi useissa maissa on arvioitu EU-politiikan vaikutuksia vastaavin menetelmin alueellistetuin panos-tuotosaineistoin. EU arvioituttaa näitä menetelmiä suhteellisen taajaan ja tässä käytettyjä menetelmiä ja malleja on arvioitu myös osana EU:ssa käytössä olevien tasapainomallien arviointia (de Vet, R., Schneider, T. & van Bork (2010)). On ehkä syytä vielä korostaa, että käytetyt menetelmät ovat laajasti tiedeyhteisön käytössä ja edustavat tämän hetken parasta tietoa. Niitä on kuvattu teoksissa (Dixon – Jorgenson (2013), Wittwer (2017)).

2 Tasapainomallien ja alueellisten tarjonta- ja käyttötaulukkojen tuottamisen vaiheet

Hankkeen etenemistä havainnollistaa kuvio 1, johon on koottu ALTA-hankkeen vaiheet. Hankkeen lähtöaineistona toimivat kansallisen tason tarjonta- ja käyttötaulukott ja aluetilinpidon tiedot alueellisesta tuotoksesta ja arvonlisästä. Kansallisten tietojen alueellistaminen tapahtui kaavion 1 esittämissä vaiheissa 1-7. Prosessin aikana raaka-aineistot koottiin avoimeen Python-koodiin perustuvin apuohjelmin suoraan Tilastokeskuksen julkaisutasoisista tietokannoista Tilastokeskuksen API-rajapinnasta. Näin koottu aineisto muutettiin tasapainomalleille tehtävissä simuloinneissa ja tietokannan hallinnassa käytettävän ohjelmistopaketin (GEMPACK-ohjelmistot) vaatimaan muotoon, jolle laaditut apuohjelmat tuottivat yhteen kansallisen ja aluerakennetta kuvaavan tiedon ja tuottivat tasapainotetun, laskentamallein testatun alueellisen mallitietokannan. Näin tuotettu aineisto muunnettiin lopuksi tavanomaisiksi, alueellisiksi tarjonta-, käyttö- ja panos-tuotos -tauluiksi. Prosessissa käytetyt ohjelmistot julkaistiin hankkeen kotisivustolla, ja ne ovat avoimesti asiantuntijoiden käytettävissä.

Seuraavassa käydään läpi alueellistamisen vaiheet kuvion 1 mukaisesti.

Kuvio 1 työvaiheiden ajoitus ja linkitys



Ensimmäisessä osassa luotiin tasapainomallien rakenteen mukainen tietokanta kansallisesta ja alueellisesta tarjonnan ja käytön rakenteesta. Ensimmäisissä vaiheissa (1, 2) tiedot luettiin kansallisista tarjonta- ja käyttötauluista. Näille tauluille tehtiin tasapainotestit sekä muita alustavia testejä. Lisätietoa työvoimasta, pääomakorvauksista ja maankäytöstä haettiin eri kansallisista lähteistä. Laskentamallin perustietokanta luotiin vaiheittain Tilastokeskuksen avoimista panos-tuotosaineistoista muokkaamalla. Muokkausvaiheet on kuvattu yksityiskohtaisesti myös varsinaisessa iPython-kooditiedostossa. Se mahdollistaa prosessin nopean toistettavuuden raaka-aineistojen päivittyessä, yksittäisten vaiheiden muokkaamisen sekä tietokannan avoimen hyödyntämisen myös muissa tutkimusyhteyksissä.

Saatuja tietoja käytettiin laskettaessa perushintaisia virtoja, jotka on esitetty YTP-muodossa (vaihe 3).

Seuraavassa vaiheessa (vaihe 4) tiedot jaettiin kohdealueille, jotka perustuvat kunkin välituote- ja loppukäyttäjän alueellisiin tietoihin (R001, R002, R003, R004, R005 ja R006): toimialat, investoinnit, kotitaloudet, valtion menot ja alueellinen vienti. Marginaalit esitettiin erikseen. Perushintaiset virrat ja marginaalit yhdistettiin, jolloin saatiin ostajahintaiset hyödykevirrat hintaan.

Seuraavassa vaiheessa (vaihe 5) johdetiin alueiden väliset kauppamatriisit. Tämä on tärkein askel kansallisen tason tietojen alueellistamisessa. Kunkin hyödykkeen kohdalla tämä matriisi näyttää kotimaisen tuotannon ja tuonnin virrat kohdealueelta muille alueille.

Vaiheiden 1-6 tuotoksena syntyi alueellisen YTP-mallin tietokanta. Tämä toimi lähteenä alueellisten panos-tuotosaineistojen kokoamiseen vaiheessa 7.

2.1 Tietokanta-arkkitehtuuri

2.1.1 Tausta

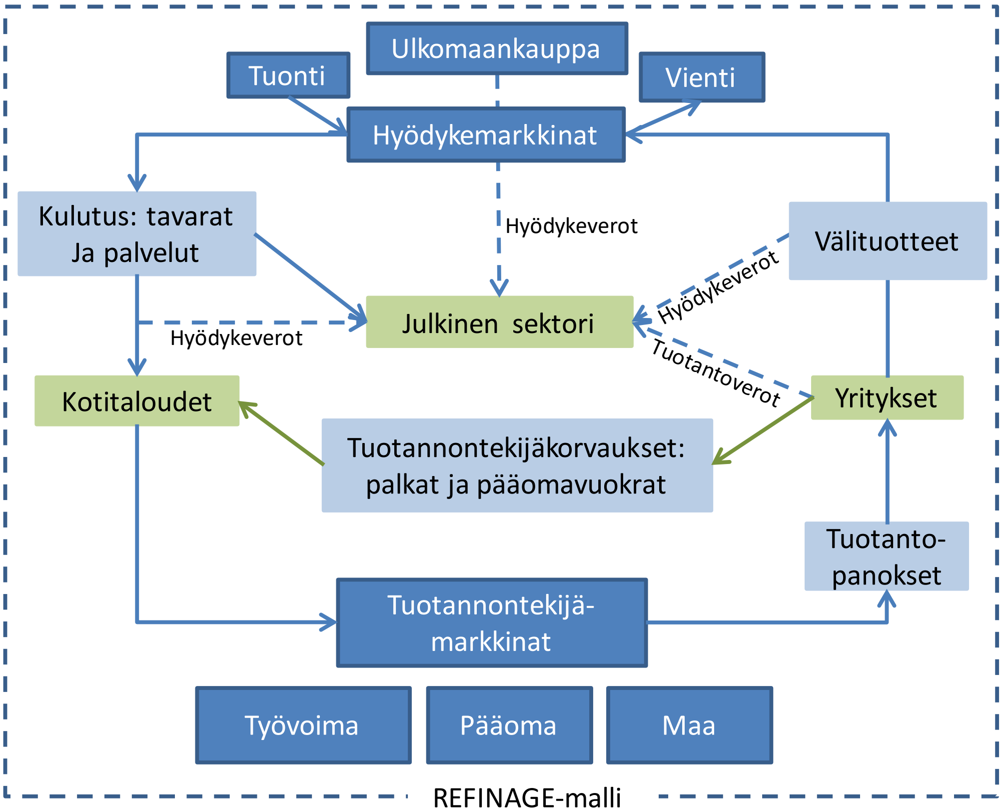
Ensimmäisessä osassa rakennettiin tietokanta ja tietokanta-arkkitehtuuri alueellisten panos-tuotosaineistojen tuottamista varten. Tietokantaan yhdistettiin tarvittavat tiedot eri tietolähteistä sekä siihen liitettiin aikaisemmassa vaiheessa luotu tieto alueellisesta tuotantorakenteesta.

Tietokanta tuotettiin yleisen tasapainon mallien lähtökohdista, ja se heijastaa siksi YTP-mallien rakennetta ja teoreettisia lähtökohtia. Laskennalliset tasapainomallit kuvaavat talouden rahavirrat seurauksina taloudellisten toimijoiden päätöksenteosta, joka puolestaan noudattaa talousteorian logiikkaa.

Tasapainomalli kuvaa taloutta kotitalouksien, kymmenillä toimialoilla toimivien yritysten ja julkisten sektorien päätöksistä käsin. Kotitalouksien keskeisiä päätöksiä ovat kulutus ja säästämispäätökset sekä työn tarjonta. Nämä päätökset kuvataan kansantaloudellisissa malleissa historiassa havaittujen kulutustottumusten pohjalta, joiden lisäksi kulutuksen kehitykseen vaikuttavat hyödykkeiden suhteellisten hintojen ja kotitalouksien käytettävissä olevien tulojen kehitys. Yritykset päättävät tuotantopanosten – työ ja pääoma ja välituotteet – käytöstä pyrkien maksimoimaan tuotannon katetta sekä investoinneista sen mukaan, kuinka eri toimialojen tuotto-odotukset kehittyvät ja suhteutuvat toimialojen historialliseen kasvuvauhtiin ja pääoman tuottoasteeseen. Julkisten sektorien toimintaa kuvaavat ennen kaikkea erilaisen verotuksen rakenne sekä tulonsiirrot kotitalouksille ja toisille julkisille toimijoille. Ulkomaita tarkastellaan lähinnä viennin ja tuonnin näkökulmasta mutta myös kansantalouden ulkoisen velan ja varallisuuden kehittymistä seurataan ja pitkän aikavälin tarkastelussa ulkoinen tasapaino nousee suorastaan määrääväksi.

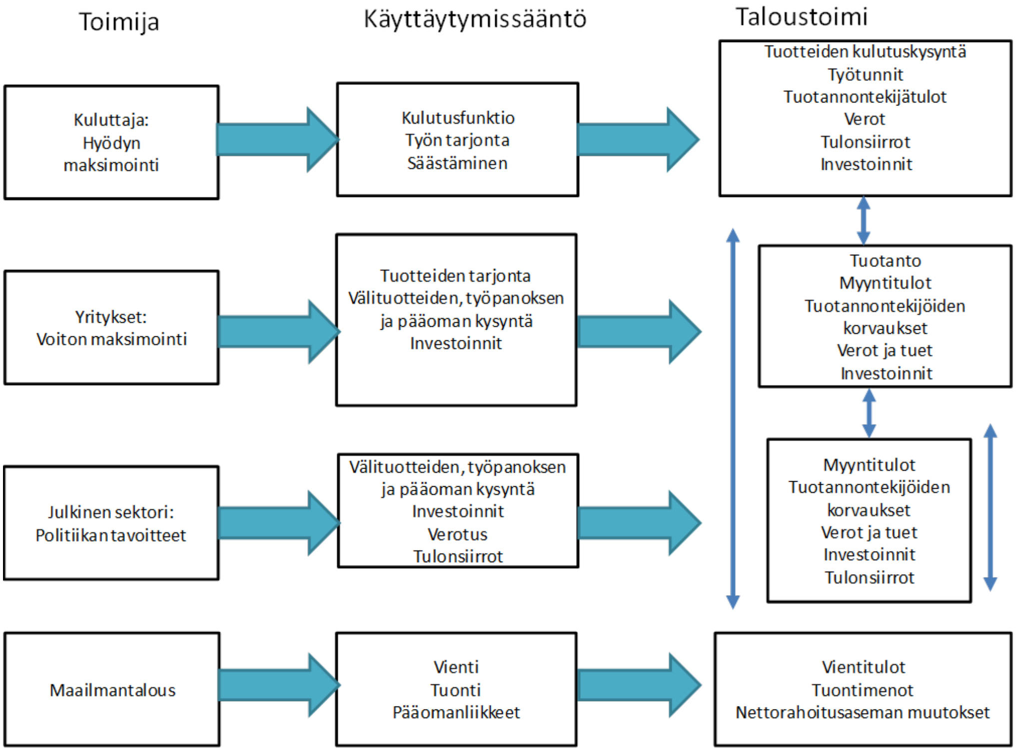
Mallin rakennetta havainnollistaa kuvio 2. Kuviossa kotitaloudet, julkinen sektori ja yritykset ovat taloudellisten päätöksen tekijöitä, joiden valinnoista kumpuavat tavaroiden ja palveluiden kulutuskysyntä ja välituotekysyntä, niiden kysyntä julkisten palveluiden ja hallinnon käyttöön sekä investointikysyntä eri toimialojen investointeihin. Lisäksi kuviosta ilmenee, kuinka osa tavaroiden ja palvelujen loppukysynnästä tulee ulkomailta, ja kuinka tuontitavarat muodostavat osan tavaroiden ja palveluiden kotimaisesta tarjonnasta. Kuviosta näkyvät myös tuotannontekijämarkkinat sekä tuotannontekijätulojen ja erilaisten verotuottojen kohdentuminen. Kysynnän ja tarjonnan tasapaino toteutuu hintamekanismien kautta.

Kuvio 2. Tasapainomallin rakenne



Kuviossa 3 kuvataan näitä lähtökohtia. Kuviossa esimerkiksi kulutuskysyntä syntyy kotitalouksien hyödynmaksimoinnissa tekemistä kulutuspäätöksistä. Yritykset puolestaan maksimoivat voittoja ja niiden käyttämien tuotannontekijöiden kysyntä voidaan johtaa tästä lähtökohdasta. Julkinen sektori puolestaan toteuttaa politiikan tavoitteita, jotka heijastuvat verotuksen, tulonsiirtojen ja julkisen palvelutuotannon rakenteessa. Kaikkien taloudellisten toimijoiden valintoja rajoittavat käytettävissä olevat resurssit – kotitalouksien tapauksessa ennen kaikkea tuotannontekijätulot ja tulonsiirrot. Lopullinen tietokanta kuvaa nämä rahavirrat siten, että ne ovat kohdennettavissa talouden toimijoille.

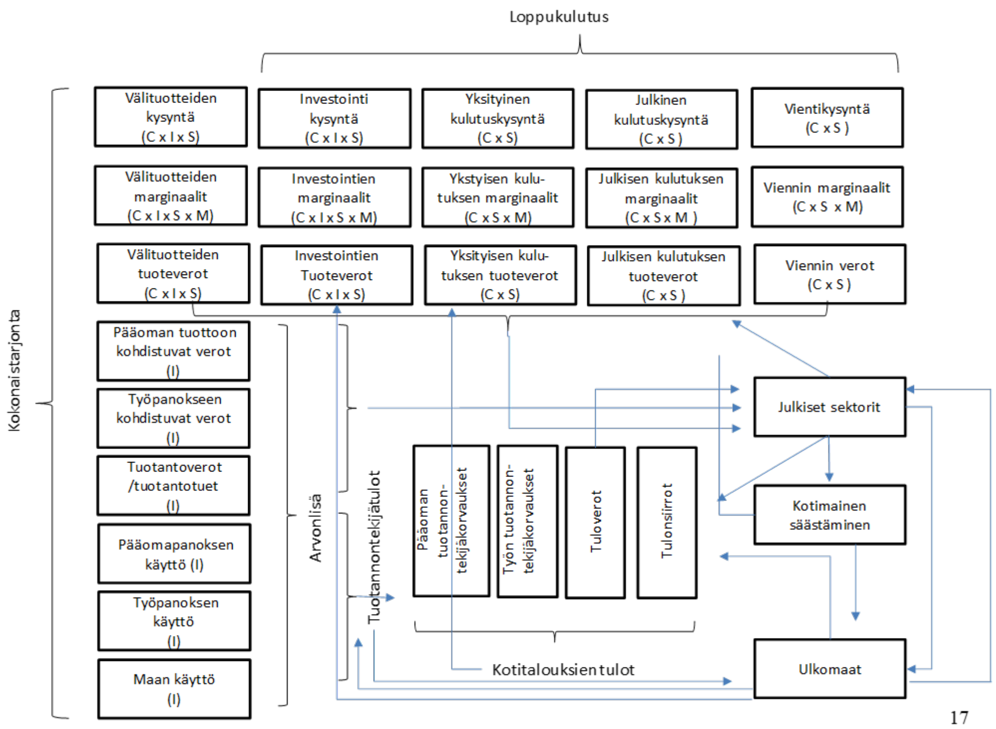
Kuvio 3 Teorian ja taloustoimien väliset yhteydet yleisen tasapainon malleissa



Laskentamallin perustietokanta luotiin vaiheittain Tilastokeskuksen avoimista panos-tuotosaineistoista muokkaamalla. Muokkausvaiheet on kuvattu yksityiskohtaisesti myös varsinaisessa iPython-kooditiedostossa. Se mahdollistaa prosessin nopean toistettavuuden raaka-aineistojen päivittyessä, yksittäisten vaiheiden muokkaamisen sekä tietokannan avoimen hyödyntämisen myös muissa tutkimusyhteyksissä.

Kuviossa 4 kuvataan tätä teorian ajamaa kansantalouden rahavirtojen, varantojen ja taloustoimien jäsentelyä tasapainomallin tietokannassa. Kuviosta näkyy selvästi, että mallin tietokantaan kuuluu monia elementtejä, joita panos-tuotosaineistoon ei sisälly. Panos-tuotosaineisto on toki yksi malliaineiston keskeinen osa, ja tavaroiden ja palveluiden käyttö ja valmistus toimialoittain on johdettavissa tietokannan tietojen perusteella. Keskeinen ero panos-tuotosmallien ja tasapainomallien välillä syntyy siitä, että vain jälkimmäisessä kuvataan hyödykkeiden, varantojen ja tuotannontekijöiden markkinoiden tasapaino, joka toteutuu markkinamekanismien – viime kädessä hintojen sopeutumisen – kautta. Kuten kuviosta 4 käy ilmi, tämä markkinoiden eksplisiittisen tarkastelun vaatimus vaikuttaa hyvin paljon myös tietokannoille asetettaviin vaatimuksiin. Lisäksi tietokannat kuvaavat talouden toimijoiden budjettirajoitteet kohtalaisen hienojakoisesti käsittäen erilaiset tulonsiirrot, suoran ja välillisen verotuksen ja sijoitusvarallisuuden kartuttamisen ja tuoton. Rakenne on toisaalta näennäisestä monimutkaisuudessaan huolimatta hyvinkin tuttu vähänkin mikrotalousteorialle altistetulle tai kansantalouden tilinpidon käsitteisiin tutustuneelle lukijalle.

Kuvio 4 Tasapainomallin tietokannan rakenne



2.1.2 Kansallisen tietokannan kokoaminen ja muokkaus

Seuraavassa kuvataan tietokannan rakentamisen vaiheita kuvion 1 mukaisesti. Prosessin aluksi raaka-aineisto (käyttö- ja tarjontataulukot) haetaan halutulle perusvuodelle Tilastokeskuksen API-rajapinnasta. Aineistoa muokataan lähinnä nimeämällä muuttujia uudelleen, mutta yhteensopivuuden varmistaminen tasapainomallin kanssa asettaa aineistolle myös joitain lisävaatimuksia. Tärkein muokkaus koskee negatiivisia lukuarvoja, jotka ovat tasapainomallin tietokannassa sallittuja ainoastaan varastojen muutoksissa. Esimerkiksi vuoden 2014 panos-tuotosaineistossa on julkisen kysynnän perusvirroissa negatiivisia arvoja yhteensä 22 miljoonan euron edestä, pääasiassa kiinteistöalan palveluissa. Koska yksittäiset negatiiviset arvot ovat hyvin pieniä, ne siirretään sellaisenaan julkisesta kysynnästä varastojen muutokseen. Tämä säilyttää alkuperäisen aineiston tasapainon ilman tarvetta erilliselle tasapainotukselle esimerkiksi

RAS-algoritmin avulla. Tässä vaiheessa varmistetaan myös, että kansantalouden tilinpidon laskentaidentiteetit perus- ja ostajahintojen, verojen sekä kaupan ja kuljetuksen lisien osalta täsmäävät tasapainomallin tietokantavaatimusten kanssa.

Perustietokanta luodaan säilyttämällä raaka-aineiston hyödyke- ja toimialajaottelun tarkkuus, 64 hyödykettä ja toimialaa. Ainoa aggregointi tässä vaiheessa on voittoa tavoittelemattomien yhteisöjen kulutusmenojen yhdistäminen kotitalouksien kulutusmenoihin.

Tietokannan alueellistamisvaiheessa aineistoa joudutaan aggregoimaan enemmän, sillä Tilastokeskuksen avoin alueellinen panos-tuotosaineisto on saatavilla ainoastaan 30 toimialan ja hyödykkeen tarkkuudella.

2.2 Kansallisen tasapainomallin tietokannan luominen

2.2.1 Tuotannontekijät

Seuraavassa vaiheessa aineistosta erotellaan kolme tuotannontekijää: työvoima, pääoma, sekä maa. Toimialoittaiset palkansaajakorvaukset saadaan suoraan panos-tuotosaineistosta, mutta tämän lisäksi tiedot on tasapainomallia varten jaoteltava vielä ammattiluokittain. Tätä varten hyödynnetään Opetushallinnon tietopalveluiden 60 ammattiryhmän Mitenna-ammattiluokitusta, ja sen TOL 2008 -toimialaluokituksen kanssa yhteensopivaa avointa tietokantaa.

Toimialakohtaisesta maankäytön arvosta panos-tuotosaineisto ei puolestaan tarjoa mitään tietoja, joten sen osuus on arvioitava muista lähteistä. Maatalousmaan arvo saadaan Maa-ja metsätalousyritysten taloustilastosta, kun taas metsä- ja kaivannaistoimialojen maan arvon arvioinnissa hyödynnetään kansantalouden tilinpidon mukaista maanparannusten arvoa.

Tässä vaiheessa aineistosta erotellaan myös muut tuotantoverot (D29MD39) sekä perushintainen tarjontataulukko.

Tarjontamatriisi (64 x 64) sisältää nollasta poikkeavia arvoja myös diagonaalin ulkopuolella. Yksi toimiala voi siis tuottaa useampaa eri hyödykettä, tai vaihtoehtoisesti sama hyödyke voi olla peräisin useammalta toimialalta. Tämä ominaisuus mahdollistaa esimerkiksi sivuvirroista tapahtuvan energiantuotannon huomioimisen maa-, elintarvike- tai metsäteollisuuden kaltaisilla toimialoilla.

Tuontitullien kohdistuminen hyödykkeittäin arvioidaan jakamalla Tullin ULJAS-tietokannasta saatava vuotuinen kokonaiskanto (163 milj. € vuonna 2014) hyödykkeittäin painotettujen tuontiosuuksien mukaan. Lisäksi oletetaan, että tuontitulli kerätään ainoastaan CN-nimikkeistön mukaisista tavarahyödykkeistä, eikä esimerkiksi palveluiden tuonnista. Vientiä lukuun ottamatta kaikki tasapainomallissa käytettävät perusvirrat (välituotekäyttö, investoinnit, kotitalouksien kulutus, julkinen kysyntä, varastojen muutos) on jaettava kotimaisen tuotannon ja tuonnin kesken. Hyödykekohtainen tuonnin osuus saadaan jakamalla tarjontataulukon CIF-hintainen tuonnin arvo käytön kokonaisarvolla.

Kaupan ja kuljetuksen marginaalit ovat olennainen osa monipuolisen tasapainomallin rakennetta. Esimerkiksi uudet liikenneinvestoinnit näkyvät tilastoissa suoraan investointikysynnän kasvuna, mutta myös epäsuorasti pienempinä kuljetuskustannuksina ja lyhyempinä matkustusaikoina. Tilastokeskuksen avoimessa aineistossa marginaalit ilmoitetaan kuitenkin ainoastaan hyödykekohtaisena kokonaisarvona. Mallinnusta varten tämä summasarake on jaettava toimialojen ja muiden käyttäjien, tuonnin ja kotimaisen tuotannon kesken sekä marginaalihyödykkeittäin (hyödykeluokat 45 – 52, eli tukku- ja vähittäiskaupan palvelut, maa-, vesi- ja ilmaliikenteen palvelut sekä varastointipalvelut). Kaupan ja kuljetuksen lisiä ei lasketa erikseen varastojen muutokselle.

Yksityiskohtaisemman tiedon puuttuessa tässä oletetaan, että 1) hyödykekohtainen marginaalien osuus on sama jokaiselle saman hyödykkeen käyttäjälle ja 2) marginaalihyödykkeiden osuudet kaikista kaupan ja kuljetuksen lisistä ovat samat kaikille käyttäjäryhmille. Nämä osuudet saadaan laskettua suoraan panos-tuotosaineistosta. Hyödykekohtainen marginaalikäytön osuus saadaan jakamalla hyödykekohtaisen marginaalin arvo ostajahintaisella kokonaiskäytöllä. Yksittäisen marginaalihyödykkeen osuus saadaan jakamalla yksittäinen arvo kaupan ja kuljetuksen lisien yhteenlasketulla kokonaisarvolla. Lopuksi marginaalit jaetaan kotimaisen tuotannon ja tuonnin kesken hyödykekohtaisella tuonnin osuudella painottaen.

2.2.2 Epäsuorat verot

Tuoteverojen ja tukipalkkioiden arvo on raaka-aineistossa saatavilla kahdesta lähteestä: käyttäjittäin eroteltuna perushintaisesta käyttötaulukosta, sekä hyödykkeittäin eroteltuna perushintaisesta tarjontataulukosta. Molemmissa tapauksissa tietueet ovat kuitenkin yksittäisiä summarivejä, kun taas laskentamallin tietokantaa varten epäsuorat verot on allokoitava erikseen kaikkien käyttäjäryhmien ja hyödykeluokkien kesken, sekä jaettava erikseen kotimaisen tuotannon ja tuonnin osuuksiin.

Ensimmäisessä vaiheessa lasketaan käyttäjäryhmittäisten verojen osuus suhteessa koko välituotekäyttöön. Käyttäjäryhmittäinen verotieto saadaan käyttötaulusta. Seuraavassa vaiheessa lasketaan tuote/käyttäjäkohtainen vero. Täten epäsuorien verojen jakautuminen tuotteittain ja käyttäjäryhmittäin perustuu hyödykkeiden käyttöön ja tarjonta- ja käyttötauluissa ilmeneviin veroihin.

2.2.3 Perushintaiset virrat

Täten perushintaiset kotimaan hyödykevirrat (kotimaisista lähteistä loppukäyttäjille ilman kaupan ja kuljetuksen lisiä tai veroja) saadaan eroteltua aineistosta seuraavasti:

$$BAS_{(u,c,dom)} = \sum_{s \in SRC} VPUR_{(u,c,s)} - BAS_{(u,c,imp)} - \sum_{s \in SRC} \sum_{m \in MAR} MAR_{(u,c,s,m)} - \sum_{s \in SRC} TAX_{(u,c,s)}$$

jossa BAS viittaa perushintaisiin virtoihin, VPUR raaka-aineistosta saataviin ostajahintaisiin virtoihin, BAS(u,c,imp) hyödykekohtaisella tuonnin osuudella painotettuun ulkomaankaupan matriisiin, MAR aiemmin laskettuihin kaupan ja kuljetuksen lisiin ja TAX yllä arvioituihin epäsuoriin veroihin. Indekseistä *u* viittaa käyttäjiin, *s* alkuperään (kotim./tuonti), *c* hyödykeryhmään ja *m* marginaalihyödykkeeseen.

2.2.4 Investointien jakaminen toimialoittain

Seuraavaksi investoinnit, jotka käyttötaulukossa ilmoitetaan ainoastaan hyödykekohtaisena summarivinä, on jaettava toimialoittain. Tässä käytettävät osuudet kootaan kahdesta lähteestä: lähtöpisteenä hyödynnetään aiemmin laskettua toimialakohtaista pääoman (toimintaylijäämän) osuutta, josta saadaan ensimmäinen arvio toimialakohtaisesta investointien osuudesta:

$$IND\_SHARE(i) = \frac{V1CAP(i)}{\sum V1CAP(i)}$$

Tätä arviota tarkennetaan kansantalouden tilinpidosta saatavilla kiinteän pääoman bruttomuodostuksen tiedoilla. Aineisto kertoo käypähintaisen bruttomuodostuksen arvon toimialoittain ja varatyypeittäin eroteltuna. Varatyypit ja panos-tuotosaineistossa käytettävä TOL-luokitus eivät kuitenkaan ole suoraan yhteensopivia, mutta valikoiduille toimialoille yhdistäminen onnistuu suoraviivaisesti:

Kuvio 5 Kiinteän pääoman bruttomuodostus

Hyödyke (TOL)	Vara
Rakentaminen (41-43)	Rakennukset ja rakennelmat (N111+N112)
Moottoriajoneuvojen ja muiden kulkuneuvojen valmistus (29,30)	Kuljetusvälineet (N1131)
Elektroniikkateollisuus, sähkölaitteiden valmistus, muiden koneiden ja laitteiden valmistus (26,27,28)	Tieto- ja viestintätekniset laitteet (N1132+N1139)
Tekniset palvelut, tieteellinen tutkimus ja kehittäminen (71,72)	Henkiset omaisuustuotteet (N117)

Sovittamalla arviot näiden pääinvestointityyppien osuuksista toimialoittain parantaa tietokannan kokonaiskuvaa investointien jakautumisesta merkittävästi: esimerkiksi vuoden 2014 aineistossa rakennusten osuus oli yli 55 prosenttia kaikista investoinneista, ja koneiden ja liikennevälineiden osuus noin 20 prosenttia.

Lopuksi saadun aineiston tasapaino on tarkistettava vielä kertaalleen. Siinä varmistetaan, että kotimaisten toimialojen kokonaiskustannukset vastaavat tarjontataulukon mukaista tuotannon arvoa, ja että kotimaisen tuotannon arvo vastaa kaiken kotimaisen käytön perushintaista arvoa.

2.3 Kansallisen tietokannan alueellistaminen

Tietokannan alueellistaminen perustui koko maan tasoisen aineiston jyvittämiseen käytettävissä jo olemassa olevia alueellisia aineistoja jakokriteereinä käyttäen aluetasolle. Aluetilinpidon aineistot tarjosivat monilta osin mahdollisuudet tähän, mutta erityisesti julkisen sektorin ja varastoinvestointien kohdentaminen vaativat muita eriä enemmän oletuksia.

Alueellistamisen keskeiset tietolähteet olivat

R001 Alueellinen tuotos: Tilastokeskus --> Kansantalouden tilinpito --> Aluetilinpito --> Tuotanto ja työllisyys, 30 toimialaa --> P1R Tuotanto perushintaan

R002 Alueelliset investoinnit: Tilastokeskus --> Kansantalouden tilinpito --> Aluetilinpito --> Tuotanto ja työllisyys, 30 toimialaa --> P51TOT Pääoman bruttomuodostus

R003 Alueellinen kulutuskysyntä: Tilastokeskus --> Kansantalouden tilinpito --> Aluetilinpito --> Kotitalouksien taloustoimet --> B6NT Kotitalouksien käytettävissä olevat tulot

R004 Alueellinen vienti: Tulli --> Hyödykkeiden vienti ja tuonti alueittain.

R005 Julkiset sektorit: Tilastokeskus --> Kansantalouden tilinpito --> Aluetilinpito --> Kotitalouksien taloustoimet --> KVAKI keskiväkilukuR006 Alueelliset varastoinvestoinnit: = Noudattavat investointeja R002

Julkisen kulutuksen alueellistamisessa käytettiin COFOG- ja PLUMO-tietoja. Julkisten sektorien maksamien tulonsiirtojen ja niiden muiden taloustoimien kuvauksessa on käytetty useita lähteitä. Valtionosuuksien maksatus on kuvattu VM:n ja Kuntaliiton tietojen perusteella. Kuntien taloutta koskeva tieto on muuten peräisin Tilastokeskuksen kuntatilastoista. Sosiaaliturvarahastojen osalta tiedot ovat KELA:n ja ETK:n tietokannoista.

2.3.1 Julkisten sektorien tulot ja menot alueittain

Kuten yllä nähtiin, kuvaa tasapainomallien tietokanta taloutta pelkkää panos-tuotos -aineistoa laajemmin. Myös nämä tiedot tulivat siksi alueellistettaviksi. Julkisten sektorien tulojen ja menojen tilastointi on varsinkin valtion menojen ja tulojen alueellisen jakauman osalta hyvin puutteellista, kun taas varsinkin kuntataloudesta on saatavissa kohtuullisen yksityiskohtaista tietoa sekä menojen että tulojen osalta. Julkistalouden alueellista jakaumaa jouduttiinkin arvioimaan useita lähteitä yhdistellen.

Julkisten menojen kohdentaminen alueittain toteutettiin sekä julkisten sektorien loppukulutuksen että tulonsiirtojen osalta. Lisäksi kansantalouden tilinpidon aineistoista kerätiin tieto hyödykeveroista, tuista, tulleista sekä julkisten sektorien muista tuloista. Julkisen sektorin osuus on noin viidesosa alueiden tuottamasta BKT:stä. Valtion osuus tästä on noin viisi prosenttia.

Julkisyhteisöjen menojen arvioinnissa on erotettava kolme pääasiallista sektoria: keskushallinto, paikallinen taso (kunnat) ja sosiaaliturvarahastot.

2.3.2 Keskushallinnon menot

Valtion- ja kuntatalouden osalta käytetiin julkisten sektorien tulojen ja menojen tilastoja, joiden pohjalta kuvattiin myös julkisen sektorin hankintamenot COFOG-luokituksen mukaisesti. Jokainen menoluokka kirjattiin PLLUMO-koodilla. Tilastokeskuksesta toimitti tiedot, joilla PLLUMO-koodit täsmäytettiin G-koodeihin, jolla aineistosta saatiin poimittua keskushallinnon menot toimintojen mukaan.

Jako tehtiin hyödyntäen aikaisempaa valtion menojen kohdentamista, jonka Tilastokeskus toteutti vuonna 2012 Työ- ja elinkeinoministeriön pyynnöstä. Tällöin valtion tilivirastoja pyydettiin kohdentamaan omat määrärahat alueittain. Sen jälkeen Tilastokeskus jakoi eri menetelmillä ne varat, joita ei pystytty selvittämään tai joiden aluejako oli hankalaa. Toteutunutta menojen jako-osuutta käytettiin nykyisessä hankkeessa siten, että suhteellisia osuuksia korjattiin viimeaikaisen alueellisen bruttokansantuotteen muutoksen mukaisesti. Tätä verrattiin alueellisilla väestömuutoksilla korjattuun menojakaumaan. Lopullisesti valittiin BKT-pohjainen korjaus.

Keskushallinnon muille julkisille sektoreille ja kotitalouksille maksamia tulonsiirtoja arvioitiin useiden lähteiden perusteella. Keskeinen lähde keskushallinnon tulonsiirroista kuntatalouteen olivat valtionosuuksien maksatusta koskevat tilastot, Lisäksi valtiontalouden osalta jouduttiin arvioimaan myös valtionvelan kertymistä.

2.3.3 Paikalliset (kunnalliset) menot

Paikallishallinnon menot saatiin Tilastokeskuksen Kuntataloustilastosta. Kulujen tyypit yhdistettiin manuaalisesti valtion menojen G-koodeihin toimintamuodon mukaan. Tästä kuntien käyttömenoja koskevasta tilastosta saatiin myös eräitä kuntien maksamia tulonsiirtoja. Kunnallisverokertymiä ja kuntien osuutta yhteisöveroa koskevat tiedot puolestaan saatiin Valtionosuuksien maksatusta koskevista tilastoista Kuntaliitosta.

2.3.4 Sosiaaliturvarahastot

Lopuksi sosiaaliturvarahastojen jakautuminen saatiin, kun YTP-mallin mukaan lasketuista alueellista kokonaismenoista vähennettiin aiemmin lasketut valtion ja paikallishallinnon menot. Sosiaaliturvarahastojen maksamien tulonsiirtojen ja eläkkeiden osalta käytettiin ETK:n ja KELA:n tilastoja, joiden perusteella jaettiin myös muiden julkisten sektorien maksamien tulonsiirtojen alueellisia jakaumia.

2.4 Kauppavirtojen estimoiminen

Kauppavirroilla on tietokannan rakentamisessa keskeinen rooli, koska ne kuvaavat alueiden keskinäistä riippuvuutta toisistaan. Päinvastoin kuin ulkomaankaupasta, maan sisäisistä kauppavirroista ei ole olemassa systemaattista tietoa Suomessa sen paremmin kuin muuallakaan, ja siksi niitä joudutaan arvioimaan erilaisin menetelmin.

Tässä käytetään painovoimamenetelmää, jossa alueiden etäisyydet toisistaan toimivat ensimmäisenä arvauksena kauppavirroille. Menetelmä hyödyntää koko maan panos-tuotosaineistojen lisäksi aluetilinpidosta saatavissa olevaa tietoa tuotannon ja kysynnän rakenteista, esimerkiksi toimialojen arvonlisästä. Alueiden välisiä kauppavirtoja ja vientiä ja tuontia arvioidaan siten alueiden välisten etäisyyksien perusteella.

Painovoimamenetelmän käytöstä tuorein esitys kuvaa Yhdysvaltojen erittäin laajan ja kattavan aineiston muodostamista (Wittwer 2017). Menetelmää on käytetty monissa muissakin maissa, kuten Australiassa, Kiinassa, Etelä-Afrikassa, Brasiliassa ja Suomessa (Honkatukia 2013). Alueellisten panos-tuotostaulukoissa käytettyjä menetelmien ominaisuuksia on jonkin verran arvioitu kirjallisuudessa. Katso (Bonfiglio and Chelli 2008; Flegg and Webber 2000) tarkempaa analyysia eri menetelmien tuottamien mittareiden suhteista.

Kauppavirrat johdetaan painovoimamenetelmää käyttäen. Tässä menetelmässä kaupan volyymi on käänteinen alueiden väliseen etäisyyteen. Kauppamatriisien alkuarvot skaalataan edelleen käyttämällä RAS-menetelmää, jotta taulukot tasapainottuisivat.

Horridge (2011) esittämän menetelmän mukaisesti kauppamatriisi johdetaan painottamalla alkuperäistä matriisia hyödykekohtaisella kertoimella, jonka arvot liikkuvat välillä 0.5 ja 2. Mitä korkeamman arvon kerroin saa, sitä vähemmän hyödyke sopii vaihdettavaksi ja sitä paikallisempaa tuotanto on.

Matriisin diagonaaliset elementit lasketaan alueellisen kysynnän osuutena kokonaiskysynnästä esitettynä hyödykekohtaisella kertoimilla painotettuina osuuksina alueellisesta tuotannosta. Tässä painotuksessa kerroin voi saada arvon väliltä 0.5 ja 1. Mitä lähempänä arvo on ykköstä, sitä hankalemmin vaihdettavissa hyödyke on.

2.5 Tietokannan tasapainottaminen

Edellä kuvatulla keinolla alueellistettu tietokanta ei välttämättä ole välittömästi tasapainossa, vaan alkuperäistä arviota joudutaan tarkentamaan RAS-menetelmän avulla. Menetelmässä kauppamatriisit mukautetaan laskentakehikon rajoituksiin siten, että relevanttien sarakkeiden ja rivien summat muodostuvat yhtä suuriksi.

RAS-lähestymistapaa käytetään kolmivaiheisesti:

Vaihe 1: Sovelletaan perinteistä RAS-menetelmää, jossa yksi rivi tai sarake tasapainotetaan kerrallaan;

Vaihe 2: Seuraavaksi etsitään ratkaisu lineaariseen järjestelmään, jolloin kaikki solut skaalataan kerralla.

Vaihe 3: Palataan takaisin ensimmäisen vaiheen perinteiseen RAS-menetelmään.

Jokaisen RAS vaiheen jälkeen tasapainon olemassaolo tarkistetaan ja saadut tulokset tallennetaan jatkovaiheita varten.

Matriisi voidaan tasapainottaa RAS-menetelmällä esimerkiksi seuraavia rajoitusehtojen vallitessa. Kauppamatriisin summa kohdealueilla pitää olla yhtä suuri kuin perushintaiset hyödykevirrat. Marginaalien summa kauppamatriisissa kohdealueiden yli laskettuna pitää olla saman kuin kokonaismarginaalit. Kotimaisten kauppamatriisien summa yli kohdealueiden täytyy olla yhtä suuri kotimaisen tarjonnan kanssa. Toimitusmarginaalien summa marginaalihyödykkeitä tuottavien alueiden yli on oltava yhtä suuri kauppamatriisin marginaalien summan kanssa.

2.6 Alueellisen tietokannan kokoaminen

Vaiheiden 1-5 tuloksena syntyi alueellisen tasapainomallin tietokanta, jota voidaan käyttää GEMPACK-ohjelmistopakettia käyttävissä malleissa, kuten REFINAGE -mallissa.

Alueellinen tietokanta rakentuu tässä vaiheessa tasapainomallien ehdoilla, ja siksi sitä myös testataan TERM -mallilla (Wittwer et al). Mallilla tehdään tässä vaiheessa myös niin sanottu homogeenisuustesti; kuten tunnettua, tasapainomallit eivät määritä absoluuttista hintatasoa, vaan se normalisoidaan kiinnittämällä jokin mallin hinnoista, ja mallin reaalimuuttujien tulisi olla riippumattomia tästä valinnasta.

Lopullinen aluemallin tietokanta rakentuu kuvion 4 mukaisesti siten, että jokaiselle alueelle rakentuu kuvion mukainen tietokanta, minkä lisäksi näin kuvatut aluetaloudet linkittyvät toisiinsa alueiden välisen kaupan myötä. Myös julkiset sektorit linkittyvät toisiinsa, minkä lisäksi kaikissa maakunnissa toimii oma kuntataloussektorinsa.

Mallin ytimessä olevat, alueellista tuotantoa ja välituotekäyttöä kuvaavat tarjonta- ja käyttötaulukot ovat tulostettavissa mallitietokannasta ja muodostavat tutkimuksen seuraava vaiheen lähtötiedot.

2.7 Alueelliset panos-tuotosaineistot

Seuraavaksi keskityttiin alueellisten panos-tuotosaineistojen tuottamiseen koko maan tasoisten panos-tuotosaineistojen ja aluetilinpidon pohjalta kootun YTP-tietokannan mukaisesti. Viimeisimmät alueelliset panos-tuotostaulukot ovat Tilastokeskuksen vuoden 2002 taulukot. Tämän jälkeen näitä taulukoita ei ole päivitetty.

Tässä osassa muutetaan YTP-mallin tuottama aineisto tarjonta-, käyttö ja panos-tuotostauluiksi. Tarjontataulu tuotetaan YTP-mallista johdetusta TERM metodologialla tuotetusta aineistosta, joka on esitetty kuviossa 6.

Kuvio 6 YTP-Tietokannan tuottamat taustatiedot

Objekti	Kuvaus	Ulottuvuudet
MAKE	Valmistusmatriisi	COM * IND * DST
USE	Perushintaiset + marginaalivirrat	COM * SRC * USR * DST
TAXES	Verot (COM: SRC: USR: DST)	COM * SRC * USR * DST
TRADE	Kuljetus ja huolintamatriisi	COM * SRC * ORG * DST
SUPPMAR	Marginaalit tuotantoyksikköjen toimittamista tavaroista ORG: stä DST: hen	MAR * ORG * DST * PRD
TRADMAR	Marginaalit	COM * SRC * MAR * ORG * DST
STOCKS	Varannot	IND * DST
V1LAB	Palkkamatriisi	IND * OCC * DST
V1CAP	Korvaus pääomalle	IND * DST
V1LND	Maanvuokra	IND * DST
V1PTX	Tuotantoverot	IND * DST

Tässä,

COM-hyödykkeet (1,…, 30);

IND - teollisuudenalat (1,…, 30);

DST - kohde (alue-1,…, alue-19);

ORG - alkuperä (alue-1,…, alue-19);

SCR - lähde (kotimainen, tuonti);

MAR - kuljetus- ja palvelualat (1,2);

PR D -tuotantoalue (alue-1,…, alue-19);

OCC - taidot

2.7.1 Tarjontataulun johtaminen

Alueellisten panos-tuotos -taulujen johtaminen lähtee tarjontataulujen koostamisella. Alueelliset tarjontataulukot saadaan yhdistämällä alueellisen valmistusmatriisin tiedot varantomatriisin. Varantomatriisit johdetaan kunkin hyödykkeen sisältävistä toimialojen varannoista. Alueelliset tuonnit sekä tuonti ulkomailta lasketaan käyttötaulujen tietojen pohjalta, jotka johdetaan seuraavaksi. Tarjontataulu on esitetty liitteen A taulukossa A0.

2.7.1.1 Käyttötaulukot

Perushintaiset käyttötaulukot

Mallissa käyttötaulukot kirjataan perushintaan yhdessä kaupan marginaalien kanssa. Mallissa on kahdenlaisia kauppamarginaaleja; omansa huolto- ja kuljetusalalle ja toinen muille kuin huolto- ja kuljetusaloille.

Kauppamarginaalit vähennetään ne sisältävästä käyttötauluista. Yhteen laskettaessa nämä kahden tyyppiset kauppamarginaalit tulevat nollaksi kunkin toimialan ja käyttäjän osalta. Nämä on esitetty liitteen A taulukossa A1.

2.7.1.2 Käyttötaulukot perushintaan (tuonti ulkomailta)

Tuonti / ulkomaan tuonti johdetaan käyttötauluista. Muiden kuin huolto- ja kuljetusalan marginaalit vähennetään tauluista. Huolto- ja kuljetusalan marginaaleja ei sisällytetä laskettaessa perushintaista tuontia ulkomailta. Nämä on esitetty liitteen A taulukossa A2.

2.7.1.3 Käyttötaulukot perushintaan (kotimainen ja alueellinen tuonti)

Perushintaisen kotimaan käyttötaulun laskemiseksi vähennetään ensiksi perushintainen ulkomainen käyttö alkuperäisestä käyttötaulusta. Saatu matriisi jaetaan kotimaisiin ja alueellisiin käyttötauluihin laskemalla oman käytön osuudella kerrottu kauppamatriisi. Tämä kerrotaan perushintaisella kokonaiskäytöllä jaettuna perushintaisella käyttötauluilla. Tämä on esitetty liitteen A taulukossa A3.

Sitten johdetaan perushintaiset alueelliset perushintaiset käyttötaulukot vähentämällä muut kotimainen käyttö perushintaisesta kotimaisen ja alueellisen käytön omaavasta käyttötaulusta.

Kotimaisiin käyttötauluihin lisätään sarakkeet alueelliselle viennille ja varastoille. Alueellinen vienti saadaan kauppamatriisista, joka kuvaa kunkin alueen viennin muille alueille.

Varastomatriisi lasketaan tarjontataulusta johdetusta matriisista laskemalla yhteen varastot kaikilla toimialoilla.

Perushintaisiin kotimaisiin käyttötauluihin lisätään verot vähennettyinä tukipalkkioilla. Kullekin toimialalle lisätään arvonlisän elementit kuten työvoima, pääoma, maa ja tuotannon verot. Nämä on esitetty liitteen A taulukossa A4.

2.7.2 Johdetut panos-tuotostaulukot

Toimialakohtaisissa panos-tuotostauluissa käytetään myynnin vakiorakenteen oletusta (Eurostat, 2008) [1] Saadut kotimaiset panos-tuotostaulukot ovat esitetty liitteen A taulukossa A5. Kotimaista tuontia muilta alueilta kuvaavat panos-tuotostaulukot ovat liitteen A taulukossa A6. Ulkomaisen tuonnin panos-tuotostaulukott ovat esitetty liitteen A taulukossa A7. Lopuksi tarjonta-, käyttö- ja panos-tuotostaulujen tasapainoehtojen tiivistelmä on esitetty liitteen A taulukossa A8.

Panos-tuotostaulujen (kokonais, alueiden välisten, ulkomaisen ja kotimaisen) perusteella johdettiin jokaista aluetta varten panos/tekniset kerroinmatriisit välituotteiden käytölle ja arvonlisälle. Tekniset kertoimet kuvaavat panosten ja arvonlisän painoja tuotannossa.

Lisäksi johdettiin käänteismatriisi sekä käänteismatriisin ja alueiden välisten kauppamatriisien tulo. Käänteismatriisin avulla on mahdollista tutkia kysynnän muutoksen kokonaisvaikutusta tuotantoon alue- ja sektoritasolla huomioiden muutoksesta syntyvän talouden ketjureaktion.

Konstruoitu käänteismatriisi seuraa alueellista panos-tuotoskehystä. Se kattaa 19 aluetta ja 30 teollisuusalaa, jolloin sen koko on 570X570.(Käänteismatriisin konstruointiin liittyvistä yksityiskohdista katso Miller ja Blair 2009, luku 3.)

3 SOTE-sektorien menot ja maakuntatalous

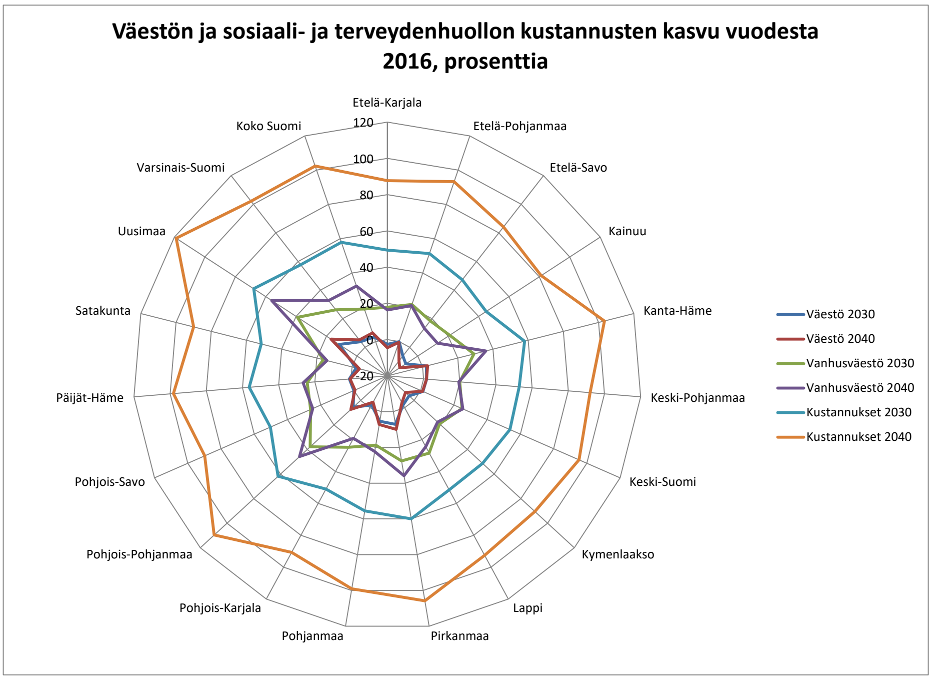
Hankkeessa syvennettiin eräiltä osin julkisten menojen kuvausta aiempaan verrattuna. Hankkeen kolmannessa vaiheessa keskityttiin julkisista menoista suurimpiin, sosiaali- ja terveysmenoihin. Hankkeen alkuperäisenä tavoitteen oli linkittää aluetalouden kasvuennuste maakunta- ja SOTE-uudistusten myötä muuttumassa olevaan, esimerkiksi VOS-kriteeristön ja järjestämisvastuun muutoksiin. Sote-uudistuksen kariuduttua tältä erää on mahdotonta arvioida, millaiseksi järjestämisvastuu on muuttumassa, ja siksi julkisten sektorien vastuita ei ole tässä vaiheessa muutettu. Kun julkisten sektorien välisiin tilinsiirtoihin tiedetään olevan tulossa päivityksiä mahdollisesti piankin, on niiden kuvauksen osalta pitäydytty välttämättömimmässä.

Sosiaali- ja terveysmenot on toisaalta kuvattu THL:n rekisteriaineistoon perustuen siten, että menot on jyvitetty ikäluokille, jolloin on mahdollista ennakoida ikärakenteen vaikutusta sotemenojen kehitykseen. Tätä menettelyä on käytetty aiemmin koko kansantalouden tasolla tuottamaan pääasiallinen arvio SOTE-sektorien menopaineesta ja sen vaikutuksista kansantalouden kasvuedellytyksiin ja julkisten sektorien rahoitusasemaan. Menettelyn myötä on mahdollista alkaa tuottaa myös lisätietoa yksityisestä palvelutarjonnasta sen merkityksen mahdollisesti alkaessa kasvaa.

Menopaineen arviointi perustuu THL:n kehittämän alueellisen SOME-malliin. Malli hyödyntää kuntatilaston tietoja sosiaali- ja terveydenhoidon kustannuksista ja THL:n kokoamia rekisteritietoja palvelujen käytöstä ja yksikkökustannuksista. Menopaineen kehitysarvio perustuu eri toimenpiteistä aiheutuvien menojen kohdentamiseen miesten ja naisten vuositasoisiin ikäryhmiin, jolloin väestöennusteen perusteella on arvioitavissa, kuinka palvelujen volyymi kehittyy tulevaisuudessa. Väestön kasvaessa kaikki kustannukset pyrkivät kasvamaan, mutta ikärakenteen muutos vaikuttaa siihen, millaisiin toimenpiteisiin kasvu kohdistuu. Sosiaali- ja terveysmenot jakautuvat varsin epätasaisesti ikäryhmien ja sukupuolien välillä. Nuorten naisten osuus ikäryhmänsä kustannuksista on suurempi kuin miesten, kun taas 65-70 -vuotiaiden ikäryhmissä miesten osuus kustannuksista on naisia suurempi. Kaikkein suurimmat kustannusosuudet ovat yli 75 -vuotiaille naisilla. Kaikkiaan yli 65-vuotiaiden osuus kustannuksista oli vuonna 2015 noin puolet. Kun kustannukset henkeä kohden laskettuna ovat suurempia vanhemmissa ikäluokissa, väestön vanheneminen pyrkii nostamaan kustannuksia. Väestörakenteen muutos lähivuosikymmeninä näyttää muodostuvan kohtuullisen suureksi: siinä missä yli 65-vuotiaiden osuus väestöstä oli vuonna 2014 noin 20 prosenttia, nousee se vuoteen 2030 mennessä noin 26 prosenttiin, jolle tasolle se näyttää asettuvan.

Kuvioon 5 on koottu maakuntakohtaiset arviot sosiaali- ja terveysmenojen reaalisesta kasvusta vuoteen 2040 mennessä, jos palveluja tuotettaisiin nykyrakenteen mukaisesti. Koko maan tasolla palvelujen volyymi kasvaisi tällöin noin 33 prosenttia.

Kuvio 5 Väestönkasvu ja sote-menopaine vuosina 2016 – 2040 (Lähde: THL)



4 Tietokantojen sovelluksista – kaksi esimerkkiä

Tämän hankkeen keskeinen tavoite oli tuottaa päivitetyt aluetalouden rakennetta kuvaavat tiedot, joiden avulla aluetalouden kehitystä voitaisiin seurata ja ennakoida. Päivitetty aineisto luo edellytyksiä monenlaiselle tutkimukselle, joita havainnollistetaan tässä luvussa kahden esimerkin avulla. Eräs alueellisten panos-tuotos-aineistoijen keskeisistä käyttötarkoituksista on rakennekehityksen seurannassa ja ennakoinnissa. Tässä hankkeessa arvioitiin päivitetyn tietokannan avulla aluetalouden rakenteen muutosta viime vuosikymmenen lopulla alkaneen laman aikana. Sama rakennetieto on toiminut myös lähtökohtana aluetalouden kehityksen ennakoinnille. Kumpikin esimerkeistä käyttää toisten hankkeiden tuloksia rakennusaineinaan: talouden rakennetta uudessa, päivitetyssä tietokannassa kuvattuna vuonna 2014 verrataan useissa hankkeissa (esimerkiksi Honkatukia et al. 2011, Honkatukia 2013) lähtökohtana käytettyyn vuoden 2008 rakenteeseen, joka on aggregoitu uuden tietokannan tasolle; talouden kasvuennuste taas johdetaan Suomen Akatemian BeMine-hankkeessa päivitettyyn alueelliseen kasvuskenaarioon, joka perustuu vuonna 2018 päivitettyn, valtakunnalliseen ENKO-skenaarioon (Honkatukia, Lehtomaa, Kohl 2018) ja on muodostanut pohjan muun muassa valtakunnalliselle liikenne-ennusteelle (Liikennevirasto 2018) ja pitkän tähtäimen ilmasto-ohjelmalle (Koljonen ym. 2017).

4.1 Talouden rakenteen alueelliset muutokset vuosina 2008 - 2014

TEM ja Valtiovarainministeriö rahoittivat useiden vuosien ajan alueellisen tasapainomallin ja sen tietokannan kehittämistä Valtion taloudellisessa tutkimuskeskuksessa. Eräitä näiden hankkeiden tulemia olivat yleiseen käyttöön tarkoitetut tasapainomallit ja niiden tietokannat. Tässä sovelletaan vuoden 2008 alueellista tietokantaa, joka rakenteeltaan ja kokoamistavaltaan vastaa tässä hankkeessa julkaisutasoisista aineistoista koottua tietokantaa (esimerkiksi Honkatukia, Kinnunen ja Ahokas 2011). Tietokantoja vertailemalla on mahdollista kuvata aluetalouden rakenteessa kuutena lamavuonna tapahtunutta muutosta.

Tässä keskitytään muutoksiin muutamissa keskeisissä rakenteissa, nimittäin:

1. Toimialojen alueellisten tuotososuuksien muutos, jolla pyritään kuvaamaan toimialojen alueellisessa merkityksessä tapahtuneita muutoksia
2. Toimialojen arvonlisän rakenteessa tapahtuneet muutokset, joita kuvataan palkkasumman arvonlisäosuudessa tapahtuneella muutoksella

3. Kotitalouksien kulutuksen rakenteessa tapahtuneet muutokset, joita kuvataan hyödykkeiden kulutusosuuksissa tapahtuneella muutoksella¨
4. Aluetalouden materiaalivirroissa tapahtuneissa muutoksissa, joita kuvataan aluetalouden kaikkien toimialojen yhteenlasketun välituotekäytön tuotekohtaisissa osuuksissa tapahtuneissa muutoksissa.

Kuvioon 6 on koottu toimialojen tuotososuuksien muutos Manner-Suomen maakunnissa vuosein 2008 ja 2014 välillä prosenttiyksikköinä mitattuna. Muutos kuvaa siis maakuntien elinkeinorakenteen muutosta tuona taloudellisesti hyvin vaikeana aikana. Toimialarakenne on vertailun perusteella säilynyt yllättävän vakaana, mutta toki lähempi tarkastelu paljastaa joidenkin toimialojen ja maakuntien osalta suuriakin muutoksia. Toimialaosuuksissa on nähtävissä useita muutoksia, jotka heijastavat lamavuosien tapahtumia. Kauan tuotososuus Etelä-Karjalassa on laskenut kolme prosenttiyksikköä, mikä selittynee rajakaupan jyrkällä laskulla vuosikymmenen alussa. Rakentamisen osuus on laskenut kaikissa maakunnissa, mikä vastaa hyvin investointien negatiivista kasvuvaikutusta vastaavana aikana (Honkatukia ja Lehmus 2016); suurinta lasku on ollut Etelä-Savossa, jossa rakentamisen osuus tuotoksesta laski kolme prosenttiyksikköä. Elektroniikkateollisuuden supistuminen näkyy sähkö- ja elektroniikkateollisuuden osuuden laskuna Pohjois-Pohjanmaalla (6,4 prosenttiyksikköä) ja Varsinais-Suomessa (11 prosenttiyksikköä), mikä johtuu tietysti Nokian kotimaisen valmistuksen alasajosta. Metallien ja metallituotteiden valmistuksen osuus laski kaikissa maakunnissa, eniten Keski-Pohjanmaalla (-11,4 prosenttiyksikköä), heijastaen metalli- ja konepajateollisuuden alamäkeä laman aikana. Paperiteollisuuden tuotososuuskin laski monissa maakunnissa, eniten Keski-Suomessa (-10,3) ja Kymenlaaksossa (-8,6), joissa molemmissa suljettiin useita tehtaita vuosien 2008 ja 2014 välillä.

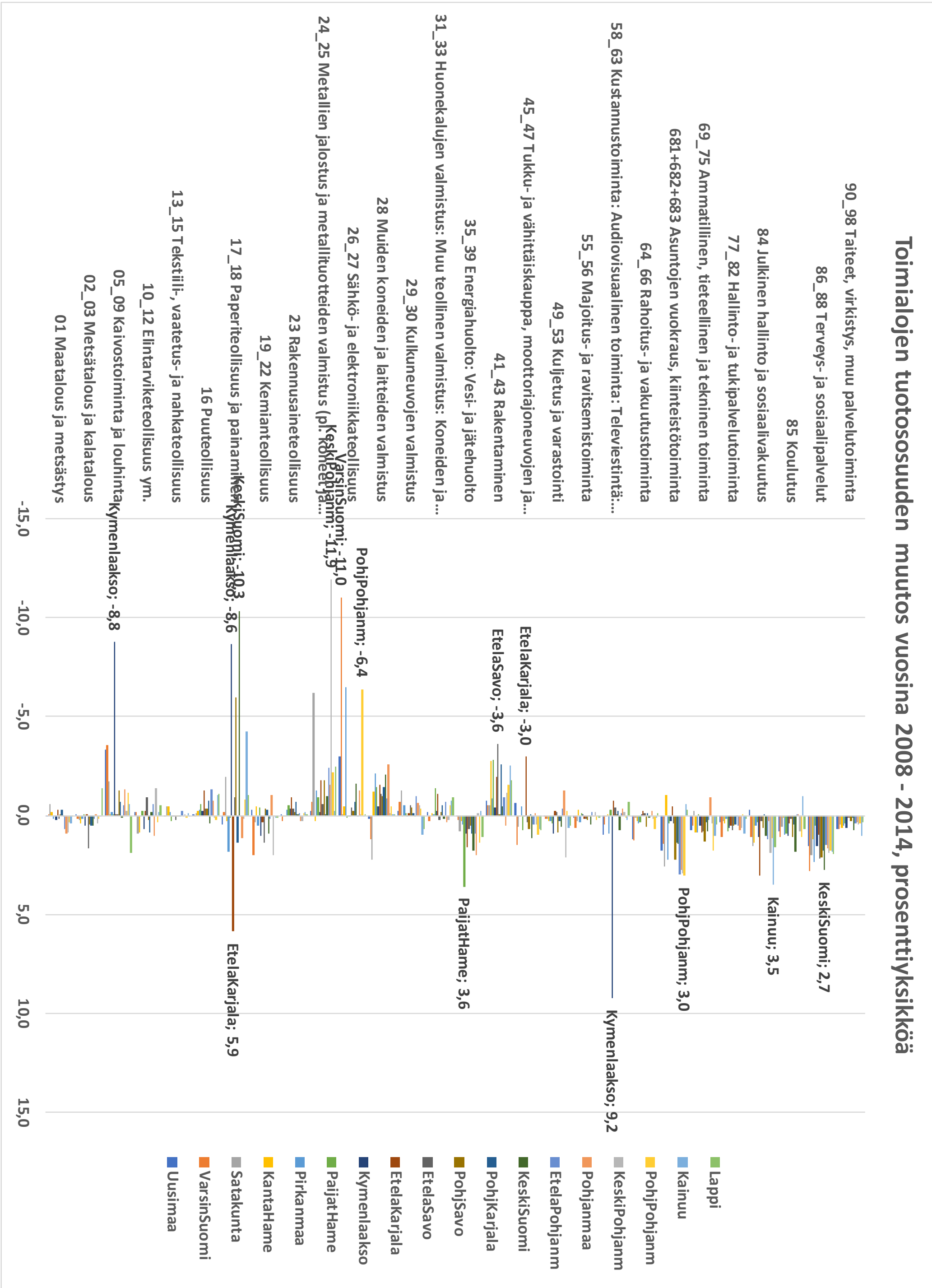
Kasvuakin jaksolle mahtui, ja niinpä terveys- ja sosiaalipalvelujen osuus kasvoi kaikissa maakunnissa, eniten Keski-Suomessa (2,7 prosenttiyksikköä). Myös julkishallinnon tuotososuus kasvoi monissa maakunnissa, Kainuussa jopa 3,5 prosenttiyksikköä. Kustannus- ja tietojenkäsittelytoimialan tuotososuus kasvoi, uusien keskusten ansiosta Kymenlaaksossa jopa 9,2 prosenttiyksikköä. Myös energiahuollon osuus kasvoi kaikissa maakunnissa, Päijät-Hämeessä jo 3,6 prosenttiyksiköllä. Paperiteollisuuden osuus taas kasvoi Etelä-Karjalassa suhteellisen paljon, 5,9 prosenttiyksiköllä. Kaivostoiminta ja louhinta menetti osuuttaan Kymenlaaksossa mutta kasvoi muun muassa Lapissa.

Palkkasumman arvonlisäosuuden muutos kuviossa 7 kertoo toimialarakenteen työvoimavaltaisuudesta eri alueilla. Usein tähän liittyy palveluvaltaisuudessa tapahtuva muutos (palvelut kun ovat tavaroiden tuotantoa työvoimavaltaisempia). Kun palvelujen osuus tuotoksesta oli enimmäkseen kasvussa, on ehkä yllättävääkin, että esimerkiksi koulutuksen palkkaosuus laski Kainuussa kolmella prosenttiyksiköllä, ja Uudellamaalla julkisen hallinnon osuus laski lähes kolmella prosenttiyksiköllä (mahdollisesti keskushallinnon alueellistamisen myötä). Palkkasumman osuus heijastaa alueen kehitystä selvästi Kainuussa, jossa rakentamisen osuus laski -2,2 prosenttiyksikköä ja toisaalta Pohjois-Pohjanmaalla ja ja Varsinais-Suomessa, joissa sähkö- ja elektroniikkateollisuuden osuus laski noin kolme prosenttiyksikköä. Kuten elektroniikkateollisuuden tapauksessa, niin myös paperiteollisuuden osalta tuotososuus ja palkkasumma muuttuivat samaan suuntaan, ja paperiteollisuuden osuus laski Keski-Suomessa (4,9 prosenttiyksikköä) ja Kymenlaaksossa (7,6 prosenttiyksikköä).

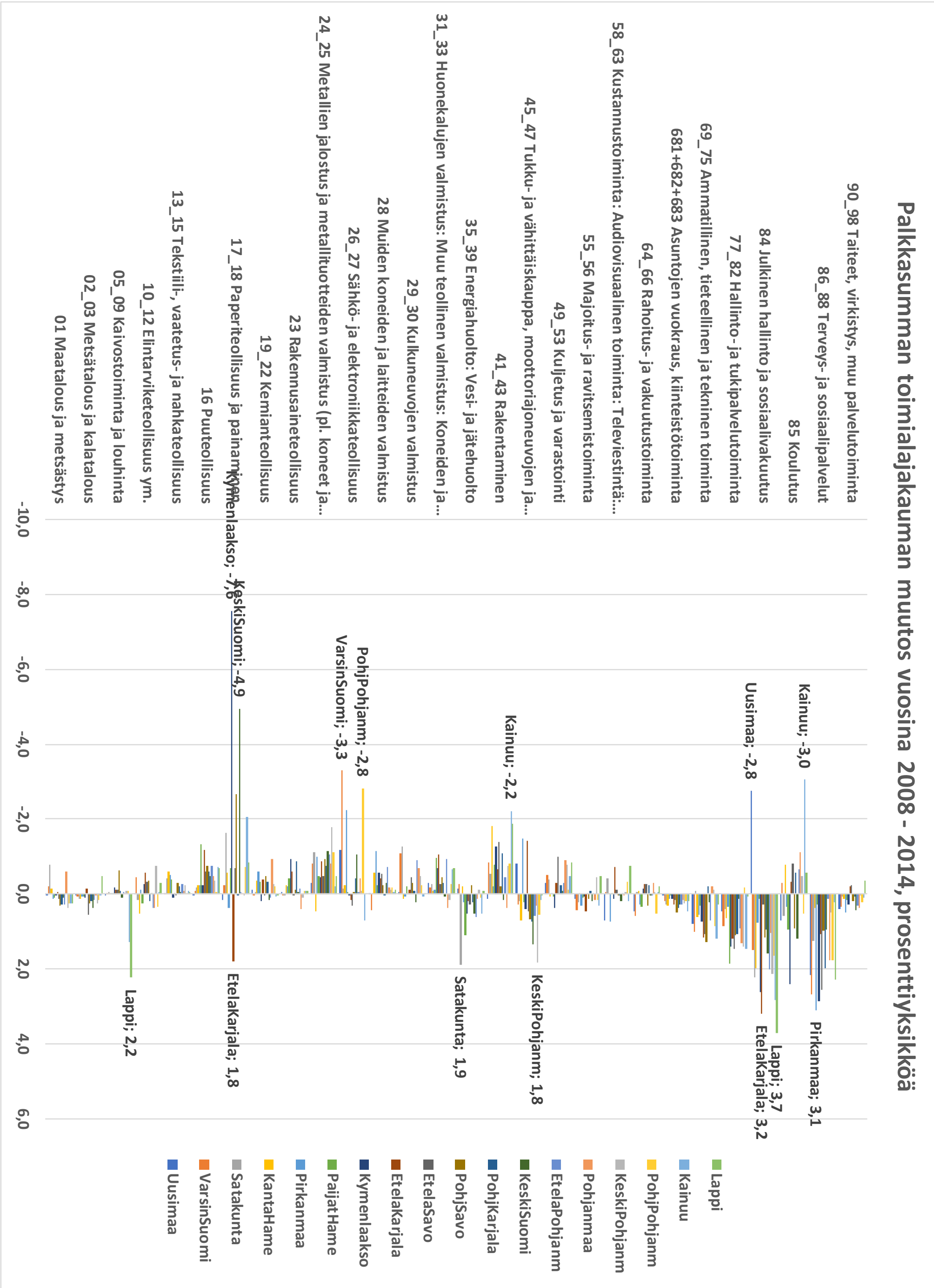
Terveys- ja sosiaalialojen osuus palkkasummasta sen sijaan kasvaa kaikkialla, eniten Pirkanmaalla (3,1 prosenttiyksikköä). Myös julkisen hallinnon palkkaosuus kasvoi Uuttamaata lukuun ottamatta kaikissa maakunnissa, eniten Lapissa (3,7 prosenttiyksikköä) ja Etelä-Karjalassa (3,2 prosenttiyksikköä). Kaupan osuus oli suhteellisen vakaa, paitsi Keski-Pohjanmaalla, jossa se kasvoi 1,8 prosenttiyksiköllä. Ympäristöhuolto ja energiahuollon osuus taas kasvoi kaikkialla myös palkkasummalla mitattuna, eniten Satakunnassa (1,9 prosenttiyksikköä). Monissa maakunnissa supistuva paperiteollisuus kasvatti palkkaosuuttaan Etelä-Karjalassa (1,8 prosenttiyksikköä), ja kaivosteollisuuden osuus kasvoi Lapissa (2,2 prosenttiyksikköä), vaikka alan osuus muuttui muuten vain vähän.

Tuotantorakenteen osalta rakennemuutoksen kuva on siis suhteellisen tuttu, ja siinä näkyy suurien teollisuudenalojen asemassa tapahtunut muutos (sekä elektroniikka- että metsäteollisuus) sekä julkisten palvelujen tarpeen kasvu (sosiaali- ja terveydenhuolto).

Kuvio 6 Toimialojen tuotososuuden muutos vuosina 2008 – 2014, prosenttiyksikköä



Kuvio 7 Palkkasumman arvonlisäosuuden muutos vuosina 2008 – 2014, prosenttiyksikköä



Vaikka tuotantorakenteen vertailu avaa mielenkiintoisa näkymiä aluetalouden kehitykseen toimialojen tasolla, on kenties vielä mielenkiintoisempaa tarkastella välituotekäytön ja loppukulutuksen hyödykerakenteen muutoksia.

Kulutuksen – sekä loppukulutuksen että välituotteiden käytön – näkökulmasta nousee esiin muitakin suuria muutoksia. Kuvioon 8. on koottu hyödykkeiden kulutusosuuden muutos vuosina 2008–2014.

Kulutusosuuksien kannalta näkyy, kuinka monien hyödykkeiden "tähti on laskussa". Niinpä esimerkiksi kustannus- ja audioalojen osuus on laskussa kaikissa maakunnissa, eniten Etelä-Pohjanmaalla (1,7 prosenttiyksikköä), heijastaen uusien medioiden nousua, kun taas kaupan osuus kasvaa kaikkialla paitsi Uudellamaalla, jossa sen osuus laskee (1,3 prosenttiyksikköä). Energiahuollon osuus laskee useissa maakunnissa eniten Lapissa (6 prosenttiyksikköä), paitsi Uudellamaalla, jossa sen osuus kasvaa (0,8 prosenttiyksikköä). Kulkuneuvojen osuus kysynnästä laskee kaikissa maakunnissa, eniten Pohjois-Karjalassa (1,7 prosenttiyksikköä), samoin elektroniikkateollisuuden tuotteiden. Sähkön lisäksi myös kemian teollisuuden tuotteiden, joihin myös polttoaineet kuuluvat, osuus laskee kaikkialla, Etelä-Pohjanmaalla ja Kymenlaaksossa jopa noin kahden prosentin verran. Elintarvikkeidenkin osuus laskee monissa maakunnissa (Lapissa ja Kymenlaaksossa lasku on noin 2,9 prosenttiyksikköä) paitsi Uudellamaalla (kasvua 0,8 prosenttiyksikköä).

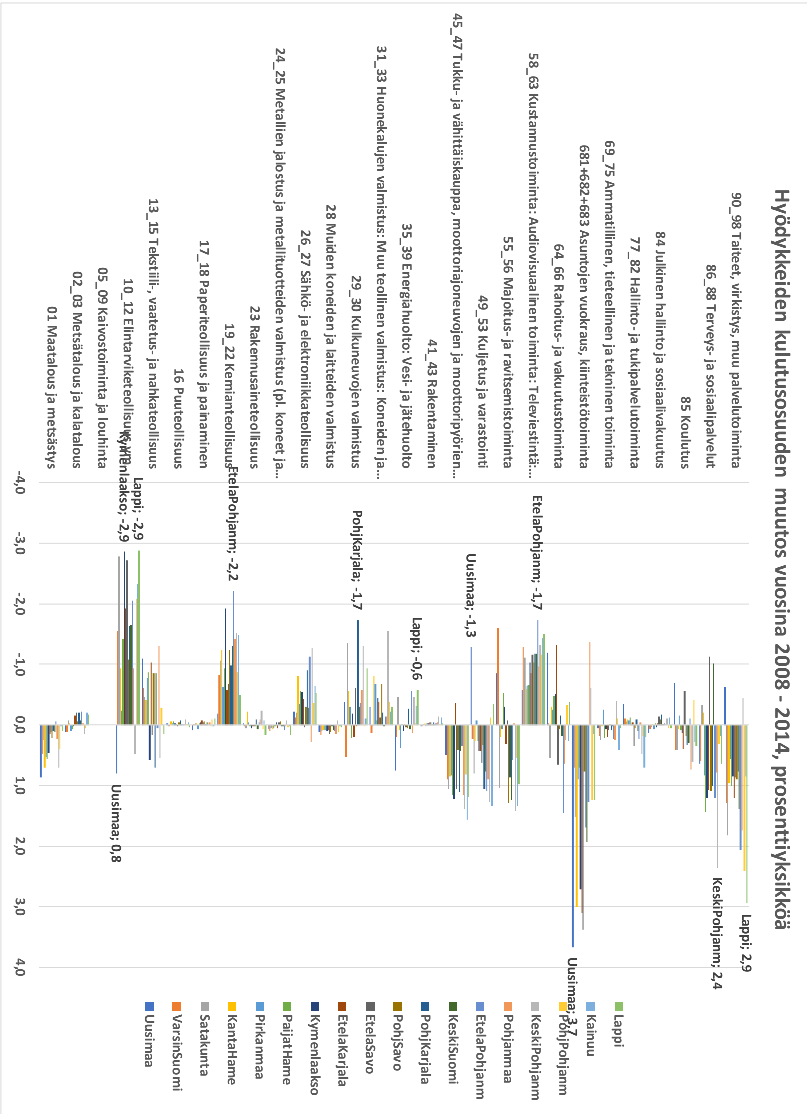
Kulutusrakenteessa näkyy siis makutottumusten muutoksen lisäksi välttämättömyyshyödykkeiden energian ja elintarvikkeiden osuuden laskua laman keskelläkin, joka viittaa vaurastumiseen – mutta niinpä kulutuskysyntä jatkoikin kasvuaan koko laman ajan (Honkatukia ja Lehmus 2016).

Kuvioon 9 on koottu toimialojen välituotteiden käyttöä kuvaava välituotteiden osuus maakunnittain.

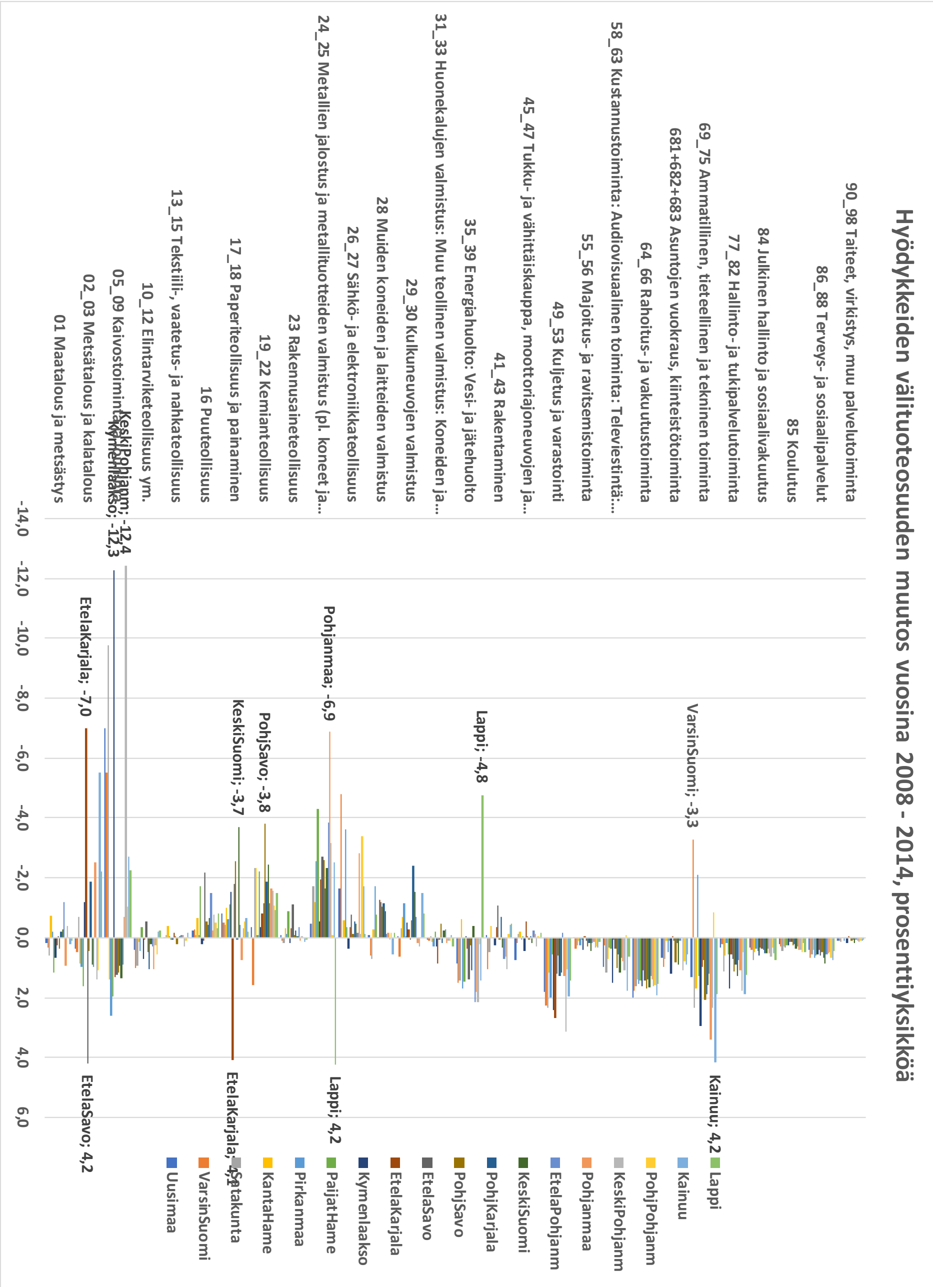
Kuviosta näkyy, että tieteellisen toiminnan ja suunnittelun osuus on laskenut Varsinais-Suomessa 3,1 prosenttiyksikköä ja Pirkanmaalla noin kaksi prosenttiyksikköä (Nokian toiminnan hiipumisen myötä), kun taas energiahuollon (sähkö ja lämpö) osuus on kasvanut monissa maakunnissa hieman, mutta laskenut Lapissa huomattavasti (4,1 prosenttiyksikköä). Metallien valmistuksen osuus välituotteista on laskenut selvästi kaikissa maakunnissa (eniten Pohjanmaalla, -6.9 prosenttiyksikköä) paitsi Lapissa (kasvua 4,2 prosenttiyksikköä). Kemian tuotteiden osuus taas on laskenut kaikissa maakunnissa, eniten Pohjois-Savossa (3,8 prosenttiyksikköä). Paperiteollisuuden osuus on laskenut kaikissa maakunnissa, paitsi Etelä-Karjalassa (kasvua 4,3 prosenttiyksikköä), heijastaen alueellisen tuotannon muutoksia. Kaivannaisten osuus on laskenut selvästi, ja eniten Keski-Pohjanmaalla ja Kymenlaaksossa (yli 12 prosenttiyksikköä kummassakin), mahdollisesti siksi, että tämä hyödykeryhmä sisältää kivihiilen ja turpeen. Etelä-Karjalassa maa- ja metsätalouden osuus on laskenut 7 prosenttiyksiköllä, mutta kasvanut hieman Etelä-Savossa.

Välituotteiden käytöstä piirtyy siis maakunnallisien osuuksien kautta toisaalta tuotoksen muutoksia peilaava kuva, mutta siihen mahtuu myös muutoksia energiaintensiivisyydessä (kemian tuotteiden osuuden laskuun vaikuttaa esimerkiksi liikennepolttoaineiden käytön lasku). Toisaalta Nokian kotimaisen valmistuksen hiipumisen myötä myös tutkimuksen ja tuotekehityksen osuus laski laman aikana.

Kuvio 8 Hyödykkeiden kulutusosuuden muutos vuosina 2008 – 2014, prosenttiyksikköä



Kuvio 9 Hyödykkeiden välituotekäytön osuuden muutos vuosina 2008 – 2014, prosenttiyksikköä



4.2 Aluetalouden kehitys 2020- ja 2030-luvuilla

Toisena esimerkkinä alueellisten tietokantojen käytöstä raportoidaan aluetalouden pitkän aikavälin kehitystä kuvaava skenaario, joka on laadittu laskennallisen yleisen tasapainon mallilla FINAGE/REFINAGE (ent. VATTAGE/VERM)[1]. Tällaista lähestymistapaa on käytetty jo pitkään kansantalouden pitkän aikavälin kehityksen arviointiin. Malli kuvaa talouden kehityksen taloudellisten toimijoiden päätöksistä seuraavina, taloudellisina toimina. Malleilla laaditut skenaariot ja niitä ajavat kytkennät ulottuvat sekä vuosissa taaksepäin, että vuosissa eteenpäin. Talousteoria luo sen kehikon, jolla historiaa tulkitaan, kun taas historiasta kumpuavat taloudelliset trendit ja muun muassa ennakoitu väestönkasvu luovat ne raamit, joissa taloudelliset toimijat tekevät päätöksiään.

Ennakointi perustuu siis useisiin skenaarioihin. Historiaskenaarioissa käytetään kansantalouden toteutuneita tietoja tilastoista yms. talouden trendien tunnistamiseen ja laskentamallin kalibroimiseen historian kanssa konsistentiksi. Tulevien vuosien skenaarioiden pohjalla ovat osaltaan historialliset trendit - muun muassa tuottavuuskasvun tai maailmanmarkkinoiden muutosten reunaehtojen kehitystä koskevat oletukset sekä tietyt, ennustettavat politiikkatoimet. Yleensä tarkasteluun liittyy myös makrotalouden kehitysennuste, jolla kiinnitetään lähimmiksi vuosiksi huoltotaseen kehitysarvio esimerkiksi ministeriöiden politiikan suunnittelussa käyttämää vastaavaksi. Mallilla tuotetussa perusskenaariossa talouden kehityksen taustatekijöiden oletetaan kehittyvän ”business-as-usual”, kun taas erilaisten talouspoliittisten tavoitteiden tai maailmantalouden tai teknologian reunaehtojen muutosten vaikutusta arvioidaan vaihtoehtoisissa skenaarioissa, joita verrataan perusskenaarioon. Tällä tavoin saadaan eristettyä tarkasteltavien ilmiöiden vaikutus talouskasvun taustatekijöistä. Tässä tutkimuksessa käytetty perusskenaario nojaa Honkatukian, Kohlin ja Lehtomaan (2018) tutkimukseen, joka alueellistettiin Suomen Akatemian BeMine-hankkeessa.

4.2.1 Kansantalouden kehitys 2015-2040

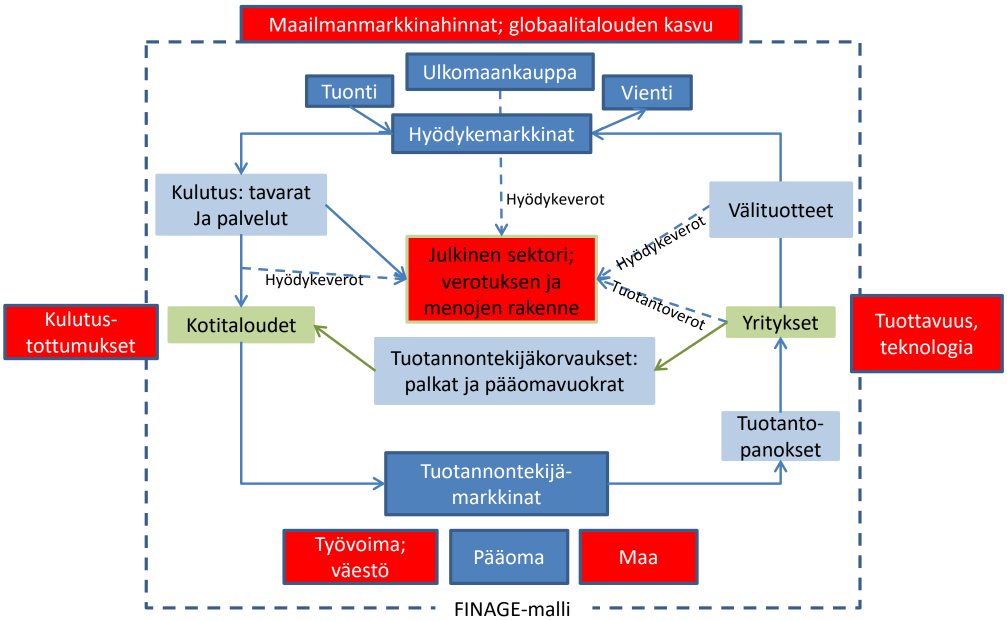
Kun tasapainomallilla lasketaan skenaarioita tulevaisuuden kehitysnäkymistä, monia keskeisistä talouskasvun ajureista määritellään mallin ulkopuolella, ja mallin tehtävä on silloin laskea sellaisten talouden tekijöiden kehitysskenaariot, jotka riippuvat näistä ulkopuolisista tekijöistä. Kuviossa 10 kuvataan tällaisia tyypillisiä, mallin ulkopuolisia oletuksia ja niiden roolia tasapainomallin skenaariokäytössä.

[1] http://www.taloustieteellinenyhdistys.fi/images/stories/kak/kak12009/kak12009honkatukia.pdf

Lähes poikkeuksetta taloudellisissa tarkasteluissa käytetään mallin ulkopuolista – eksogeenista – arviota väestön kasvusta. Suomea koskevissa tarkasteluissa käytetään Tilastokeskuksen väestöennustetta. Maailmantalouden kasvuennusteet ovat yhden maan tarkasteluissa eksogeenisia, samoin arviot eri hyödykkeiden maailmanmarkkinahintojen kehityksestä ja joskus myös hyödykkeiden kysynnän kasvuvauhdista (mutta esimerkiksi viennin määrä riippuu kotimaisten hyödykkeiden mallissa määräytyvästä hintakehityksestä maailmanmarkkinahintoihin nähden).

Julkisen sektorin osalta monet asiat ovat eksogeenisia, mikä on sikäli luontevaa, että ne ovat viime kädessä seurausta politiikkaa koskevista päätöksistä. Arvioissa oletetaan, että kansantalouden keskeisten kasvuedellytysten kehitys on sama kaikissa skenaarioissa. Erot skenaarioiden välille syntyvät energiajärjestelmän, teollisuuden ja kulutuksen rakennetta koskevista ratkaisuista.

Kuvio 10 Talouden kehityksen ajurit



Tässä raportoitavassa skenaariossa kansantalouden lähivuosien kehitysarvio perustuu Valtiovarainministeriön syksyn 2018 ennusteeseen. Pidemmällä aikavälillä toimialakehityksen taustalla ovat pitkän aikavälin tuottavuus- ja kysyntätrendit sekä julkisten menojen osalta etenkin väestöennuste. Julkisen talouden osalta monet rakenteelliset uudistukset ovat hyvin merkittäviä, koska ilman niitä julkisen talouden alijäämä jatkaisi kasvuaan (Honkatukia ja Lehmus 2016). Keskeinen, tulevaisuuden kasvuedellytyksiä parantava politiikkatoimi on käynnistynyt eläkeuudistus, joka lisää työn tarjontaa etenkin 2020-luvulle tultaessa. Talouskasvua tukevat uudistukset liittyvät toisaalta työmarkkinoihin, toisaalta julkisten menojen kasvun hillintään. Työmarkkinajärjestöjen sopima eläkeuudistus astui voimaan vuonna 2017, ja se nostaa portaittain kunkin eläkkeelle siirtyvän ikäluokan eläkeikää, kunnes päästään uudistuksessa asetettuun 65 vuoden eläkeikään. Eläketurvakeskus laskee uudistuksen nostavan 15–74-vuotiaiden työllisyysastetta noin prosenttiyksiköllä ja vähentävän lakisääteisiä eläkemenoja suhteessa bruttokansantuotteeseen 0,7 prosenttia vuonna 2025. Tässä oletetaan eläkeuudistuksen vaikuttavan työn tarjontaan ja eläkemenoihin ETK:n arvion mukaisesti. Eläkeuudistuksen vaikutukset alkavat näkyä 2020-luvun edetessä ja nostavat työn tarjontaa noin kolmella prosentilla vanhaan järjestelmään verrattuna.[2] Skenaariossa on mukana myös julkiset menosäästöt, jotka pienentävät julkisten sektorien menopainetta ja vapauttavat resursseja talouden muiden sektorien käyttöön. Arviossa on oletettu SOTE-sektorien tehostuvan siten, että Sipilän hallituksen hallitusohjelmassa asetetut säästötavoitteet toteutuisivat 2020-luvulla.

Työn tarjonnan kasvu muuttaa perustavanlaatuisesti talouden kasvuedellytyksiä. Kun työikäisen väestön määrä on ollut laskussa jo muutaman vuoden, on kansantalouden kasvu ollut pitkälti investointien ja tuottavuuskasvun varassa. Eläkeuudistuksen myötä työpanoskin voi kasvaa 2020-luvun lopulle asti, mikä puolestaan vauhdittaa investointeja. Niinpä työpanoksen ja pääomapanoksen kautta syntyvä kasvukontribuutio ovat merkittävän suuria. Tuottavuuden kasvua vauhdittaa sekä julkisen sektorin oletettu tuottavuuskasvu että tuotannontekijöiden suuntautuminen avoimille sektoreille. Niinpä talouden hyvä kehitys jatkuu myös 2020-luvulla rakenneuudistusten kannattelemana.

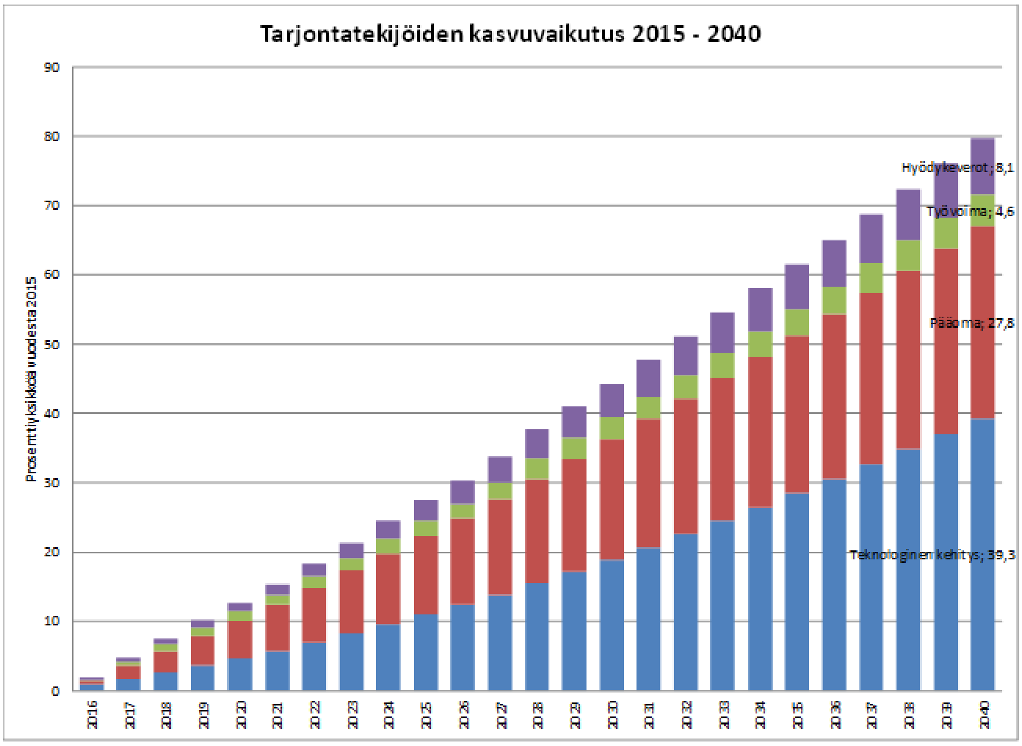
Perusuralla otetaan myös huomioon ilmasto- ja energiapolitiikka. Vuoteen 2030 mennessä se edellyttää jo kohtuullisen suuria investointeja ennen kaikkea liikenteessä, jossa on sitouduttu päästöjen vähentämiseen jopa 40 prosentilla vuoteen 2005 verrattuna. Tähän on arvioitu päästävän kehittämällä liikenteen taloudellista ohjausta biopolttoaineiden ja sähkön käytön merkittävää lisäämistä tukevaksi ja niiden jakeluinfrastruktuurin sekä kotimaisen tuotantokapasiteetin lisäämistä. Energiankulutuksen kasvun hidastuminen ja painottuminen uusiutuvaan energiaan vaikuttaa kansantaloudellisessa tarkastelussa valtiontalouteen ennen kaikkea polttoaineverokertymän kautta – biopolttoaineiden verotus on fossiilisia kevyempää. Myös uusien autojen myynti muuttuu perinteisiä kalliimpien sähköautojen, hybridien ja kaasuautojen osuuden kasvaessa. Biojalostamot taas vaativat tarkastelussa ainakin ajoittain investointitukia. Ne luovat toisaalta lisäkasvua koko metsäklusteriin. Perusskenaario on näiden investointien ja ohjauksen osalta kansallisen ilmastosuunnitelman vaikutusarvioiden mukainen (Energia- ja ilmastostrategian vaikutusarviot, VNK 21/2017).

[2] Ks. Honkatukia ja Lehmus (2016).

Työn tarjonnan kasvu muuttaa perustavanlaatuisesti talouden kasvuedellytyksiä. Kun työikäisen väestön määrä on ollut laskussa jo muutaman vuoden, on kansantalouden kasvu ollut pitkälti investointien ja tuottavuuskasvun varassa. Eläkeuudistuksen myötä työpanoskin voi kasvaa 2020-luvun lopulle asti, mikä puolestaan vauhdittaa investointeja. Niinpä kuviossa 7 kuvatussa perusskenaariossa työpanoksen ja pääomapanoksen kautta syntyvä kasvuvaikutus ovat merkittävän suuria: vuoteen 2040 mennessä työpanoksen kansantuotetta kasvava vaikutus on lähes viisi prosenttia vuoden 2015 kansantuotteesta ja pääomapanoksen noin 28 prosenttia. Kokonaistuottavuuden kasvu on silti merkittävin kasvun lähde: sen vaikutus kasvuun on noin 39 prosenttia vuoteen 2030 mennessä. Tuottavuuden kasvua vauhdittaa sekä julkisen sektorin oletettu, korkea tuottavuuskasvu että sen mahdollistama tuotannontekijöiden suuntautuminen avoimille sektoreille, joilla tuottavuuden kasvu on ollut nopeampaa kuin usein niitä työvoimavaltaisemmilla kotimarkkinasektoreilla. Kaikkiaan talous kasvaa yli kahden prosentin vuosivauhtia 2020-luvulla ja henkeä kohti laskettu kasvukin on tarkastelujaksolla keskimäärin noin 1,9 prosenttia. Tämä on viime vuosiin verrattuna huomattavan paljon, mutta historiallisesti kansantuote on kasvanut pitkiä aikoja nopeamminkin. Uudistusten osuus kasvun tukemisessa on suuri, jo eläkeuudistuksen ansiosta vuosikasvu on keskimäärin 0,1 prosenttia nopeampaa kuin se muutoin olisi ja SOTE-uudistuksen tuottavuusvaikutuksen kautta on arvioitu syntyvän samansuuruinen kasvuvaikutus (Honkatukia ja Lehmus 2016).

Kuvioon 11 on kuvattu kansantuotteen käytön vaikutus kansantuotteen kasvuun perusskenaariossa. Kun koko kuluvan vuosikymmenen talouskasvu on ollut kotimarkkinoiden varassa, korostuu viennin elpyminen vuosikymmenen loppua kohti tultaessa ja seuraavilla vuosikymmenillä. Kuten Honkatukia ja Lehmus (2016) toteavat, ajaa viennin elpymistä työmarkkinoiden oletettu lähivuosien maltillisuus ja 2020-luvulla eläkeuudistuksen aikaansaama työn tarjonnan kasvu, jotka parantavat viennin kilpailukykyä. 2030-luvulle tultaessa työikäisen väestön määrä alkaa kasvaa, mikä osaltaan pitää kasvua yllä kaukaisemmassakin tulevaisuudessa. Vuoteen 2040 tultaessa viennin vaikutus kansantuotteen kasvuun on vajaa kolmannes, kotimaisen kulutuskysynnän taas hieman yli kolmannes. Julkisen kulutuksen – joka tässä kattaa julkishallinnon lisäksi koulutuksen ja terveys- ja hoivapalvelujen tuotannon, myös yksityisen - kasvuvaikutus on sen sijaan pieni, mikä heijastaa oletusta uudistusten onnistumisesta. Kasvavan kotimaisen valmistuksen ja loppukulutuksen myötä myös tuonti kasvaa, mikä näkyy negatiivisena kasvuvaikutuksena. Suuri osa tuonnista päätyy vientituotteiden välituotteiksi, ja tästäkin syystä nettoviennin vaikutus on selvästi positiivinen.

Kuvio 11. Kansantuotteen tarjontatekijöiden kasvuvaikutus perusskenaariossa, prosenttiyksikköä vuodesta 2015

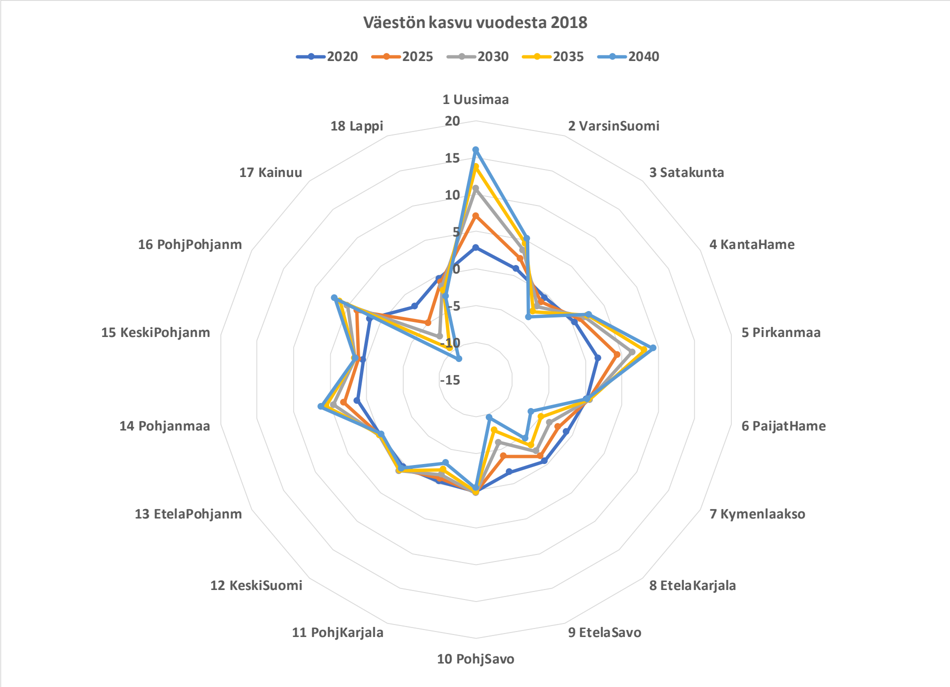


4.2.2 Aluetalouden kehitys 2019-2040

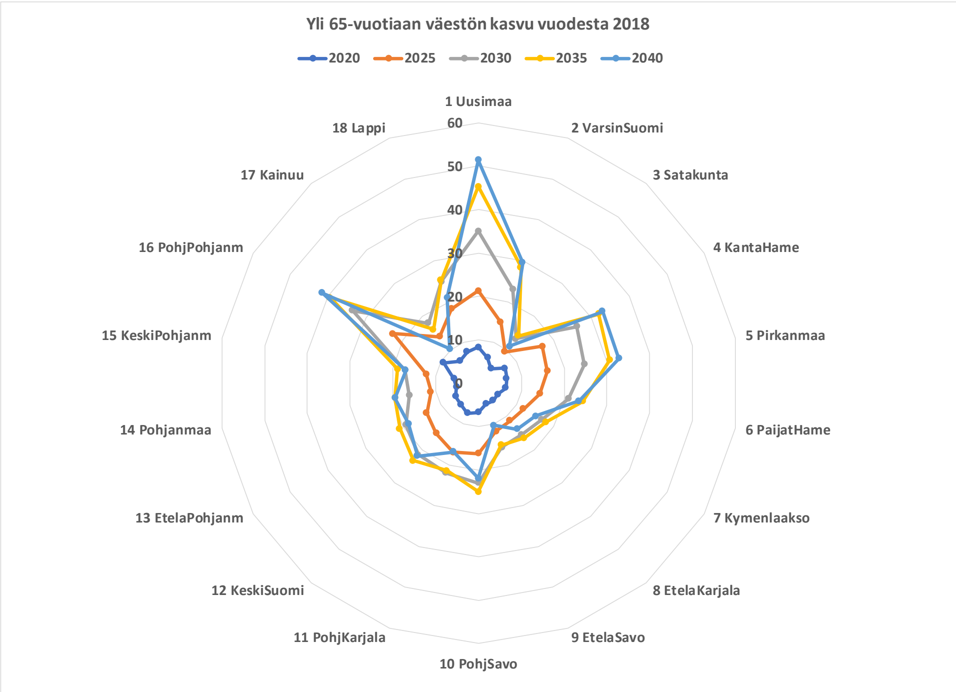
Aluetalouden perusskenaario on laadittu kullekin maakunnalle niiden omista väestö- ja elinkeinorakenteista lähtien, mutta koko kansantalouden tasoisia tuloksia hyödyntäen. Aluetasolla talouskasvun suureen kuvaan vaikuttaa ennen kaikkea väestökehitys, sekä väestön kasvun että sen ikärakenteen kautta. Tässä tutkimuksessa käytetään Tilastokeskuksen viimeisintä, alueellista väestöennustetta (2015), jonka mukaan vanhusväestön osuus on monissa maakunnissa jo nyt huomattavan suuri ja sen ennakoidaan kasvavan tulevaisuudessa. Väestön vanheneminen näkyy hyvin kuvioissa 4-6, joihin on koottu alueelliset ennusteet koko väestön, vanhusväestön ja työikäisen väestön kasvusta. Vanhusväestön osuus kasvaa keskimäärin kymmenisen prosenttiyksikköä vuoteen 2040 mennessä. Tämä lisää sekä hoivapalveluiden että terveydenhoidon kysyntää ja sitoo työvoimaa syrjäyttäen muiden toimialojen kasvumahdollisuuksia. Eläkeuudistus hidastaa lähivuosina tätä alueellista työvoimavajetta, mutta ei suinkaan pysäytä sitä. Niinpä työvoiman saatavuus on keskeinen talouskasvua aluetasolla rajoittava tekijä.

Alueellista työikäisen väestön ennustetta kuvataan kuviossa 14. Kuvioon 15 on koottu ennuste työllisyyden kehityksestä eri maakunnissa. Kuviossa 16 puolestaan on kuvattu alueellisen kokonaistuotannon kehitystä. Kuvioista on helppo huomata, kuinka vahvasti väestönkasvu – ja työvoiman saatavuus – korreloivat talouskasvun kanssa. Alueellinen keskittymienn jatkuu skenaariossa hyvin selvänä, ja Etelä-Suomi ja etenkin Uusimaa ovat entistäkin keskeisemmässä asemassa kansantalouden kasvun näkökulmasta. Alueiden toimialarakenne vaikuttaa kuitenkin alueelliseen kasvupotentiaaliin, koska tarkastelussamme otetaan huomioon toimialojen tuottavuuskasvun historiallisesti suuret erot. Selvimmin nämä erot näkyvät juuri työvoimaintensiivisten julkisten palvelujen ja välituote- ja pääomaintensiivisten vientiteollisuuden ja -palvelujen vaikutuksessa talouskasvuun. Kuvioon 17 on koottu toimialojen vaikutus kasvuun 2020- ja 2030-luvuilla. Kuviosta näkyy, kuinka esimerkiksi Varsinais-Suomessa teollisuuden vaikutus kasvuun on puolitoistakertainen Uuteenmaahan verrattuna, jossa taas julkiset ja yksityiset palvelut ovat kasvuvaikutukseltaan suurempia. Useissa Pohjois-Suomen maakunnissakin teollisuuden vaikutus kasvuun on selvästi muita toimialoja suurempi. Toimialojen kautta tarkasteltuna kasvu siis keskittyy erlaisiin yksityisiin palveluihin (kauppa, liikenne, kiinteistöala) ja teollisuuteen. Investointitarve ja väestön alueellinen keskittyminen näkyvät myös rakentamisen suhteellisen suurena kasvuvaikutuksena. Julkisten palvelujen vaikutus jää pienemmäksi, koska skenaariossa oletetaan, että julkisten palvelujen tuotantoa ja hallintoa onnistutaan tehostamaan.

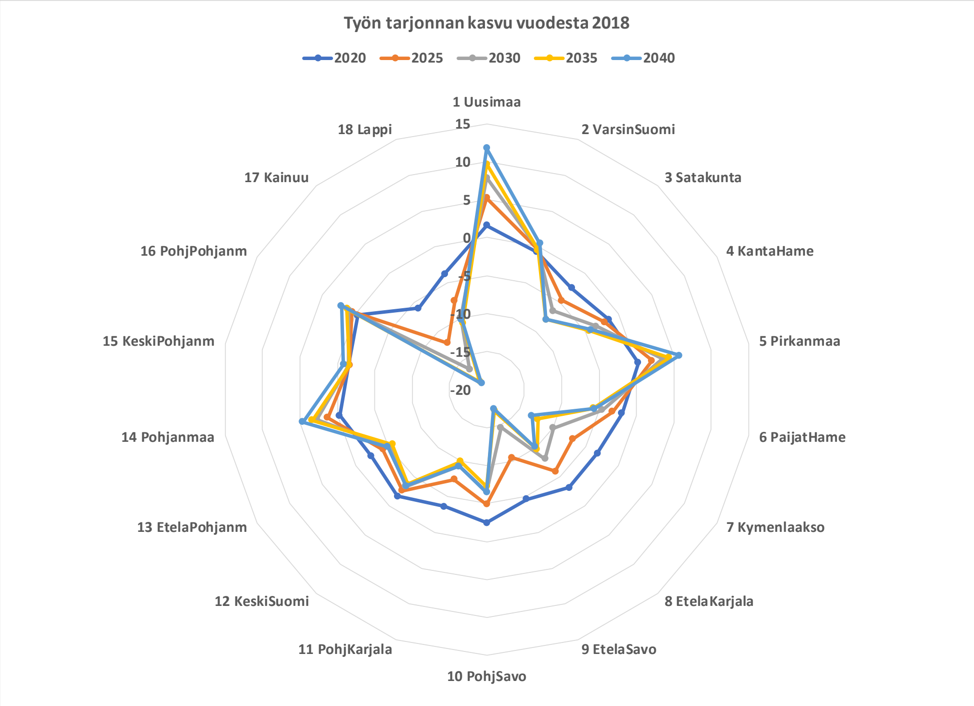
Kuvio 12 Väestönkasvu 2018 – 2040, prosenttia



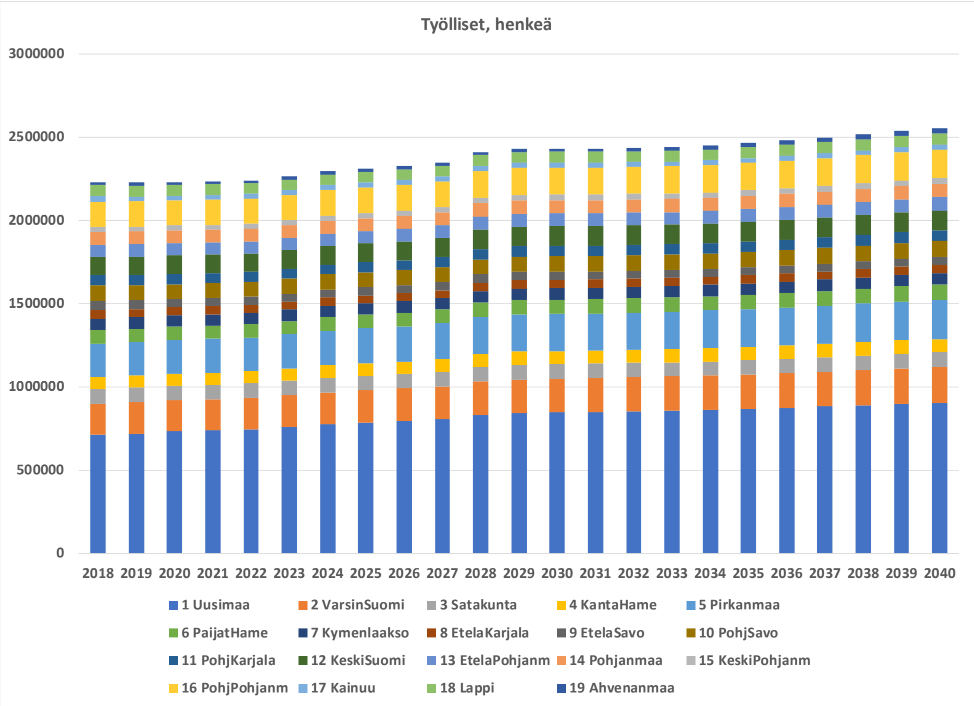
Kuvio 13 Vanhusväestön kasvu 2018 – 2040, prosenttia



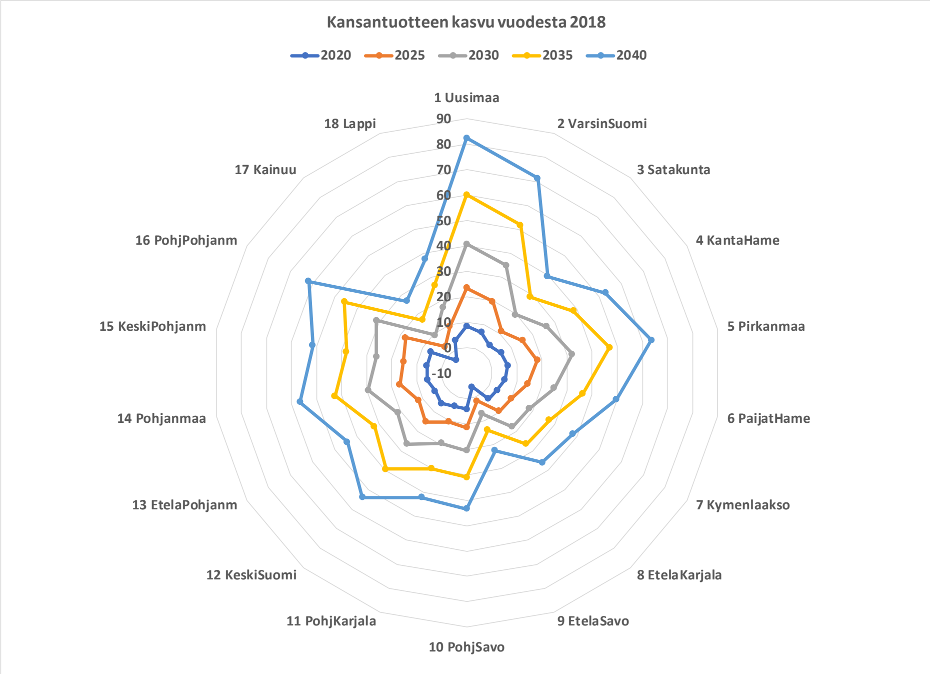
Kuvio 14 Työn tarjonnan kasvu 2018 – 2040, prosenttia



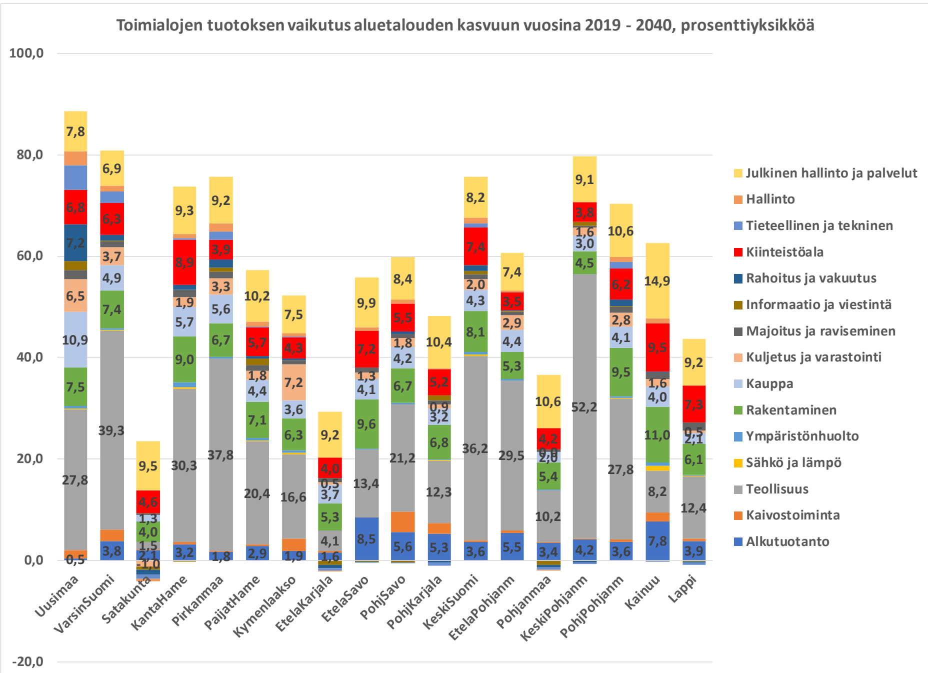
Kuvio 15 Työllisyyden kehitys maakunnissa 2018 – 2040



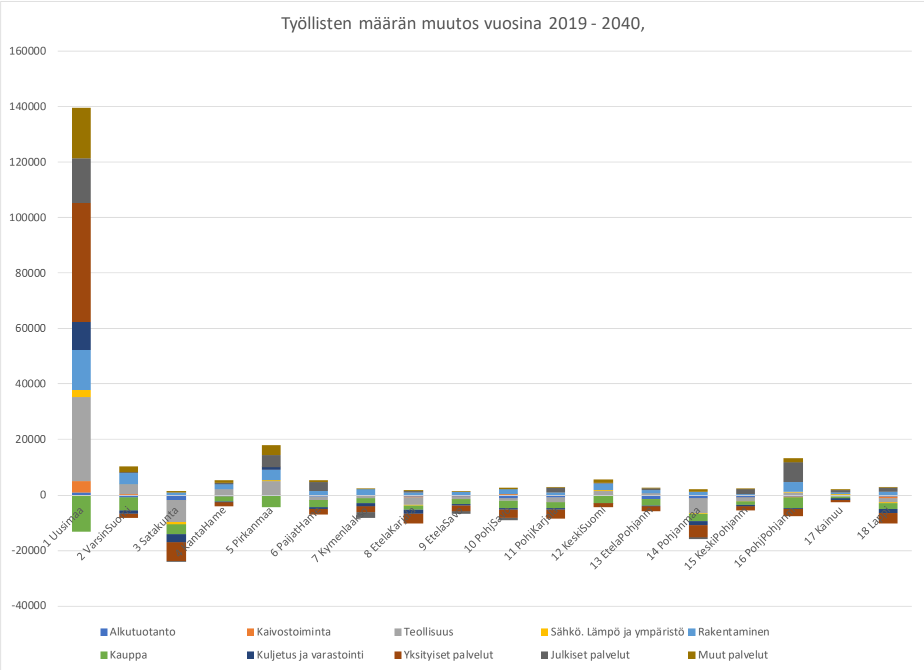
Kuvio 16 Alueellinen kokonaistuotanto



Kuvio 17 Toimialojen vaikutus kasvuun 2019 – 2040



Kuvio 18 Työllisten määrän muutos 2019 – 2040



5 Johtopäätökset

Tässä hankkeessa tuotettiin Tilastokeskuksen aluetilinpidon kanssa yhteensopiva, julkisesti käytettävissä oleva alueellisen taloustiedon tietokanta, jonka lähteet on dokumentoitu, ja joka on päivitettävissä vuosittain. Tietokanta sisältää alueellisen panos-tuotosaineiston mutta myös laajemman aluetalouden tietokannan, jota voidaan käyttää alueellisissa yleisen tasapainon malleissa.

Lähtökohdat kokonaisvaltaisen ja kattavan alueellisen tilinpidon ja kansantuotteen maakunnittaisen mittaamisen kehittämiseksi tässä hankkeessa olivat verraten hyvät. Aikaisemmat tulokset (lähinnä BeMine- hankkeesta) tukivat suoraan tässä hankkeessa tehtyä työtä. Tässä raportissa esiteltyjen menetelmien avulla tuotettiin Tilastokeskuksen julkaisutasoiset, alueelliset panos-tuotosaineistot ja nykytilannetta kuvaavat, päivitetyt alueelliset sosiaalitilinpidon ja julkisten tulonsiirtojen kuvaukset.

Tietokannan kokoamiseen ja päivittämiseen käytettävä koodi on julkaistu avoimen lähdekoodin lisenssillä. Koodia säilytetään Githubissa, jossa se on vapaasti muokattavissa avoimien ohjelmistojen periaatteiden mukaisesti. Linkki löytyy liitteestä B. Hankkeen tuotokset mahdollistavat panos-tuotostutkimuksen aluetasolla sekä yleisten tasapainon mallien avulla tehtävän simulaatiotutkimuksen ja muun alueellisen talouspolitiikan analyysin ja suunnittelun ajantasaisilla tiedoilla.

Hankkeessa arvioitiin aineiston käyttömahdollisuuksia talouden rakenteen muutoksien arviointiin kahden esimerkin avulla, nimittäin vertaamalla talouden rakenteessa tapahtuneita muutoksia tämän vuosikymmenen alun laman aikana sekä tuottamalla uudelle mallille käyttökelpoiset aluetalouden kasvuarviot. Rakennemuutoksen vertailu toteutettiin vertailemalla tämän hankkeen vuoden 2014 aluetalouksia vuodelle 2008 vastaavin menetelmin koottuun aineistoon (Honkatukia 2013). Aineiston avulla on mahdollista kuvata uudella tavalla tuotanto- ja kulutusrakenteen muutoksia. Jatkossa tällainen vertailu tulee mahdolliseksi myös vuositasolla.

Aluetalouden kasvuennuste perustettiin Suomen Akatemian BeMine-hankkeessa toteutettuun alueelliseen kehitysarvioon, jota on käytetty myös eräissä muissa hankkeissa. Kun hankkeen resurssit kohdentuivat pääosin itse tietokantojen tuottamiseen, on selvää, että nämä arviot ovat lähinnä esimerkkejä alueellisten aineistojen käyttömahdollisuuksista. Ne kuvaavat kuitenkin hyvin niitä mahdollisuuksia, joita päivitettyjen alueellisten tietokantojen tuottaminen voi tulevaisuudessa avata. Kun monet kansantalouden suurimmista haasteista tulevat muokkaamaan talouden rakenteita syvältä, tällaisen tiedon keräämisellä tulee olemaan tärkeä roolinsa politiikkatoimien arvioinnissa ja suunnittelussa.

Lisäksi hankkeesa toteutettiin FINAGE/REFINAGE-mallien (entinen VATTAGE/VERM) koodien ja mallien kuvauksen päivitys uusien aineistojen tasolle. Malleja on käytetty taajaan politiikan arvioinnissa, talouskehityksen ennakoinnissa ja akateemisissa opinnäytteissä ja niiden kehitystä on rahoitettu useista eri lähteistä. Mallikoodin ja aineistojen julkaiseminen osana tätä hanketta tukee kuitenkin mallien aiempaa laajempaa käyttöä.

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Liitteet

Liite A Taulukot

Taulukko – A0: Tarjontataulukot

	Toimialat	Toimialat yhteensä	Tuonti alueittain	Tuonti ulkomailta	Kokonais-tarjonta
Tuotteet	V^T	**q**	**imp_reg**	**imp_for**	**s_u**
Tuotteet yhteensä	$\mathbf{g}^T$	$\sum q = \sum g^T$	∑ imp_reg	∑ imp_for	∑ s_u

q, g, imp_reg, imp_for, ja **s_u** ovat sarakevektoreita
$\mathbf{V}^T = \mathbf{make\_obj}_{(COM,\ IND,\ DST)} + \mathbf{Stocks}_{(COM,\ IND,\ REG)}$

Taulukko – A1: Käyttötaulukot (yhteensä)

	Toimialat	Toimialat yhteensä	Loppukäyttö							
			Kotitaloudet	Investoinnit	Julkinen	Vienti alueellinen	Vienti ulkomainen	Varastot	Loppukäyttö perushintaan	Kokonaiskäyttö perushintaan
Tuotteet	**U**= Välituotekäyttö	$\sum U$	**H**	**I**	**G**	**Exp_reg**	**Exp_for**	**Inv**	$\sum$ Loppukäyttö	**s_u**
			Y							
Tuotteet yhteensä	$\sum U$	$\sum$	$\sum H$	$\sum I$	$\sum G$	$\sum$ Exp_reg	$\sum$ Exp_for	$\sum$ Inv	$\sum$	$\sum$ s_u
Verot vähennettynä tuilla	tax_interm.	$\sum$	Verokäyttö						$\sum$ Lopullinen verokäyttö	$\sum$ kaikki sarakkeet
Kokonaisvälituotekäyttö	Välituotekäyttö + Verot vähennettynä tuilla	$\sum$	Loppukäyttö + Verot vähennettynä tuilla						$\sum$ Lopullinen	$\sum$ kaikki sarakkeet
Arvonlisä (työ, pääoma, maa)	**W**	$\sum$								
Bruttoarvonlisä perushintaan	$\sum W$	$\sum$								
Tuotos perushintaan	$\mathbf{g^T}$	$\sum$								

Taulukko- A2: Käyttötaulukot (ulkomainen)

<table>
<tr><td rowspan="2"></td><td rowspan="2">Toimialat</td><td rowspan="2">Toimialat yhteensä</td><td colspan="7">Loppukäyttö</td><td></td></tr>
<tr><td>Kotitaloudet</td><td>Investoinnit</td><td>Julkinen</td><td>Vienti alueellinen</td><td>Vienti ulkomainen</td><td>Varastot</td><td>Loppukäyttö perushintaan</td><td>Kokonaiskäyttö perushintaan</td></tr>
<tr><td rowspan="2">Tuotteet</td><td rowspan="2">U_f=Ulkomaisen tuotteen välituotekäyttö</td><td rowspan="2">∑ Ulkomaisen tuotteen välituotekäyttö</td><td>H_for</td><td>I_for</td><td>G_for</td><td>Exp_reg_f</td><td>Exp_for_f</td><td>Inv_f</td><td>∑ Loppukäyttö</td><td>∑ kaikki sarakkeet</td></tr>
<tr><td colspan="6">Y_f</td><td></td><td></td></tr>
<tr><td>Tuotteet yhteensä</td><td>∑ Ulkomaisen tuotteen välituotekäyttö</td><td>∑</td><td>∑ H_for</td><td>∑ I_for</td><td>∑ G_for</td><td>∑ Exp_reg_f</td><td>∑ Exp_for_f</td><td>∑ Inv_f</td><td>∑</td><td>∑ imp_for</td></tr>
</table>

Taulukko- A3: Käyttötaulukot (kotimainen)

	Toimialat	Toimialat yhteensä	Loppukäyttö							
			Kotitaloudet	Investoinnit	Julkinen	Vienti alueellinen	Vienti ulkomainen	Varastot	Loppukäyttö perushintaan	Kokonaiskäyttö perushintaan
Tuotteet	**U_d**=Kotimainen välituotekäyttö	∑ Kotimainen välituotekäyttö	**H_dom**	**I_dom**	**G_dom**	**Exp_reg_d**	**Exp_for_d**	**Inv_d**	∑ Loppukäyttö	**q**
			Y_d							
Kotimaisten tuotteiden kokonaiskäyttö	∑Kotimainen välituotekäyttö	∑	∑ H_dom	∑ I_dom	∑ G_dom	∑ Exp_reg_d	∑ Exp_for_d	∑ Inv_d	∑	∑ q
Kotimaisen tuonnin käyttö	Alueellisen tuonnin välituotekäyttö	∑	Alueellisen tuonnin loppukäyttö						∑ Alueellisen tuonnin loppukäyttö	∑ imp_reg
Ulkomaisen tuonnin käyttö	Ulkomaisen tuonnin välituotekäyttö	∑	Ulkomaisen tuonnin loppukäyttö						∑ Ulkomaisen tuonnin loppukäyttö	∑ imp_for
Verot vähennettynä tuilla	Välilliset verot	∑	Lopullinen verokäyttö						∑ Lopullinen verokäyttö	∑ kaikki sarakkeet
Kokonaisvälituotekäyttö	Kotimainen välituotekäyttö + kotimainen käyttö. + ulkomainen käyttö + verot vähennettynä tuilla	∑	Kotimainen loppukäyttö + Alueellisen tuonnin loppukäyttö + Ulkomaisen tuonnin loppukäyttö + Loppukäytön verot						∑ Lopullinen	∑ kaikki sarakkeet
Arvonlisä (työ, pääoma, maa)	**W**	∑								
Bruttoarvonlisä perushintaan	∑ W	∑								
Tuotos perushintaan	$\mathbf{g}^T$	∑								

Taulukko- A4: Käyttötaulukot (paikallinen)

	Toimialat	Toimialat yhteensä	Loppukäyttö							
			Kotitaloudet	Investoinnit	Julkinen	Vienti alueellinen	Vienti ulkomainen	Varastot	Loppukäyttö perushintaan	Kokonaiskäyttö perushintaan
Tuotteet	U_reg= Alueellisen tuotannon välituotekäyttö	∑ Alueellisen tuotannon välituotekäyttö	**H_reg**	**I_reg**	**G_reg**	**Exp_reg_r**	**Exp_for_r**	**Inv_r**	∑ Loppukäyttö	∑ kaikki sarakkeet
			Y_reg							
Tuotteet yhteensä	∑ Alueellisen tuotannon välituotekäyttö	∑	∑ H_reg	∑ I_reg	∑ G_reg	∑ Exp_reg_r	∑ Exp_for_r	∑ Inv_r	∑	∑ imp_reg

Taulukko- A5: Panos-tuotostaulukot (kotimainen)

	Toimialat	Toimialat yhteensä	Loppukäyttö							
			Kotitaloudet	Investoinnit	Julkinen	Vienti alueellinen	Vienti ulkomainen	Varastot	Loppukäyttö perushintaan	Kokonaiskäyttö perushintaan
Tuotteet	**B_d** = Kotimainen välituotekäyttö	∑ Kotimainen välituotekäyttö	**H-io**	**I - io**	**G- io**	**Exp_reg- io**	**Exp_for- io**	**Inv-io**	∑ Loppukäyttö	**g**
			F_d							
Kotimaisten tuotteiden kokonaiskäyttö	∑ Kotimainen välituotekäyttö	∑	∑ H_dom	∑ I_dom	∑ G_dom	∑ Exp_reg_d	∑ Exp_for_d	∑ Inv_d	∑	∑ g
Kotimaisen tuonnin käyttö	Alueellisen tuonnin välituotekäyttö	∑	Alueellisen tuonnin loppukäyttö						∑ Alueellisen tuonnin loppukäyttö	∑ imp_reg
Ulkomaisen tuonnin käyttö	Ulkomaisen tuonnin välituotekäyttö	∑	Ulkomaisen tuonnin loppukäyttö						∑ Ulkomaisen tuonnin loppukäyttö	∑ imp_for
Verot vähennettynä tuilla	tax_interm.	∑	Lopullinen verokäyttö						∑ Lopullinen verokäyttö	∑ kaikki sarakkeet
Kokonaisvälituotekäyttö	Kotimainen välituotekäyttö + kotimainen	∑	Lopullinen kotimainen käyttö + Lopullinen alueellisen tuonnin käyttö + Lopullinen ulkomaisen tuonnin käyttö + Loppukäytön verot						∑ Lopullinen	∑ kaikki sarakkeet
Arvonlisä (työ, pääoma, maa)	**W**	∑								
Bruttoarvonlisä perushintaan	∑ W	∑								
Tuotos perushintaan	g^T	∑								

Taulukko- A6: Panos-tuotostaulukot (alueellinen)

<table>
<tr><td rowspan="2"></td><td rowspan="2">Toimialat</td><td rowspan="2">Toimialat yhteensä</td><td colspan="6">Loppukäyttö</td><td colspan="2"></td></tr>
<tr><td>Kotitaloudet</td><td>Investoinnit</td><td>Julkinen</td><td>Vienti alueellinen</td><td>Vienti ulkomainen</td><td>Varastot</td><td>Loppukäyttö perushintaan</td><td>Kokonaiskäyttö perushintaan</td></tr>
<tr><td rowspan="2">Tuotteet</td><td rowspan="2">B_reg=Alueellisen tuotannon välituotekäyttö</td><td rowspan="2">∑ Alueellisen tuotannon välituotekäyttö</td><td>H_reg - io</td><td>I_reg - io</td><td>G_reg - io</td><td>Exp_reg_r - io</td><td>Exp_for_r - io</td><td>Inv_r - io</td><td>∑ Loppukäyttö</td><td>∑ kaikki sarakkeet</td></tr>
<tr><td colspan="5">F_reg</td><td></td><td colspan="2"></td></tr>
<tr><td>Tuotteet yhteensä</td><td>∑ Alueellisen tuotannon välituotekäyttö</td><td>∑</td><td>∑ H_reg - io</td><td>∑ I_reg - io</td><td>∑ G_reg - io</td><td>∑ Exp_reg_r- io</td><td>∑ Exp_for_r - io</td><td>∑ Inv_r - io</td><td>∑</td><td>∑ imp_reg</td></tr>
</table>

Taulukko- A7: Panos-tuotostaulukot (ulkomainen)

<table>
<tr><th rowspan="2"></th><th rowspan="2">Toimialat</th><th rowspan="2">Toimialat yhteensä</th><th colspan="7">Loppukäyttö</th><th></th></tr>
<tr><th>Kotitaloudet</th><th>Investoinnit</th><th>Julkinen</th><th>Vienti alueellinen</th><th>Vienti ulkomainen</th><th>Varastot</th><th>Loppukäyttö perushintaan</th><th>Kokonaiskäyttö perushintaan</th></tr>
<tr><td rowspan="2">Tuotteet</td><td rowspan="2">B_for= Ulkomaisen tuotannon välituotekäyttö</td><td rowspan="2">∑ Ulkomaisen tuotannon välituotekäyttö</td><td>H_for - io</td><td>I_for - io</td><td>G_for - io</td><td>Exp_reg_f - io</td><td>Exp_for_f - io</td><td>Inv_f - io</td><td>∑ Loppukäyttö</td><td>∑ kaikki sarakkeet</td></tr>
<tr><td colspan="6">F_for</td><td></td><td></td></tr>
<tr><td>Tuotteet yhteensä</td><td>∑ Ulkomaisen tuotannon välituotekäyttö</td><td>∑</td><td>∑ H_for - io</td><td>∑ I_for- io</td><td>∑ G_for - io</td><td>∑ Exp_reg_f- io</td><td>∑ Exp_for_f - io</td><td>∑ Inv_f- io</td><td>∑</td><td>∑ imp_for</td></tr>
</table>

Taulukko- A8: Tasapainoehdot

	Rivi/Sarake Tasapainot	**Tarjontataulukko** (test_supp2014_5.xlsx)	**Kokonaiskäyttötaulukko** (test_use2014_5.xlsx)	**Kotimaisen käytön taulukko** (test_use_dom2014_5.xlsx)	**Alueellisen tuonnin käyttötaulukko** (test_use_reg2014_5.xlsx)	**Ulkomaisen tuonnin käyttötaulukko** (test_use_imp2014_5.xlsx)	**Kotimainen panos-tuotos -taulukko** (test_io_2_2014_5.xlsx)	**Alueellisen tuonnin panos-tuotos -taulukko** (test_io_reg2014_5.xlsx)	**Ulkomaisen tuonnin panos-tuotos -taulukko** (test_io_imp2014_5.xlsx)
Tasapainot	**Sarake**	Kokonaistarjonta	Kokonaiskäyttö perushintaan						
	Sarake	Kokonaistuotos		Kokonaiskäyttö perushintaan					
	Sarake	Tuonti alueellinen			Kokonaiskäyttö perushintaan				
	Sarake	Tuonti ulkomainen				Kokonaiskäyttö perushintaan			
	Rivi	Tuotos perushintaan	Tuotos perushintaan	Tuotos perushintaan			Rivit [Tuotos perushintaan] = Sarake [Kokonaiskäyttö perushintaan]		
	Summa (Tuotos perushintaan)	[Tuotteet yhteensä --Kokonaistuotos]	[Tuotosperushintaan – Toimialat yhteensä]; {[Tuotteet yhteensä –Kokonaiskäyttö perushintaan] *miinus* Kaikki tuonti (alueellinen ja ulkomainen)}	[Tuotos perushintaan – Toimialat yhteensä]; [Tuotteet yhteensä—Kokonaiskäyttö perushintaan]			[Tuotos perushintaan – Toimialat yhteensä]; [Kotimaisen tuotannon kokonaiskäyttö—Kokonaiskäyttö perushintaan]		
	Summa (Kotimainen loppukäyttö)			Summa[Kotimaisen tuotannon kokonaiskäyttö. -- Loppukäytöt (Kotitalous, Investoinnit, Julkinen, Vienti, Alueellinen vienti, Varastot)]			Summa[Kotimaisen tuotannon kokonaiskäyttö -- Loppukäytöt (Kotitalous, Investoinnit, Julkinen, Vienti, Alueellinen vienti, Varastot)]		
	Summa (Alueellinen tuonti)	[Tuotteet yhteensä –Alueellinen tuonti]		[Alueellisen tuonnin käyttö—Kokonaiskäyttö perushintaan]	[Tuotteet yhteensä –Kokonaiskäyttö perushintaan]		[Alueellisen tuonnin käyttö -- Kokonaiskäyttö perushintaan]	[Summa--Summa]	
	Summa (Ulkomainen tuonti)	[Tuotteet yhteensä –Ulkomainen tuonti]		[Ulkomainen tuonti-- Kokonaiskäyttö perushintaan]		[Tuotteet yhteensä -- Kokonaiskäyttö perushintaan]	[Ulkomaisen tuonnin käyttö-- Kokonaiskäyttö perushintaan]		[Summa--Summa]
	Summa (Ulkomaisen tuonnin loppukäyttö)					Summa[Tuotteet yhteensä -- Loppukäytöt (Kotitalous, Investoinnit, Julkinen, Vienti)]			[Rivi summa – Loppukäytöt (Kotitalous, Investoinnit, Julkinen, Vienti)]
	Summa (Alueellisen tuonnin loppukäyttö)				Summa[Tuotteet yhteensä -- Loppukäytöt (Kotitalous, Investoinnit, Julkinen, Vienti)]			[Rivi summa – Loppukäytöt (Kotitalous, Investoinnit, Julkinen, Vienti)]	

Liite B Linkki verkosta löytyviin taulukoihin:

http://www.ptt.fi/julkaisut-ja-hankkeet/kaikki-hankkeet/alueellisen-taloustilastojen-tieto-kanta-alta.html

Liite C Raportti The FINAGE/REFINAGE General Equilibrium Models of the Finnish Economy, Juha Honkatukia

The FINAGE/REFINAGE
General Equilibrium Models of the Finnish Economy

Juha Honkatukia

Contents

SUMMARY

This report contains a description of the FINAGE and REFINAGE models of the Finnish economy. Both are applied general equilibrium models of the Finnish economy, but whereas FINAGE perates at the national level with more emphasis on industry detail, REFINAGE is about the regional economies and the interactions of the several layers of public sectors that are of importance at the regional level. Both models have been used to extensively to study the effects of policies on the economy, and have become integral parts of the anticipation of long-term developments of the economy, employment and regional development. They have also found their uses in teaching, and thus there are many good reasons to update their description evey now and then. This report contains a full description of the model codes and the underlying theory.

Applied general equilibrium models have become a standard tool for the analysis of structural policies in many countries and international research organisations. Their use has been prompted by the growing need for quantitative policy analysis, calling for the use of numerical methods, but there are several other reasons to suggest the use of AGE models in particular. Chief among these is the applicability of models that rely on explicit optimisation on the analysis of welfare impacts of structural policies. Many policy issues are intractable by theoretical models, for example, when the policies concern several sectors of the economy or involve contradicting effects. The AGE approach also lends itself to the construction of scenarios of the future of the economy, and the effects of policies on those futures, where the requirement for explicitly stating the underlying assumptions facilitates a critical study of the driving forces behing economic growth, and where the AGE approach assures the internal consistency of the scenarios.

AGE models have been used in the analysis of a wide variety of issues, but their most natural applications are in the analyses of changes in policies or in the operating environment. Policy analyses have covered the effects on the economy of changes in taxes, tariffs, environmental policies, public expenditures and social security, to name a few, whereas the effects on the economy of changes in world markets, the availability of natural resources or technologies are some of the questions covered by AGE modelling. AGE models also often contain a great deal of detail, allowing results to be examined at different levels ranging from the regional to the sectoral to the national. Often the models also cover distributional issues.

This report takes a two-pronged approach to explaining the theoretical logic of FINAGE/REFINAGE. First, we describe the structure and the behavioural assumptions used in the models in an informal way. Second, we explain the theory of the model in detail in algebraic form and in terms of the model code.

The report does not introduce the reader to the simulation software, but it does describe the main features of the programming code, the TABLO language, to facilitate an understanding of the presentation of the behavioural equations used in the model, using examples from the FINAGE/REFINAGE programme codes. The report also gives the full programme code of the

regional model. The final chapter of the report explains the derivation of the main behavioural equations of the model, linking the theory to its presentation in the model code.

1. Introduction

Applied General Equilibrium (AGE) models have become a standard tool for the analysis of structural policies in many countries and international research institutions. In Finland, they have been used to study the effects of a broad variety of policies on regional and national growth, employment, welfare and public finances. They have also found their place as a tool for producing internally consistent, often quite complex scenarios for the development of the economy, as well as the anticipaton of demand for labour and education.

This report describes the dynamic, FINAGE and REFINAGE models of the Finnish economy. Both models have been used to extensively to study the effects of policies on the economy, and have become integral parts of the anticipation of long-term developments of the economy, employment and regional development. They have also found their uses in teaching, and thus there are many good reasons to update their description evey now and then. This report contains a full description of the model codes and the underlying theory.

The increased use of AGE models has been prompted by developments in economics, but also on the growing demand for quantitative policy analysis. The analysis of actual policy options mandates the use of numerical methods, but there are several reasons to suggest the use of AGE models in particular. Chief among these is the applicability of models that rely on explicit optimisation in the analysis of welfare impacts of structural policies. It may also be the case that many policy issues are untraceable with theoretical models. For example, when the policies affect several sectors of the economy or include opposing effects, numerical analysis suggests itself.

AGE models can be seen as a natural extension of input-output models, which have been used for policy analysis for decades. This is because both rely on input-output data to capture the basic structure of production. Where IO models use rigid multipliers drawn from the data, AGE models use functions of prices to capture the same input shares. The difference is deeper than appears at first glance, however, since AGE models rely extensively on optimization theories to model the demand for inputs, and cover all other aspects of the economy as well.

The distinguishing features of AGE models can be summarised with three points:

1. Generality – AGE models cover explicitly the optimising behaviour of several agents in the economy. Optimisation draws attention to the sig-

nificance of the prices of goods and primary factors for demand and production decisions. Often these models also cover the decisions of the public sector, investment, or wage setting.

2. Market equilibrium – AGE models cover the effects of supply and demand on prices in every market.
3. Computability – All of the coefficients and parameters of AGE models are evaluated on the basis of data. While a central part of this data is formed by input-output data on the use of goods and primary factors, IO data alone is not sufficient for the specification of an AGE model. It has to be accompanied by data on income flows and income distribution, for example.

Data are also needed to specify the many behavioral parameters used in the theoretical models of consumption and production that underlie an AGE presentation of an economy.

The first AGE models stem from the work of Johansen (1960), which meets all three criteria above. The development of AGE models is also connected to advances in theoretical GE modelling, and in particular the work of Scarf, who developed algorithms for solving such models. This spawned the first AGE models in the 1970s (Scarf 1973, Shoven and Whalley 1972, 1973, 1974). The rapidly improving computational capabilities and the increasing availability of simulation software speeded up interest in these models and by the early 1990s, AGE models had become one of the standard tools of applied economics used in many areas of applied research and in academic research. AGE modelling had also been included in the curriculum of many universities, and several standard texts had been published (Dervis et al. 1982, Shoven and Whalley 1992 and Dixon et al. 1992, 2002, 2015). FINAGE and REFINAGE are derivatives of the models developed in the Centre of Policy Studies in Australia, with some Finnish institutional and perhaps interpretative twists. This report also benefits greatly from the generosity of Professor Peter Dixon, whose texts it liberally borrows.

AGE-models have been applied to the analysis of a wide variety of issues, but their most natural applications are in the analyses of changes in policies or in the operating environment. Policy analyses have covered the effects on the economy of changes in taxes, tariffs, environmental policies, public expenditures and social security, to name a few, whereas the effects on the economy of changes in world markets, the availability of natural resources or technologies are some of the questions covered by AGE modelling. AGE models also often contain a great deal of detail, allowing results to be examined at different levels ranging from the regional to the sectoral to the national. Often the models also cover distributional issues.

This report describes the theoretical logic and underlying data of FINAGE/REFINAGE. We shall describe the structure of the behavioural assumptions used in the model and relate these to source data in the national accounts. While we do not introduce the reader to the simulation software, we do describe the main features of the programming code, the TABLO language, to facilitate an understanding of the presentation of the behavioural equations used in the model. The report is organised as follows.

Chapter two contains a general description of the model and the model database and reports its sources in the Finnish national accounts and other official statistics.

Chapter three gives an outline of the main characteristics of the TABLO language using examples from the FINAGE/REFINAGE programme codes. The emphasis is on explaining the basic logic of the commands and conventions used in setting up the model. Chapter four reports the full FINAGE/REFINAGE programme code. Chapter five offers the derivation of the main behavioural equations of the model, linking the theory to its presentation in model code.

2. An overview of FINAGE/REFINAGE

2.1 Introduction

This report contains a description of the FINAGE and REFINAGE models of the Finnish economy. Both are applied general equilibrium models of the Finnish economy, but whereas FINAGE perates at the national level with more emphasis on industry detail, REFINAGE is about the regional economies and the interactions of the several layers of public sectors that are of importance at the regional level. They can be applied to study the effects of a wide range of economic policies. The model databases contain detailed information about commodity and income taxes as well as the expenditures and transfers of the public sectora and thus covers most policy instruments available to the government. For regional policy analysis, the model also covers transfers between the three main public sectors in Finland, namely, the central government, local governments, and the social security funds. The aim has been to cover the dues and taxes collected by these institutions as closely as possible.

FINAGE and REFINAGE are based on the dynamic models developed at the Centre of Policy Studies in Monash University. MONASH-type models are used in countries ranging from China (SINOTERM) and South Africa to the United States (USAGE); (Dixon and Rimmer, 2002, Wittwer 2017). In Europe, models based on MONASH have been developed for Denmark, the Netherlands, and the Finnish VATTAGE (Honkatukia 2009). REFINAGE is also predated by the VERM model for Finland (Honkatukia 2013), but includes several extensions over the original model. These include a more useful formulation of the utility functions for regional households, and an updated formulation of public sector finances and public demands. REFINAGE takes its dynamics and the description of the public sectors from FINAGE, which is a MONASH-type model of the Finnish economy. The regional TERM model developed by Mark Horridge at CoPS, in turn, has lent its AGE core to REFINAGE to cover the interlinkages between the regional economies, as well as its many tools for handling the core AGE database, whereas FINAGE more closely follows the original MONASH formulation. In time, both have adopted many of the notational conventions of USAGE.

AGE-models, or CGE-models as they are also known, have grown both in popularity and variety during the past decade. While the optimizing, general equilibrium approach appears to relate them to macro-economic DSGE-models, they are actually a rather different breed. DSGE-models are mostly concerned over the (forecasting of) short-run effects of shocks – policy or otherwise – to the steady-state development of the economy, whereas AGE models are about the effect on the structure of the economy caused by changes of the drivers of growth or by policy and other shocks. AGE models thus tend to contain much more sectoral detail than DSGE models. Another difference concerns the approach to dynamics. DSGE models focus on the study of the economy on an estimated steady-state gwoth path, whereas AGE modelling often tries to capture the actual sectoral history of the economy. This is especially the case with models following the original MONASH-approach, such as FINAGE and REFINAGE, but also the very large MONASH-style models of the US and Chinese economies.

Several factors explain the popularity of MONASH-type models. The main ones are the advanced and user-friendly software packages that facilitate data handling and the set-up for complicated policy simulations that also allow a very detailed post-simulation analysis of the simulation results. MONASH-type models are also very adaptable to the analyses of different types of policies and different time frames. In forward-looking policy analysis, MONASH-type models offer a disciplined way to forecast the baseline development of the economy. Last, but not least, they also allow the user to replicate and explain the historical development of an economy in great detail.

The dynamics of the model lead to gradual adjustment to policies or external shocks to the baseline development of the economy. There are three types of inter-temporal links connecting the consecutive periods in the model: (1) accumulation of fixed capital; (2) accumulation of financial claims; and (3) lagged adjustment mechanisms, notably in the labour markets. Different fiscal rules for the balancing of the public sector budgets can also be specified. The speed of adjustment depends on several parameters: 1) the rates of depreciation of capital at the industry level; 2) the rate of adjustment of returns to capital; and 3) the rate of adjustment of real wages (when sluggish wage adjustment is assumed). These parameters can be derived from national accounts data and econometric studies of, notably, the labour markets. Policies can also affect the rate of adjustment. For example, if it is assumed that the government is willing to run deficits during the adjustment period of the economy to, say, an external shock to raw material prices, the parameter controlling this adjustment process will affect the speed at which the economy converges to a new equilibrium growth path.

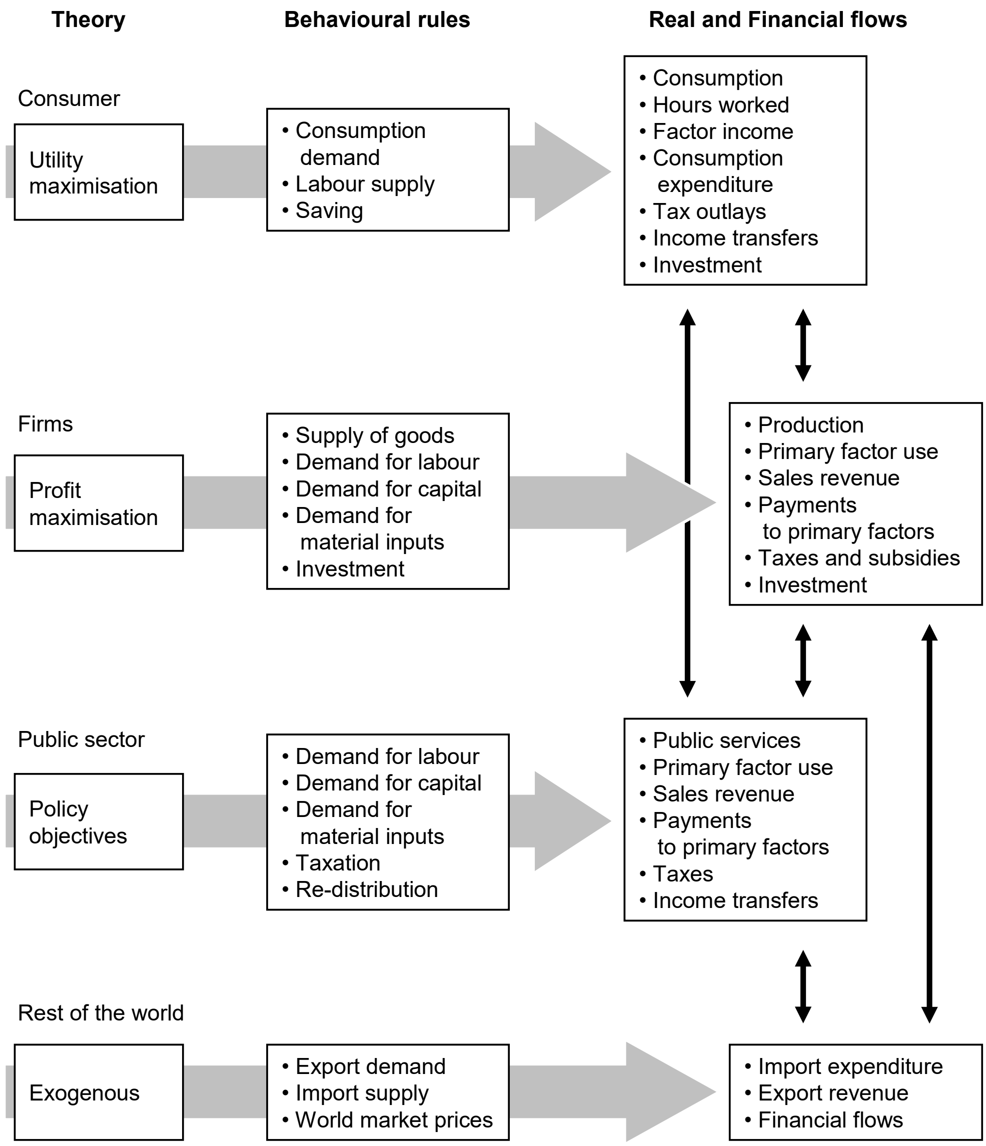
This chapter gives a general outline of FINAGE/REFINAGE. The chapter is divided into three sections. In section 2.2, we describe the model databases. Section 2.3 gives an overview of the AGE theory behind demand, government finances and labour demand. Each part of this theory is explained more thoroughly in chapter 5, where the implementation of the model in TABLO code is also explained. Section 2.4 is devoted to the dynamic mechanisms of the models. Section 2.4.1 explains the theory of investment over time, section 2.4.2 asset dynamics, section 2.4.3 deals with the (optional) sluggish wage mechanism.

2.2 The FINAGE/REFINAGE database

The models utilise extensive databases that describe the transactions between different agents in the economy. In the core of the models are optimization problems of economic agents that result in the demand and supply functions of goods and primary factors. The transactions covered by the database and the models are illustrated in Figure 2.1.

The FINAGE/REFINAGE database collects information about the structure of the Finnish economy derived from the national accounts, arranged in a presentation reflecting the theoretical structure of the model. The database also contains the behavioural parameters that are used to operationalise the behavioural assumptions made in the model. National accounts collect data on the use goods and services by industry and by product, but it also contains accounts for production as well as financial positions by institutional sector. (Eurostat 1997, 1.) The institutional sectors are viewed as independent decision-makers, and it is the behaviour of these decision-makers that the model parameters and coefficients derived from the data describe and control.

Figure 2.1. The structure of an Applied General Equilibrium model



A large part of the database uses input-output data to capture the structure of demand for intermediate goods and primary factors by industry and final goods consumption by the consumers, the public sector, and the rest of the world. However, input-output data does not contain data on income flows, which must be obtained from other sources in national accounts; neither does it cover the wide variety of redistribution (of incomes) between the institutional sectors of the economy, which is often in the core of regional policy analyses. Thus a large part of the database is devoted to transactions between the institutional sectors of the economy.

In the database, transactions take place both between domestic sectors, and between domestic and foreign sectors. The domestic sectors are usually divided into five sub-categories: Non-financial corporations, Financial corporations, General Government, Households and Non-profit institutions serving households (Eurostat (1997), Eurostat (2003)) whereas the foreign sectors represent foreign countries and multinational and international organisations. These institutional sectors are mutually exclusive and their role in the economy can thus be unequivocally presented. For example, export demand is final demand for domestic goods and services by the foreign sectors.

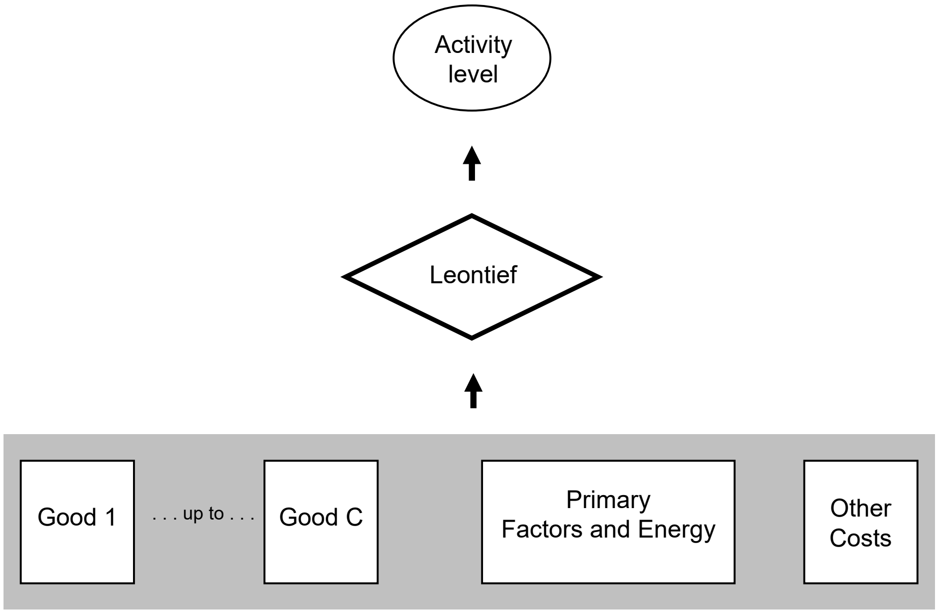
REFINAGE models production with conventional, nested production functions. The idea behind industrial classification is to group activities whose production processes or the products they make are similar. However, REFINAGE also allows for multi-production of commodities.

2.3 An overview of the AGE theory of FINAGE/REFINAGE

2.3.1 Demand for intermediate goods and primary factors

FINAGE and REFINAGE models production as consisting of two broad categories of inputs: intermediate inputs and a primary factor-energy bundle (referred to as the KLE-bundle). Firms are assumed to choose the mix of inputs that minimises the costs of production for their level of output. They are constrained in their choice of inputs by a three-level nested production technology. At the first level, intermediate-input bundles and primary-factor bundles are used in fixed proportions to output. These bundles are formed at the second level. Intermediate input bundles are combinations of international imported goods and domestic goods. The primary-factor bundle is a combination of labour, capital, energy and land. At the third level, the input of labour is formed as a combination of inputs of labour from five different occupational categories.

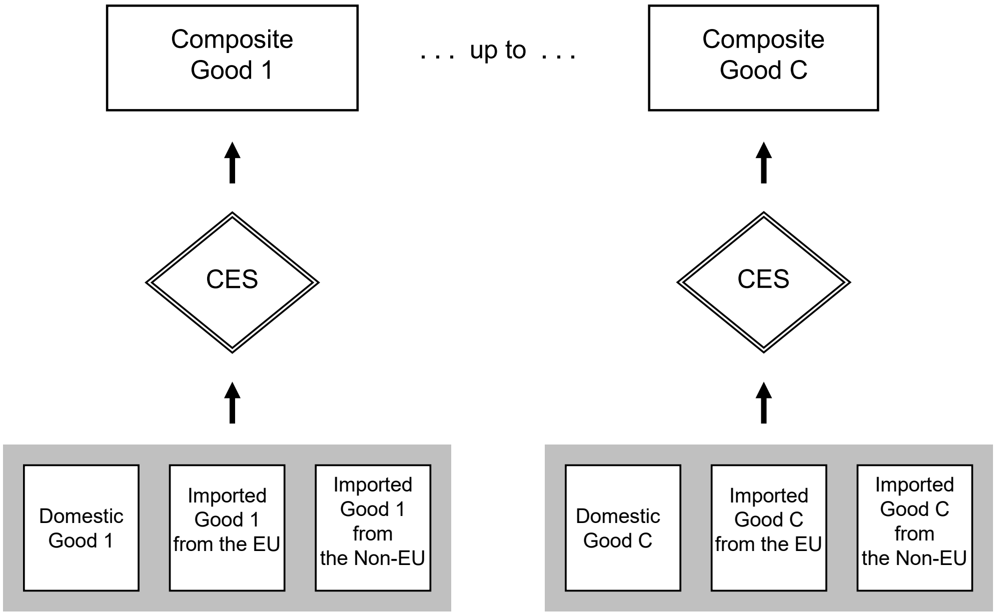
Figure 2.2. **Top-level of the input mix**



At the bottom level of the intermediate good nest are the demands for commodities from various sources. The firms decide on their demands for the domestic commodities and the foreign imported commodities under a CES assumption, which amounts to the standard Armington assumption that domestic commodities are imperfect substitutes to foreign varieties. Figure 2.3 illustrates the structure giving rise to the demand for the composite goods and individual commodities.

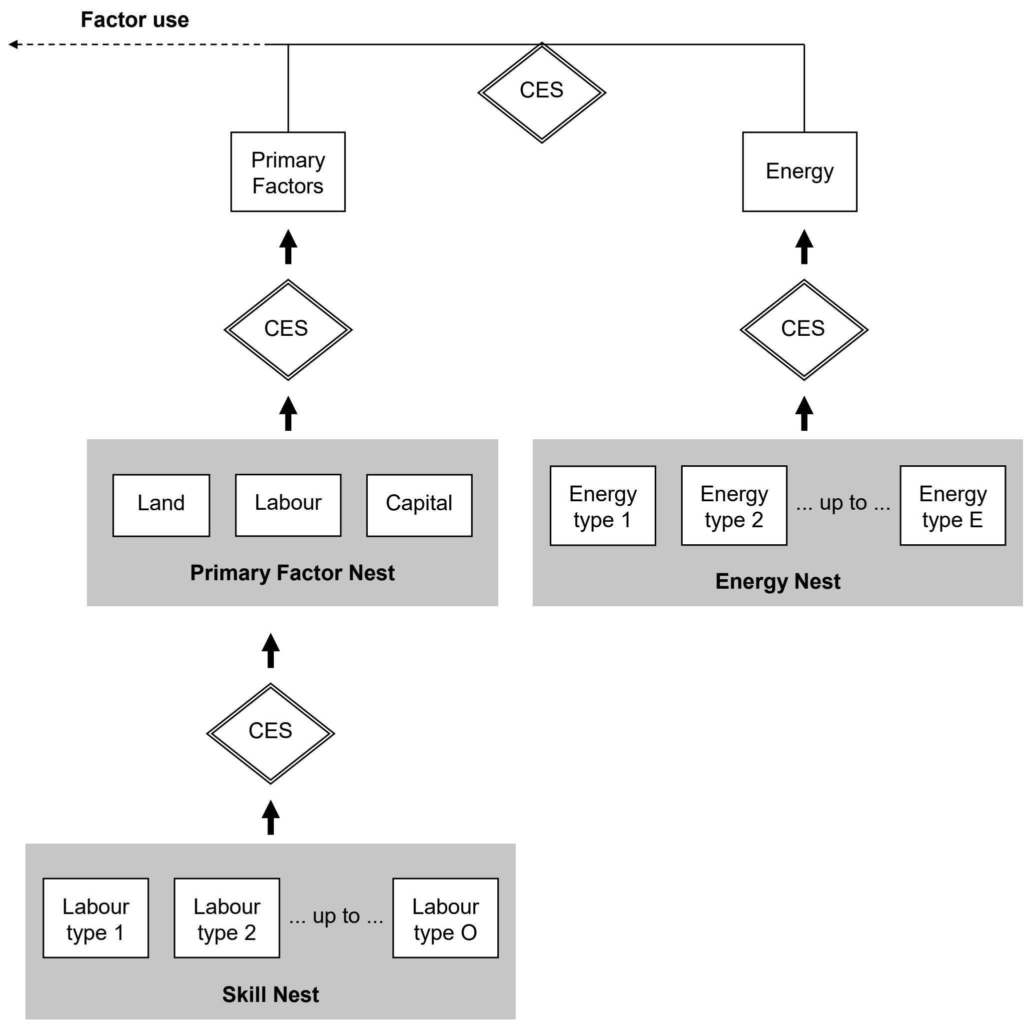
In figure 2.2, an item called other cost tickets is also included. Other costs are costs not related to the use of primary factors or material and energy inputs. In industries with high profitability they often explain profits not directly related to rates of return to capital.

Figure 2.3. The sourcing of inputs



The demand for primary factors and energy composite are determined by the top nest in figure 2.2. Primary factors and energy are assumed to be combined with energy to form a primary factor-energy nest, often called the KLE-nest, as depicted in figure 2.4 below. The demands for labour of different skills, capital, and energy are derived from this structure. An important characteristic of this structure is that energy and primary factors can be substituted for each other in many industries. Without this assumption, it would be pointless to study policies involving changes in the relative prices of energy and other inputs.

Figure 2.4. The primary factor-energy composite



2.3.2 Multiproduct industries and multi-industry products

In the database, many goods are produced by several industries and many industries also produce multiple commodities. This is most notably the case for energy products, where petroleum products stem from refining and where the relative price of the products affects the output mix. There are also some products, such as wood and wood residue used for heating and energy production that can stem from several industries.

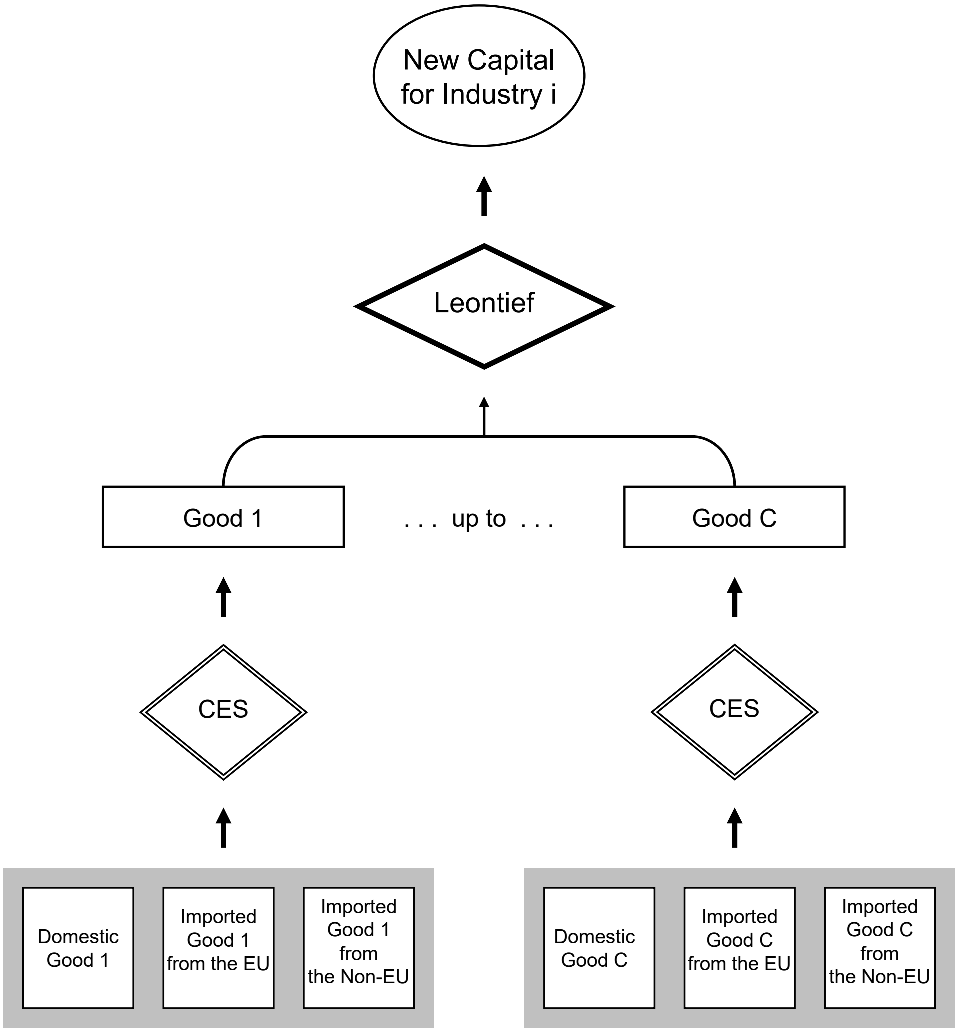
The sourcing of goods from industries raises from national accounts data. The model allows for the possibility that industries are affected by relative prices when deciding their output mix. This decision is modelled as a profit maximisation problem under the assumption of CET transformation technologies between possible outputs.

2.3.3 Demands for inputs to capital creation and the determination of investment

FINAGE/REFINAGE follow standard AGE practice in modelling the production of capital goods with an investment sector, whose task it is to combine inputs to form units of capital. In choosing these inputs they minimise costs subject to a Leontief technology. Figure 2.5 shows the nesting structure for the production of new units of fixed capital.

Capital is produced with inputs of domestically produced and imported commodities. No primary factors are used directly as inputs to capital formation. The use of primary factors in capital creation is recognised through inputs of the commodities, for example, construction services. Where REFINAGE differs from most AGE models is in the description of the capital goods themselves. In REFINAGE, capital is genuinely sector specific, in other words, the commodity inputs for capital to each industry are unique. This means that capital is not malleable but that it will only adjust slowly, over time.

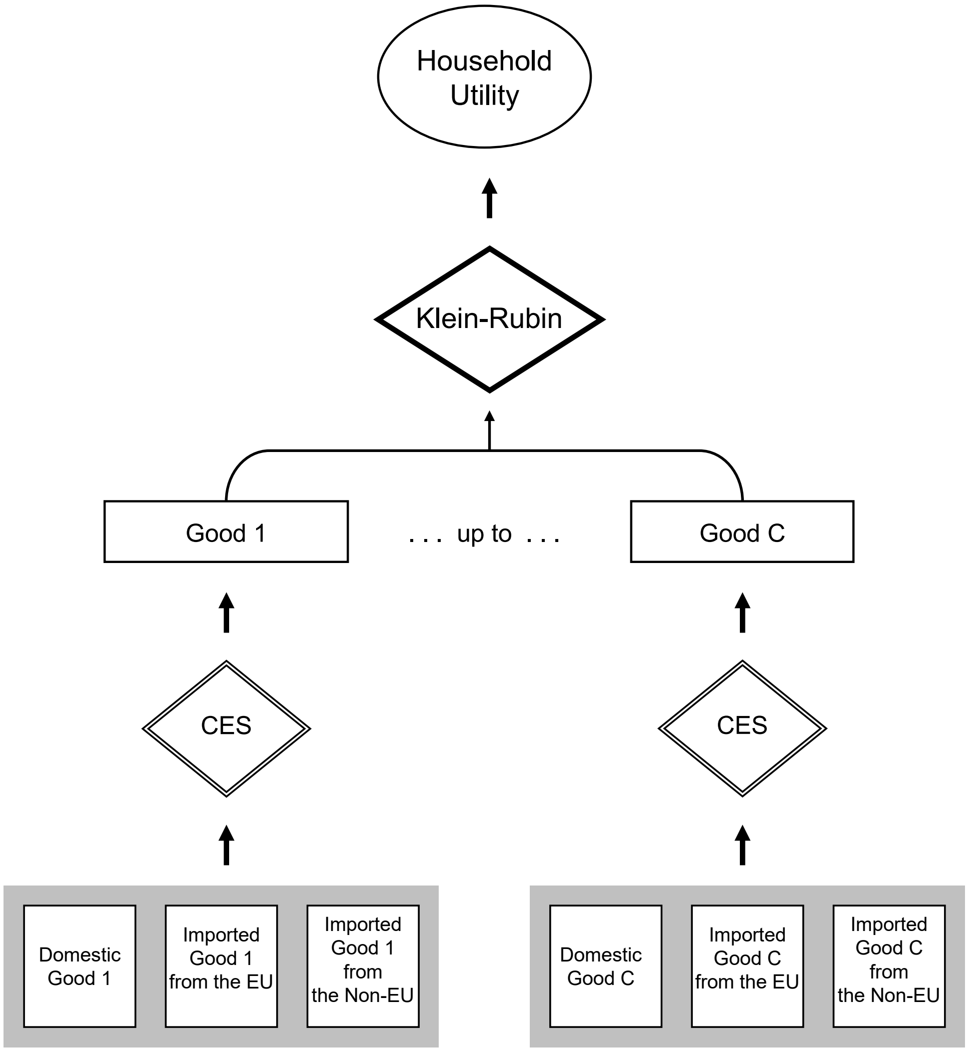
Figure 2.5 Production of investment goods in FINAGE/REFINAGE



2.3.4 Household demand

In FINAGE and REFINAGE, households are assumed to be the recipients of factor incomes. However, they also possess assets and liabilities abroad and domestically, which implies that a part of domestic incomes will be channelled abroad. A Keynesian consumption function then determines the level of household expenditure as a function depending on the (observable) average propensity to consume and on household disposable income, while the demands for individual goods are modelled as a utility maximisation problem subject to a household expenditure constraint. Whether we treat the average propensity to consume as constant depends on the application. When the model is used to accommodate an outside forecast for the macroeconomy, for example, the propensity to consume is endogenous, allowing the model to capture the forecast path of household consumption, whereas in policy applications is usually exogenous. It is also possible to model the effects of expectations, as in Honkatukia (2016). In the regional setting, it may well be the case that there are differences in the propensities to consume between the regions. However, there are also instances where outside information on changes in the propensity to consume, stemming from studies of consumption patterns, can be used in the construction of baseline scenarios. The structure of the utility function is shown in figure 2.6.

Figure 2.6. The structure of household demand in FINAGE/REFINAGE



2.3.5 Export demand

Export demand is modelled by price-sensitive export demand functions. However, there are several possibilities to refine this basic set-up. First, export demands in can be made to distinguish between traditional and collective exports. For traditional export sectors, each export good faces its own downward-sloping foreign demand curve. Thus a shock that improves price competitiveness of an export sector will result in increased export volume, but at a lower world price. The non-traditional, or collective, exports, on the other hand, face a single export demand function, that is, these exports move together. The composition of collective export demand is also exogenous. The distinction between traditional and collective exports can be used to rule out feedbacks from world prices to domestic prices, which may be of relevance for the service sectors. However, most commodities are modelled with the individual export demand functions. The supply decision to domestic and exports markets can also be modelled as being price dependent on the relative prices in these markets under the assumption of a CET technology.

2.3.6 Public sector demands for commodities

Commodities are demanded by the public sectors (the central government, the communal sector, and the social secutrity funds). There are several ways of handling these demands, including: (i) endogenously, by a rule such as moving government expenditures with household consumption expenditure or with domestic absorption; (ii) endogenously, as an instrument which varies to accommodate an exogenously determined target such as a required level of government deficit; and (iii) exogenously, by assuming they follow forecasts stemming from outside of the model. In baseline simulations, the last assumption is often used, with official estimates of government spending giving the path that government expenditures take.

2.3.7 Indirect taxes and margin demands

In FINAGE and REFINAGE, supply and demand of commodities are determined through optimising behaviour of agents in competitive markets. The assumption of competitive markets implies equality between the producer's price and marginal cost in each industry and each region. Demand is assumed to equal supply in all markets. However, indirect taxes and margins affect the purchaser’s prices.

The government imposes ad valorem sales taxes on commodities, income and payroll taxes on labour incomes, and capital taxes on capital income. The government also sets production taxes and collects tariffs from imports. These taxes place wedges between the prices paid by purchasers and prices received by the producers. The model recognises margin commodities (e.g., retail trade and road transport freight) which are required for each market transaction (the movement of a commodity from the producer to the purchaser). The costs of the margins are included in purchasers' prices. Needless to say, there are marked inter-regional differences in the cost shares of these margins.

2.4 An overview of FINAGE/REFINAGE dynamics

FINAGE and REFINAGE are dynamic models that allow the economy to adjust over time to changes in the economic environment or in policies. The most important determinant of this adjustment process is the accumulation of physical capital via investment or disinvestment, and the accumulation of financial assets over time. However, sluggish, time-dependent wage adjustment can also be specified, and there may be an element of sluggishness in policy responses to changes in employment. Many income transfers are also explicitly indexed to reflect changes in CPI and real wages over time. The dynamic structure of the models closely follows the approach first applied in the MONASH-model. (Dixon et Rimmer, 2002). This section describes the dynamics in general terms, with a more detailed description being given in chapter 5.

An integral part of dynamic applications of the models is the baseline, or forecast, scenario of the economy. The baseline forms the reference, to which the effects of changes in policies are compared. In most applications, the baseline is formed on the basis of medium term forecasts and long run scenarios of the development of the macroeconomy that stem from outside of the model, REFINAGE often using national level forecasts produced with FINAGE. The baseline also uses forecasts for industry-specific historical trends in productivity, employment, investment, exports, as well as import and export prices, that stem from the process of updating the model's database. This latter process in effect ensures that the model traces the development of the economy during the past few years. However, in constructing the baseline, it is also possible to introduce industry-specific expert forecasts for particular industries, a feature that has often been used for the large export or regionally dominant industries, and for the sectors producing public services.

2.4.1 Capital stocks, investment and the inverse-logistic relationship

In each year of year-to-year simulations, we assume that industries' capital growth rates (and thus investment levels) are determined according to functions which specify that investors are willing to supply increased funds to industry j in response to increases in j's expected rate of return. However, investors are cautious. In any year, the capital supply functions limit the growth in industry j's capital stock so that disturbances in j's rate of return are eliminated only gradually.

The treatment of capital and investment in year-to-year simulations can be compared with that in models recognizing costs of adjustment (see, for example, Bovenberg and Goulder, 1991). In costs-of-adjustment models, industry i's capital growth (and investment) in any year is limited by the assumption that the costs per unit of installing capital for industry i in year t are positively related to the i's level of investment in year t. In the MONASH approach, it is assumed that the level of i's investment in year t has only a negligible effect (via its effects on unit costs in the construction and other capital supplying industries) on the costs per unit of i's capital. Instead of assuming increasing installation costs, we assume that i's capital growth in year t is limited by investor perceptions of risk. Investors are willing to allow the rate of capital growth in industry i in year t to move above i's historically normal rate of capital growth only if they expect to be compensated by a rate of return above i's historically normal level.

This theory is fully explained in chapter 5; here, we note that the treatment of capital goods as being industry-specific also introduces an element of sluggishness.

In every region, the evolution of the industry-specific capital stock follows the familiar equation:

$$K_{i,t+1} = (1 - D_i)*K_{i,t} + I_{i,t} \qquad (2.1)$$

where

$K_{i,t}$ is the capital stock at the beginning of year t in industry i;

$K_{i,t+1}$ is the capital stock at the end of year t in industry i;

$I_{i,t}$ is investment during year t in industry i; and

D_i is a parameter giving the rate of depreciation in industry i.

In computations for year t, $K_{i,t}$ is set exogenously to reflect i's end-of-year capital stock in year t–1.

In baseline computations, investments in the reference year are given by the data for that year, whereas for the following years in a baseline forecast, they are determined by the returns to capital.

2.4.2 Asset dynamics

Financial assets – liabilities and deficits – provide another inter-temporal link in FINAGE and REFINAGE. The model recognises current account deficits, with the related foreign liabilities, and public sector deficits, which in turn are related to government debt. These deficits are described in detail, and the dynamics depicting the accumulation of the related financial assets.

Accumulation of financial assets and liabilities is modelled with inter-temporal links of the form:

$$D_{q,t+1} = D_{q,t,t} * V_{q,t,t+1} + \left(\frac{D_{q,t} + D_{q,t+1}}{2} \right) * R_{q,t} + J_{q,t} * V_{q,tm,t+1} , \qquad (2.2)$$

where

$D_{q,t}$ is the level of asset or liability of type q at the beginning of year t

$R_{q,t}$ is the average rate of interest or dividend rate for asset or liability of type q during year t

$J_{q,t}$ is the active accumulation of q during year t

$V_{q,t,t+1}$ is the factor translating the value of q from the beginning of year t to beginning of year t+1

and

$V_{q,tm,t+1}$ is the factor translating the value of q from the middle of year t to the beginning of year t+1.

The factors *V* take into account the effects of exogenous changes in exchange rates and interest rates. For example, since REFINAGE deals separately with the EU and non-EU countries, the effects of an appreciation of the US dollar can be taken into account when the debt portfolio is known.

Active accumulation means here new borrowing or investment beyond accumulation of interest and dividends. For example, in a simple foreign debt equation a deficit on the balance of trade is active accumulation while accrued interest and revaluation effects are passive accumulation. While accounting for assets makes the model more complex, it brings with it considerable benefits. Most importantly, by recording the assets and liabilities, REFINAGE is able to generate results for the wealth of Finns which can be taken into account in welfare analysis.

2.4.3 Labour market dynamics

The models also allow for different treatments of the labour markets. The labour market equations relate population and population of working age, and define unemployment rates in terms of demand and supply of labour.

In dynamic simulations, labour supply is typically taken as exogenous, while wages adjust only gradually and unemployment is determined endogenously. Especially with FINAGE, several studies have also focused on the links of utility-maximization-based labour-supply decisions (Most recently Tamminen, Honkatukia, Leinonen and Haanperä2019).

In a dynamic setting however, it is not unreasonable to assume that there is an element of sluggishness in real wage adjustment. In Finland, this was very much the case until very recently, when wage setting has become more decentralised. The basic set-up of FINAGE/REFINAGE then captures the idea that wage setting may be centralized at the national level.

Specifically, we assume that real, after tax wages are sticky in the short run and flexible in the long run. In this labour market specification, policy shocks generate short-run changes in aggregate employment and long-run changes in real wages. Algebraically, we assume that

$$\left(\frac{W_t}{W_t,old}-1\right)=\left(\frac{W_{t-1}}{W_{t-1},old}-1\right)+\alpha_1\left[\left(\frac{W_{t-1}}{W_{t-1},old}-1\right)-\left(\frac{E_t}{E_t,old}-1\right)^{\alpha_2}\right]$$

(2.3)

In this equation, *old* indicates a base case forecast value. $W_{t,old}$ and $E_{t,old}$ are the real wage rate and the level of employment in year t in the base case forecasts, and W_t and E_t are the real wage rate and the level of employment in year t in the policy simulation. Under this specification, the adjustment of the real wage rate depends on deviations from the expected real wage development and on the deviation of employment from the expected employment growth. The speed of adjustment is controlled by parameter α_1, whereas α_2 determines, whether employment returns to its expected growth path after a policy shock. The real wage equation is close to NAIRU-theories of unemployment, and its parameters have been estimated for Finland is studies such as Alho (2002) and McMorrow and Roeger (2000).

2.4.4 Government finances

The public sector is where FINAGE/REFINAGE most distinctly differs from their Australian counterparts. The reason lies simply in the differences between the division of power between the central government and the regional and local authorities. Finland has a strong central and local government but lacks the regional/state level present in many other countries, and also in Australia. In addition, social secutrity funds have a markedly larger role in the economy than in many other countries. This has a bearing on the modeling of the roles and powers of the various levels of government.

In many ways, the similarities to other countries are still there, of course. Thus the models utilise a detailed database on indirect taxes, payroll taxes and income taxes. Indirect taxes on commodities are modelled as *ad valorem* rates of tax levied on the basic price of the underlying flow. The basic price is the price received by the producer. FINAGE and REFINAGE allow for differentiation of indirect taxes to environmental taxes and other taxes for certain commodities. Production taxes are modelled as part of value added, while payroll taxes are directly levied on wages. Income taxes are levied on labour and capital incomes. Finally, import duties are levied as ad valorem taxes on imports.

The models include revenue equations for income taxes, sales taxes, excise taxes, taxes on international trade and for receipts from government-owned assets. As described already, the model accounts for public expenditures on commodities (or services). It also contains outlay equations for transfer payments to households (e.g., pensions, social secutrity benefits and unemployment benefits), and transfer payments between the central government, the local authorities, and the social security funds. The specification of government finances makes the models suitable for analysing the effects of changes in many different kinds of policies.

3. TABLO programming language and its use in the REFINAGE

FINAGE and REFINAGE computations are performed by the GEMPACK programmes. The GEMPACK suite of programmes consists of; text editors that are used for preparing the model and various command files for the simulations; of programmes used for processing the data; of the actual simulation software; and of various programmes used for viewing and analysing the simulation results. In this chapter, we give a brief overview of the GEMPACK package and the methodology of solving large models.

However, we concentrate mostly on the TABLO programme, which is used for representing the FINAGE/REFINAGE models. Although close to ordinary algebra, the TABLO language has a particular structure and some unavoidable idiosyncrasies in its vocabulary and syntax. A complete explanation is given in the GEMPACK manuals (Harrison and Pearson, 2002, 2005). This chapter gives a general outline of the structure of the FINAGE/REFINAGE model code and of the notation and TABLO commands used in the code with a view of enhancing the tractability of the full programme codes.

The chapter is divided into three sections. Section 3.1 places TABLO in the context of the suite of GEMPACK programmes. It also deals with the concept of closures, showing how the model can be used for studying history, for forecasting, and for policy analysis. Section 3.2 contains notes on TABLO vocabulary and syntax and on the conventions followed in FINAGE and REFINAGE. The final section gives an overview of the structure of the TABLO presentation of FINAGE/REFINAGE and shows examples of the use of TABLO in implementing the models.

3.1 Overview of the GEMPACK computations for FINAGE/REFINAGE

3.1.1 GEMPACK solutions

GEMPACK performs model computations as a sequence of solutions of linear systems of the form

$$A(\overline{Z})z = 0 \qquad (3.1)$$

where

A($\overline{Z}$) is a matrix of coefficients (e.g., cost and sales shares) evaluated at a solution $\overline{Z}$ of the model

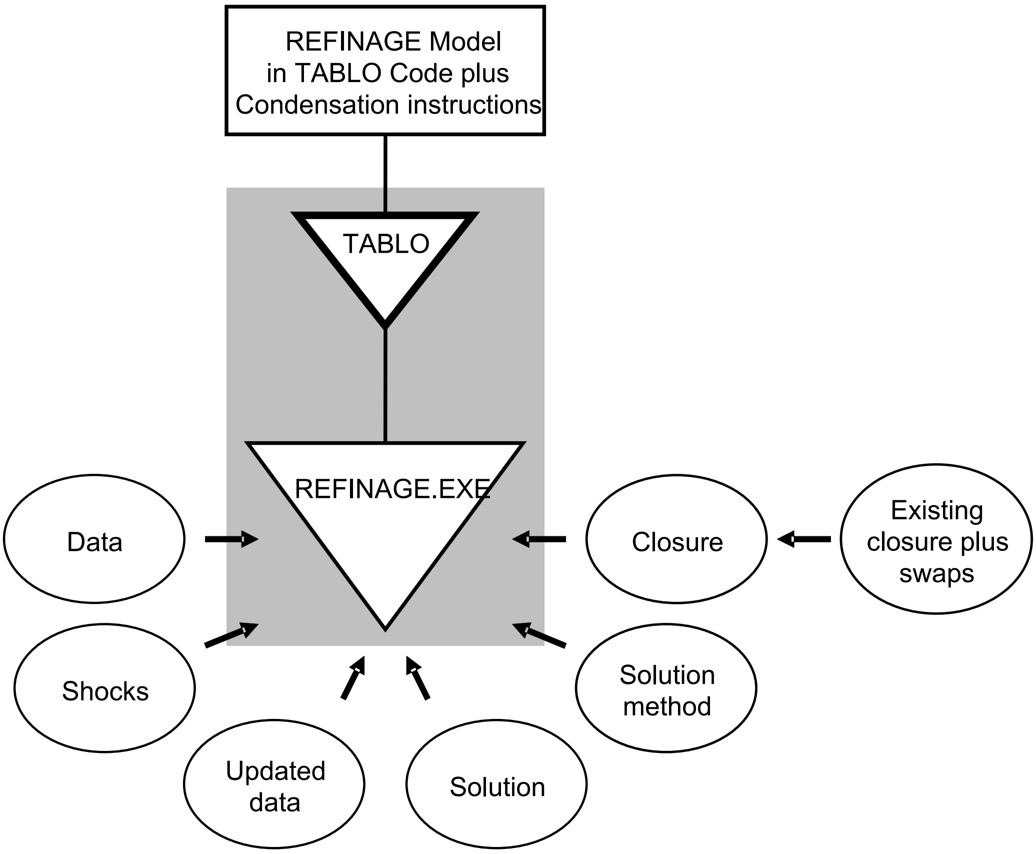
and

z is the vector of deviations in the model's variables away from $\overline{Z}$. Thus, while the theoretical models underlying REFINAGE are non-linear, for the purposes of simulation, they are explicitly linearised in their TABLO implementation.

The sequence of solutions may be single- or multi-step computations for a single year, or for a series of years. At each step in the sequence, the A matrix is evaluated at a different vector $\overline{Z}$. The vector ($\overline{Z}(q)$) used in the qth step (q>1) is usually derived substantially from the solution of (3.1) obtained in the (q–1)th step and the vector ($\overline{Z}(1)$) is derived from data. The methodology of solving linear systems in several steps is related to the accuracy of the solutions and is explained in more detail in the next section.

Figure 3.1 is a flow diagram showing how GEMPACK creates and solves the sequence of linked equation systems (3.1).

Figure 3.1. GEMPACK solution of REFINAGE



The GEMPACK TABLO programme creates an executable image of REFINAGE, RE-FINAGE.EXE, by operating on the TABLO representation given in chapter 4. TABLO also processes condensation instructions to reduce the model to a manageable size. An example of condensation instructions is given in section 3.1.3, where we also discuss model closures more thoroughly.

The executable image programme REFINAGE.EXE uses several inputs to perform the simulation. These include the data files, the command files determining the policy shocks, choice of solution method, and the closure of the model.

The data is used to evaluate the coefficients in the A matrix. It is prepared with the help of the data processing programmes in the GEMPACK suite and contains all the information about the economy arranged in several data files. These data files are described more thoroughly in the next section.

There are several options for the solution method, ranging from single-step Euler to various more elaborate methods such as Gragg or Johansen/Euler. Finally, the values of the shocks are given in separate command files. Changes in policies or technology are referred as shocks and they are mostly given as deviations of the exogenous variables from their initial or baseline values.

With the data, closure, shocks and solution methods specified, REFINAGE.EXE produces the solution showing the effects on the endogenous variables of the shocks to the exogenous variables. It also produces updated data files. These have identical format to the data input files and reflect the post-solution situation. For example, the input-output flows in the updated file are those from the input file altered by the changes in prices and quantities which form part of the solution. The updated files from the (q–1)th step in a sequence of solutions of (3.1) normally become the input data for the qth step.

3.1.2 The Percentage-Change Approach to Model Solution

GEMPACK solves FINAGE/REFINAGE by representing it as a series of linear equations relating percentage changes in model variables. This section explains how the linearised form can be used to generate exact solutions of the underlying, non-linear, equations, as well as to compute linear approximations to those solutions (see Dixon et. al. 1992).

The solution of the model can be represented in the levels as:

$$\mathbf{F}(\mathbf{Y},\mathbf{X}) = \mathbf{0}, \qquad (3.2)$$

where **Y** is a vector of endogenous variables, **X** is a vector of exogenous variables and **F** is a system of non-linear functions. The problem is to compute **Y**, given **X**. Normally we cannot write **Y** as an explicit function of **X**.

Several techniques have been devised for computing **Y**. The linearised approach starts by recognising that we already possess some solution to the system, $\{\mathbf{Y}^0,\mathbf{X}^0\}$, i.e.,

$$\mathbf{F}(\mathbf{Y}^0,\mathbf{X}^0) = \mathbf{0}. \qquad (3.3)$$

Normally the initial solution {$\mathbf{Y}^0$,$\mathbf{X}^0$} is drawn from an historical input-output database combined with supplementary historical data – we assume that our equation system was true for some point in the past. With conventional assumptions about the form of the **F** function it will be true that for small changes **dY** and **dX**:

$$\mathbf{F}_Y(\mathbf{Y},\mathbf{X})\mathbf{dY} + \mathbf{F}_X(\mathbf{Y},\mathbf{X})\mathbf{dX} = \mathbf{0}, \qquad (3.4)$$

where $\mathbf{F}_Y$ and $\mathbf{F}_X$ are matrices of the derivatives of **F** with respect to **Y** and **X**, evaluated at {$\mathbf{Y}^0$,$\mathbf{X}^0$}. For reasons explained below, we find it more convenient to express **dY** and **dX** as small percentage changes **y** and **x**. Thus y and x, some typical elements of **y** and **x**, are given by:

$$y = 100dY/Y \quad \text{and} \quad x = 100dX/X. \qquad (3.5)$$

Correspondingly, we define:

$$G_Y(\mathbf{Y},\mathbf{X}) = F_Y(\mathbf{Y},\mathbf{X})\mathbf{Y},^{\wedge} \quad \text{and} \quad G_X(\mathbf{Y},\mathbf{X}) = F_X(\mathbf{Y},\mathbf{X})\mathbf{X},^{\wedge},$$

(3.6)

where **Y,**^ and **X,**^ are diagonal matrices. Hence the linearised system becomes:

$$\mathbf{G}_Y(\mathbf{Y},\mathbf{X})\mathbf{y} + \mathbf{G}_X(\mathbf{Y},\mathbf{X})\mathbf{x} = \mathbf{0}. \qquad (3.7)$$

Such systems are easy for computers to solve, using standard techniques of linear algebra. But they are accurate only for small changes in **Y** and **X**. Otherwise, linearisation error may occur. The error is illustrated by Figure 3.2, which shows how some endogenous variable Y changes as an exogenous variable X moves from X0 to XF. The true, non-linear relation between X and Y is shown as a curve. The linear, or first-order, approximation:

$$y = -\,\mathbf{G}_Y(\mathbf{Y},\mathbf{X})^{-1}\mathbf{G}_X(\mathbf{Y},\mathbf{X})x \qquad (3.8)$$

leads to the Johansen estimate YJ – an approximation to the true answer, Y exact.

Figure 3.2. Linearisation error in a single-step process

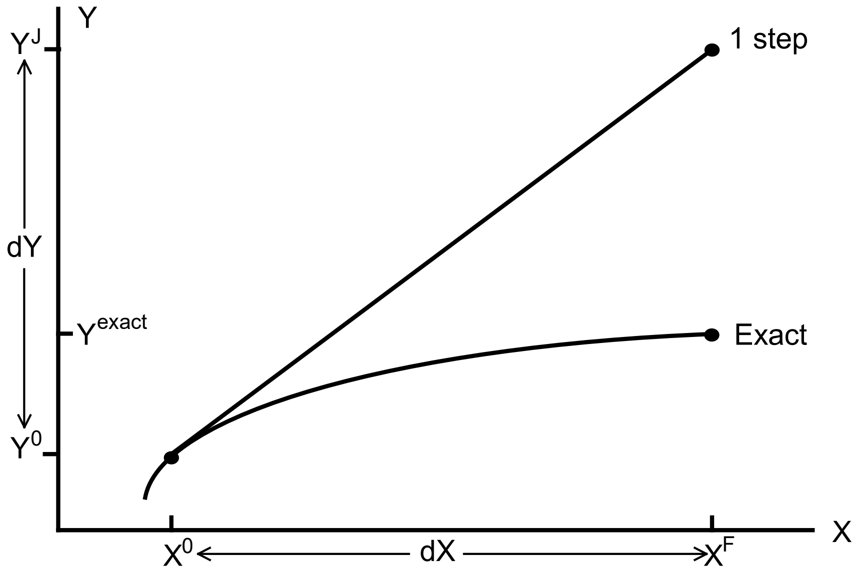


Figure 3.2 suggests that, the larger x is, the greater is the proportional error in y. This observation leads to the idea of breaking large changes in X into a number of steps, as shown in Figure 3.3. For each sub-change in X, we use the linear approximation to derive the consequent sub-change in Y. Then, using the new values of X and Y, we recompute the coefficient matrices $\mathbf{G}_Y$ and $\mathbf{G}_X$. The process is repeated for each step. If we use 3 steps (see Figure 3.3), the final value of Y, Y3, is closer to Y exact than was the Johansen estimate YJ. We can show, in fact, that given sensible restrictions on the derivatives of $\mathbf{F}(\mathbf{Y},\mathbf{X})$, we can obtain a solution as accurate as we like by dividing the process into sufficiently many steps.

The technique illustrated in Figure 3.3, known as the Euler method, is the simplest of several related techniques of numerical integration – the process of using differential equations (change formulae) to move from one solution to another. GEMPACK offers the choice of several such techniques. Each requires the user to supply an initial solution $\{\mathbf{Y}^0,\mathbf{X}^0\}$, formulae for the derivative matrices $\mathbf{G}_Y$ and $\mathbf{G}_X$, and the total percentage change in the exogenous variables, $\mathbf{x}$. The levels functional form, $\mathbf{F}(\mathbf{Y},\mathbf{X})$, need not be specified, although it underlies $\mathbf{G}_Y$ and $\mathbf{G}_X$.

The accuracy of multistep solution techniques can be improved by extrapolation. Suppose the same experiment were repeated using 4-step, 8-step and 16-step Euler computations, yielding the following estimates for the total percentage change in some endogenous variable Y:

y(4-step) = 4.5%,

y(8-step) = 4.3% (0.2% less), and

y(16-step) = 4.2% (0.1% less).

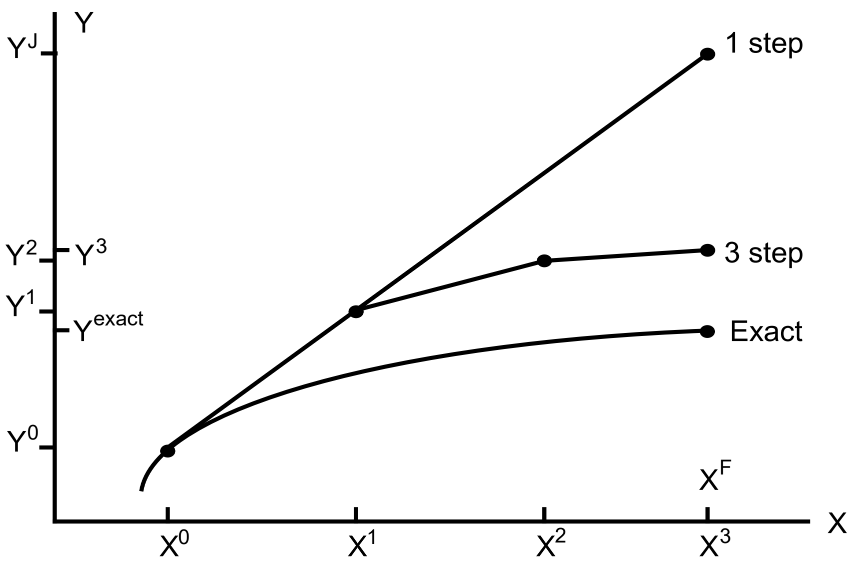
Extrapolation suggests that the 32-step solution would be:

y(32-step) = 4.15% (0.05% less),

and that the exact solution would be:

y(∞-step) = 4.1%.

Figure 3.3. Multistep process to reduce linearisation error



The extrapolated result requires 28 (=4+8+16) steps to compute but would normally be more accurate than that given by a single 28-step computation. Alternatively, extrapolation enables us to obtain given accuracy with fewer steps. As we noted above, each step of a multi-step solution requires: computation from data of the percentage-change derivative matrices $\mathbf{G}_Y$ and $\mathbf{G}_X$; solution of the linear system (3.7); and use of that solution to update the data (**X**,**Y**).

In practice, for typical AGE models, it is unnecessary, during a multistep computation, to record values for every element in **X** and **Y**. Instead, we can define a set of *data coefficients* **V**, which are functions of **X** and **Y**, i.e., **V** = **H**(**X**,**Y**). Most elements of **V** are simple cost or expenditure flows such as appear in input-output tables. $\mathbf{G}_Y$ and $\mathbf{G}_X$ turn out to be simple functions of **V**; often indeed identical to elements of **V**. After each small change, **V** is updated using the formula $\mathbf{v} = \mathbf{H}_Y(\mathbf{X},\mathbf{Y})\mathbf{y} + \mathbf{H}_X(\mathbf{X},\mathbf{Y})\mathbf{x}$. The advantages of storing **V**, rather than **X** and **Y**, are twofold:

- the expressions for $\mathbf{G}_Y$ and $\mathbf{G}_X$ in terms of **V** tend to be simple, often far simpler than the original **F** functions; and
- there are fewer elements in **V** than in **X** and **Y** (e.g., instead of storing prices and quantities separately, we store merely their products, the values of commodity or factor flows).

3.1.3 Closures and condensation instructions

In dynamic mode, FINAGE and REFINAGE contain hundreds of thousands of equations. It is not practical to solve directly equations systems of this size. The problem is made manageable in two ways: by omitting arrays of exogenous variables that are not shocked and by substituting out arrays of endogenous variables that are not of interest. The arrays that are targeted for these treatments typically have large numbers of components.

An example of an array that is usually omitted is

$$\text{fa1mar(c,s,i,m)} \quad \text{for } c \in \text{COM},\ s \in \text{SOURCE},\ i \in \text{IND and } m \in \text{MAR}.$$

This is an array of technical change shifters concerned with the usage of margin commodity m to facilitate the flow of commodity c from source s to industry i for the purpose of current production. The array is occasionally useful in simulating technical changes but in most applications it is set exogenously on zero. Thus, in most applications it can be deleted. Alternatively, if fa1mar(c,s,i,m) is endogenous, it can be substituted out, which means that it is replaced by the variables determining it in equation

E_fa1mar(c,s,i,m) in the model code.

The concept of closure is central to simulations performed with GEMPACK. By closure we mean the specification of variables as exogenous and endogenous. The need for a closure specification arises from several reasons. First, REFINAGE does not contain explicit equations for all of its variables. For example, shifts in technology or tastes are typically treated as exogenous. Secondly, closure changes provide a practical way of modifying the model to suit to specific applications.

The concept of closure can be illustrated by considering the solution to the model from a slightly different point of view than that in equation 3.8. For each year, the solution takes the form

$$F(X) = 0 \qquad (3.9)$$

where F is an m-vector of differentiable functions of *n* variables *X*, and *n*>*m*. The variables *X* include prices and quantities applying for a given year and the *m* equations in (3.9) impose the usual AGE conditions such as: demands equal supplies; demands and supplies reflect utility and profit maximising behaviour; prices equal unit costs; and end-year capital stocks equal depreciated opening capital stocks plus investment. It is important to realise that there always exists a solution ($X_{initial}$) of (3.8) derived mainly from input-output data for a particular year. In simulations we compute the movements in *m* variables (the endogenous variables) away from their values in the initial solution caused by movements in the remaining *n* – *m* variables (the exogenous variables) away from their values in the initial solution. By closure we mean the division of the model's variables into endogenous and exogenous. There is no single way to do this. Instead, the closure depends largely on the application.

As MONASH-type dynamic models usually do, so do FINAGE and REFINAGE recognise four types of closures:

- decomposition closure,
- historical closure,
- forecasting closure and
- policy closure.

In a decomposition closure, we include in the exogenous set all naturally exogenous variables, that is variables not normally explained in a AGE model. These may be observable variables, such as tax rates, or unobservables, such as technology and preference variables.

Historical closures include in their exogenous set two types of variables: observables and assignables. Observables are those for which movements can be readily observed from statistical sources for the period of interest. Historical closures vary between applications depending on data availability but typically include a wide array of macro and industry variables, as well as intermediate input flows between industries.

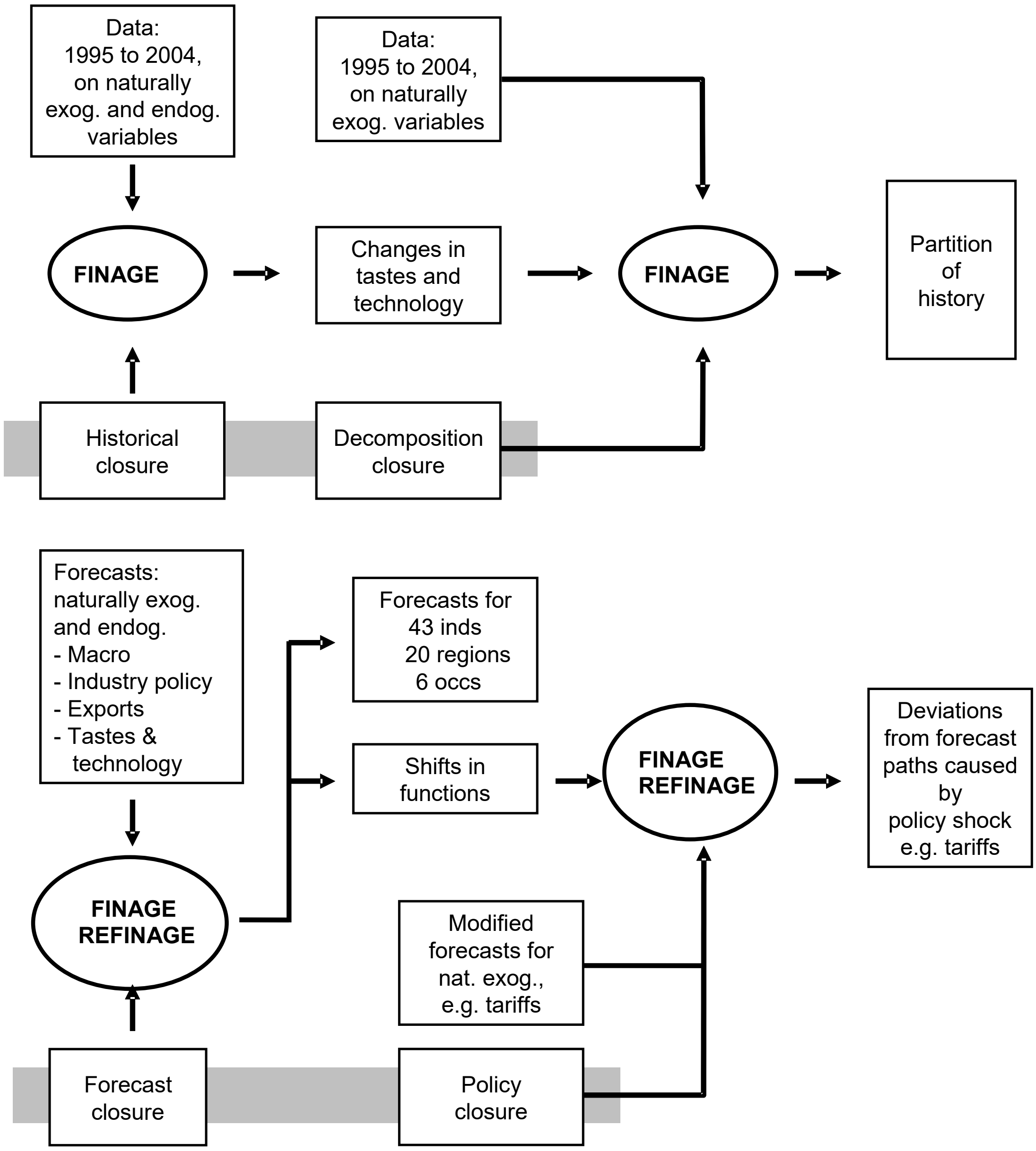
Forecasting closures are close in philosophy to historical closures. Instead of exogenising everything that is known about the past, in forecasting closures we exogenise everything that we think we know about the future. Thus in forecasts, we exogenise numerous naturally endogenous variables, including, for example, export volumes (where outside forecasts or scenarios are available), and most macro variables (where medium and long term forecasts prepared by ministries or the EU can be used). To allow these variables to be exogenous, a number of naturally exogenous variables need to be endogenised, for example the positions of foreign demand curves, the positions of domestic export supply curves, and many macro coefficients such as the average propensity to consume.

Policy closures are similar to the decomposition closures. In policy closures naturally endogenous variables, such as exports and macro variables, are endogenous, since they must be allowed to respond to the policy change under consideration. Correspondingly, in policy closures naturally exogenous variables, such as the positions of foreign demand curves, the positions of domestic export supply curves and macroeconomic coefficients, are exogenous, and are set at the values that they have in the forecasts.

The relationship between forecasting and policy simulations is similar to that between historical and decomposition simulations. Historical simulations provide values for exogenous variables in corresponding decomposition simulations. Similarly, forecasting simulations provide values for exogenous variables in corresponding policy simulations. However there is one key difference between the relationships. An historical simulation and the corresponding decomposition simulation produce the same solution. This is because all the exogenous variables in the decomposition simulation have the values they had (either endogenously or exogenously) in the historical solution. In a policy simulation, most, but not all, of the exogenous variables have the values they had in the associated forecast solution. The policy variables of interest are set at values that are different from those they had in the forecasts. Thus policy simulations generate deviations from forecasts.

There is an important limitation stemming from the infrequent updates of regional data. While at the national level it is actually possible to use consecutive, yearly, supply and use tables (including input-output matrixes) to conduct a historical simulations, at the regional level, this is not feasible. Thus in practice REFINAGE uses the detailed industry-level results from FINAGE as a starting point for its forecasting/baseline simulations, as illustrated in figure 3.4 below. Naturally, when the focus is at the national level, is is possible to use FINAGE similarly. This approach has the advantage of resulting in consistency between national level and regional forecasts.

Figure 3.4. Historical and Decomposition Simulations



3.2 Introduction to TABLO syntax and conventions

While the TABLO syntax resembles many other simulation programmes, it does have certain specific rules and conventions that it is useful to be aware of. This section gives a summary of the most common ones. The examples in the next section demonstrate how TABLO handles data and parameters, while the following section gives some examples of equations expressed in TABLO syntax. The points we have chosen to list here will be helpful to readers when they are following the examples in the next two sections, and for looking for the first time at the TABLO code in chapter 4. Chapter 5 contains more specific examples of the expressions derived from the model's theoretical equations.

The TABLO code contains instructions for the handling of data and for performing actual numerical evaluations following the formulas and equations of the model. Instructions are expressed with key words. Often, the TABLO also contains comments and remarks that are not processed. These remarks and explanations come in two varieties. First, material in the TABLO code enclosed by exclamation marks (!) is not processed by TABLO. It merely provides explanatory comments. Second, material enclosed by cross-hatches (#) does not play a role in computations. However, it is recorded by TABLO and used in the labelling of various GEMPACK printouts.

Among the key words in the TABLO language are: File, Set, Coefficient, Read, Formula ,Variable, Update and Equation. These are followed by statements giving instruction for the programme. All TABLO statements end with a semicolon (;).

The key word File is used to assign logical names to the various data sources used in the computations. Examples of the use of File are given in section 3.3.1.

Key word Set is used to define the dimensions for the coefficients contained in the data. Sets can be either labelled explicitly in the programme or command files, or they can be read from data files.

The model data are handled as coefficients that are to be evaluated and updated. Coefficients must always be declared with the key word Coefficient, and they must always be assigned values either by instructing GEMPACK to use specific data sources for the evaluation of them (the key word Read) or to evaluate them with formulas using already evaluated coefficients, in which case the key word Formula is used. Coefficients are updated by the model's variables unless they stem from formulas.

The key word Variable declares a specific variable, whence the variable is explained in an equation unless it is exogenous. Key words need not always be repeated when they are applicable to an unbroken sequence of statements. For example, if we are declaring two variables, a and b, we can write

```
Variable  a     # example variable # ;
Variable  b     # another example variable # ;
```

Alternatively we can write

```
Variable
a # example variable # ;
b # another example variable # ;
```

TABLO contains several devices that can be used for exception handling. For example, in evaluating coefficients, it is often the case that a vector of values may contain some elements with a zero value. TABLO includes a device which is sometimes convenient for avoiding zero-divide difficulties. This is illustrated by the following TABLO code:

```
Zerodivide Default 1.0  ;
    Formula
    A = B/C  ;
    E = F/G  ;
Zerodivide off  ;   .
```

If C happens to be zero, then A is evaluated as 1.0. Similarly, if a division by zero occurs on the RHS of any other formula listed before the command Zerodivide off, then the LHS of the formula is evaluated as 1.0. Thus if G is zero then E is 1.0. Another approach used in TABLO code to deal with potential divisions by zero is to add the coefficient TINY to denominators. TINY is set at a very small number, 10^{-12}.

TABLO restricts the lengths of names and of comments contained between cross-hatches. This requires the use of abbreviations in the TABLO code. Furthermore, TABLO does not allow Greek letters or subscripts and superscripts.

TABLO does not distinguish between upper- and lower-case letters. To enhance the readability of the TABLO representation of REFINAGE, a useful convention is to use lower-case letters for variable names and upper-case letters for the names of coefficients, sets and files. For TABLO key words, we the first letter, e.g., Sum, Equation, Update, etc. is often capitalised.

3.3 Overview of the structure of the TABLO representation of REFINAGE

The TABLO code in chapter 4 is concerned with a single step in the sequence of solutions of (3.1).

It specifies rules: for reading the data input (such as input-output flows and substitution parameters); for forming the equation system (3.1); and for revising the data in preparation for the next step in the sequence of solutions. Here, we give examples of typical TABLO usage as they appear in REFINAGE code.

3.3.1 Data files

The REFINAGE model code in chapter 4 starts by indicating that the data inputs needed for creating the system (3.1) are drawn from nine files, with logical names BASEDATA, EXTRA, ..., ROREXT. In implementing the TABLO representation of REFINAGE we must specify the specific files in our computer to play the roles of BASEDATA, EXTRA, etc. The contents of these specific files are indicated in by comments between cross-hatches (#).

The model code also lists a data output file (New) with the logical name SUMMARY. The specific file which plays the role specified in the TABLO code for SUMMARY collects information useful in checking and explaining results. Implicit in the TABLO code are instructions for the creation of several other output files.

The contents of the most important data file, the BASEDATA, are illustrated in figure 3.5.

The figure shows how the use of goods and services is distributed within industries and institutional sectors. As explained earlier, the basic structure in REFINAGE consists of the general equilibrium theory that underlies the demand structure of the model, and theory explaining the dynamic evolvement of the economy over time. The theory behind the model is reflected in the database. The database shown in figure 3.5 identifies the following agents in the model economy:

- domestic producers divided into I industries;
- investors divided into I industries;
- regional, representative households;
- foreign purchasers of exports;
- foreign sources of imports;
- demand categories corresponding to local and central government demands, as well as demand by social security funds.
- C commodities, stemming from 2 sources
- O occupational groups

In naming variables and coefficients, we use almost invariably the following conventions: 0 indicates production; 1 indicates intermediate usage; 2 indicates demand for use in capital creation; 3 indicates demands by households; 4 indicates exports; 5 indicates government demands; and 6 indicates demands for inventories. The letters c, s and i are often used to indicate commodity, source and industry. For example, x1(c,s,i) refers to intermediate usage distinguished by commodity, source and industry.

The exception to the simple notational convention concerns the bottom-level flows of goods, where we follow the compact notation stemming from Mark Horridge's TERM model, where trade flows are denoted by `xtrad(c,s,r,d) -` where the dimensions are commodity by source by region of origin by region of use. This notation is also adapted for the related price variables.

In figure 3.5 the rows show the structure of the purchases made by each of the agents identified in the columns. Each of the c commodity types identified in the model can be obtained from domestic producers or imported from overseas. The source-specific commodities are used by industries as inputs to current production and capital formation, are consumed by households and governments and are exported. Commodities stem from either a domestic source, or from abroad. Margins are treated as margins goods (M). Intermediate use of goods is presented by using industry (I). Finally, household consumption, public consumptions, and inventories are all covered by single row entries.

Figure 3.5. **The combined supply and use matrix**

		Supply and use matrix					
		1	2	3	4	5	6
		Producers	Investors	Households	Export	Government	Stocks
	Size	□□□□I□□ □□	□□□□I□□ □□	□□1□□□□	□□□□ V□□□□□	□□□1□□	□□□1□□
Basic Flows	CxS	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	CxSxM	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	CxS	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	O	V1LAB					
Capital	1	V1CAP					
Land	1	V1LND					
Production tTx	1	V1PTX					
Other Cost	1	V1OCT					

C=Number of Commodities
I=Number of Industries

S=3: Domestic, Imported from the EU, Imported from the Rest of the World
O=Number of Occupations

M=Number of Commodities used as Margins
V=2: Export to the EU, Export to the Rest of the World

	Make Matrix
Size	□□□□□□□□□□I□ □□□□□□□□□
C	MAKE

	Import Duty
Size	□□□□□□□1□□□ □□□□
C	V0TAR

The other data files contain data on the public sector – such as taxes and transfers – as well as the balance of payments. There are also several files that are used for inputs in dynamic simulations. These files contain data on capital stocks, rates of return and the like. The reason for several files stems from the need to keep track of timing. While there are no restrictions in TABLO governing the number of data files or the distribution of data across them, the interdepencies of data elements do have a practical effect on the division of data inputs. For example, if data items X and Y are both in the same input file Z, then we are limited to solutions of $\overline{V}$ that reflect values of X and Y arising from the process which generates the file Z. If this process imposes a link between X and Y which should not apply at each step in the sequence of solutions, then X and Y should be in different files. For example, REFINAGE computations with forward-looking expectations involve a sequence of solutions in which the values of rates of return used in forming $\overline{V}_q$, q>1, are derived from the solution in the (q–1)th step.

On the other hand, some of the data, for example, rates of return, used in the qth step are not always generated in the (q-1)th step. Consequently, rates of return are placed in a different file from the main data, thus allowing the data to be independent of the data for rates of return.

3.3.2 Sets and subsets

The next section of the TABLO code first declares in alphabetical order the names of most sets and either specifies their contents or indicates where these can be found. For example, SOURCE is declared explicitly as a set consisting of three objects, "dom", “eu” and “non_eu”; in contrast, the set COM is a set consisting of objects whose names will be found in a section of the BASEDATA file labelled "COM".

The set declarations give a good overview of the objects with which REFINAGE is concerned. For example, these include commodities (COM) produced by the domestic industries (IND) or imported from foreign sources. The set declarations are followed by statements indicating that some sets are subsets of others. For example, TRADEXP is a subset of COM. Via this subset declaration, TABLO knows that the object "C_01" in TRADEXP is the same object as "C_01" in COM.

The main sets defined in REFINAGE are:

COM	Commodities
DST	Regions of use
IND	Industries
MAR	Margin commodities (a subset of COM)
OCC	Occupations
ORG	Regions of origin

PRD	Regions of margin production
FUEL	Energy commodities (a subset of COM)
DEST	Destinations of goods
LOCUSER	Domestic destinations of goods (a subset of DEST)
PSEC	Government sectors (Central,Local,Social security fund)
SRC	Source of commodities

3.3.3 Coefficients

Section 3 of FINAGE/REFINAGE code contains declarations for the coefficients in the model. Coefficients are the main building blocks in the construction of $A(\overline{V})$ in equation 3.1. Apart from numerous zeros and ones, and a few other numbers, the components of $A(\overline{V})$ are coefficients or functions of coefficients.

For each coefficient, the TABLO code gives evaluation instructions. Evaluation can either be from a data file via a read statement, or in terms of other coefficients via a formula. Some formulae are implemented in every step of a multi-step computation whereas others are implemented only in the first step for each year.

For many of the coefficients evaluated via read statements, the TABLO code contains update instructions, i.e., instructions on how the post-solution value of the coefficient should be computed. Where an update instruction is provided, we have included a U in the cross-hatched comments. The update statements are in section 7 of the code and are discussed in subsection 3.3.6. below.

To finish the present subsection, we give a few examples that may be helpful in clarifying the meaning of the coefficient declarations.

Example 1

AGGCAP is interpreted in our economic theory as the total payments to capital. It is evaluated as a function of coefficients according to a formula given in subsection 5.10 of the code. Because in each step of a sequence of solutions of (3.1) the value of AGGCAP is obtained via a formula, AGGCAP is not updated.

Example 2

USE matrixes

```
(all,c,COM)(all,s,SRC)(all,d,DST)
   USE(c,s,"hou",d) = x3(c,s,d)*puse(c,s,d);
```

USE(c,s,"hou",d) in REFINAGE code is interpreted as the basic value of the flow of good c from source s for use in consumption by the household in region d.

Example 3

SIGMA1(c) is interpreted in our economic theory as the elasticity of substitution between domestic and imported good c for use in current production. In TABLO, SIGMA1 is a vector taking values for all c in the set COM. Values for SIGMA1 are obtained from data accessed via a Read statement. No update instructions are given. Import/domestic substitution elasticities are usually held constant throughout a sequence of solutions of (3.1), i.e., they are treated as parameters.

3.3.4 Read statements and formulas

As already mentioned, Section 4 of the REFINAGE code contains instructions for the evaluation of coefficients from data files. The command Read, used throughout the code instructs the programme to access numerical data. By contrast, the command Read Elements, instructs post-TABLO programmes to access alpha-numeric information.

If a coefficient is determined by a formula, the instructions for evaluating the coefficient are given after the key word Formula. Contrary to the declarations for coefficients and variables, formulas cannot be arranged in a simple order, such as alphabetical. This is because no coefficient can appear on the RHS of a formula unless instructions for its evaluation have appeared earlier in the TABLO code. Thus, if coefficient A is to be set equal to coefficient B, and B is to be set equal to 10, we cannot use the alphabetical ordering:

Formula A = B ;

Formula B = 10 ; .

Instead we must write

Formula B = 10 ;

Formula A = B ;   .

The TABLO code allows a wide range of operators to be used in formula statements. The meaning of most of these is clear. Here we interpret a few of the formulas from section 5 in the code to give a flair of some of the operators commonly used in formulas.

Example 1

This example shows how the keyword Initial can be used. The example stems from subsection 5.18 of REFINAGE code and gives instructions for evaluating the maximum growth rate of the capital stock in industry i:

```
Formula
   (initial)(all,i,IND)(all,d,DST)
    K_GR_MAX(i,d)=TREND_K(i,d)+DIFF+if(QCA-
PATT(i,d)<=0.00001,1.0);
```

In the formula, the growth rate is given a value that is the sum of the trend growth rate of the capital stock in industry i, a difference parameter, and, if there is no capital in the industry, the value 1. The word Initial in parentheses indicates that in a multi-step solution for year t, the coefficient K_GR_MAX(i), the maximum growth rate of the capital stock in the investment function, is evaluated via the formula above only in the first step. Provided there are no further instructions in our TABLO code regarding its evaluation, the coefficient will retain this first-step value throughout the remaining steps for year t.

The Initial option is particularly valuable in the modelling of processes involving lags. Examples in REFINAGE can be found in several sections, including 5.7, as well as section 5.8, which deals with sticky real wages. With lags, we often need to hold a coefficient in the year t computation at a value reflecting the solution for year t–1. This can be achieved via the Initial option provided the initial solution for year t is the final (required) solution for year t–1.

Example 2

The next example show how a parameter can be directly defined. This example is from subsection 5.3 of the model code:

```
Formula TINY = 0.000000000001 ; .
```

TINY, which is permanently set at 10^{-12}, is often used to avoid division by zero or the occurrence of an endogenous variable with a zero coefficient in all equations.

Example 3

The next example shows usage of TINY in a formula that evaluates export shares of commodity c to destination d. The example is from subsection 5.13 of REFINAGE code:

```
Formula
  (all,c,COM)(all,d,XDEST)
   EXPSHR(c,d)  = V4BAS(c,d)/[MAKE_I(c)+TINY];
(all,c,COM)(all,r,REG) EXPSHR(c,r) =
ROWDEM_D(c,r)/[0.001+MAKE_I(c,r)];
```

In the formula, V4BAS is the basic flow of exports of commodity c to destination d and MAKE is the total production of commodity c.

3.3.5 Variables

In TABLO, variables have to be declared before they can be used. The declarations give names and dimensions to the components of v in (3.1), or, equivalently, they give names and widths to collections of columns of A $(\overline{V})$.

Most of the variables are interpreted in our economic theory as percentage changes. For example, p1cap(i) is the percentage change, away from its value in $\overline{V}$, of payments to capital in industry i.

However, many variables are changes. For example, d_govsav is the change in the (level of) government saving, not the percentage change. For variables that are to be interpreted as changes, TABLO requires us to include in their declarations the word

Change in parentheses. We have also elected to give change variables names starting with either d_ or del_.

Failure to distinguish in the variable declarations between change and percentage-change variables will not affect single-step solutions for year t. Difficulties arise, however, in the calculation of results from multi-step solutions. If the (Change) instruction is omitted from the equation for d_eror(I,d), the change in expected returns to capital, given by

```
(all,i,IND)(all,d,DST) d_eror(i,d) =  d_ror_se(i,d) +
d_ff(i,d);
```

then, in a two-step calculation, we would obtain:

$$d\_ eror(i,d)_{result2} = 100*\{(1 + d\_ eror(i,d)_1/100)(1 + d\_ eror(i,d)_2/100) -1\} ,$$

where $d\_eror(i,d)_{result2}$ is the result for the two-step computation and $d\_eror(i,d)_1$ and $d\_ eror(i,d)_2$ are the solutions in steps 1 and 2. With d_ eror(i,d) declared as a change variable, we obtain the correct two-step result; i.e.,

$$d\_eror(i,d)_{result2} = d\_ eror(i,d)_1 + d\_ eror(i,d)_2 .$$

The following conventions are used (as far as possible) in naming variables. Names consist of a prefix, a main user number and a source dimension. The prefixes are:

a	⇔ technological change, change in preferences;
d_, del_	⇔ ordinary (rather than percentage) change;
f	⇔ shift variable;
p	⇔ prices;
x	⇔ quantity demanded;
q	⇔ quantity supplied.

The main user numbers are the same as in the database, namely:

1 ⇔ firms, current production;

2 ⇔ firms, capital creation;

3 ⇔ households;

4 ⇔ foreign exports;

5 ⇔ government;

The number 0 is also used to denote basic prices and values. The source dimensions are:

s ⇔ all sources, (i.e., 1 domestic and 2 foreign);

Variable names may also include an (optional) suffix description. These are:

cap ⇔ capital;

imp ⇔ imports;

lab ⇔ labour;

lnd ⇔ agricultural land;

mar ⇔ margins;

oct ⇔ other cost tickets;

prim ⇔ all primary factors (land, labour or capital);

sub ⇔ linear expenditure system (subsistence part).

Variables that are not related to production, for example, variables that are used to describe the public sector and its policy instruments such as direct taxes, assets and benefits, are given names that bear a resemblance to their true meaning. For example, changes in age benefits are given by a variable called age_ben, whereas changes in the income tax rate for labour income is given by a variable called tax_l_rate.

3.3.6 Update statements

Earlier in this section, we saw that FINAGE/REFINAGE take data from several files with logical names BASEDATA, EXTRA etc. For each of these data input files, the TABLO code contains implicit (hidden from the GEMPACK user) instructions for the creation of ten post-solution files with logical names: updated BASEDATA; updated EXTRA, etc. The implicit TABLO instructions require that the updated files have structures identical to those of the corresponding input files, i.e., identical header (location) names and data arrangements. The data values will also be identical except where explicit instructions are given for their alteration.

Update instructions are given by Update statements, which are collected in alphabetical in order in section 7 of REFINAGE code. Here we provide a few illustrative interpretations.

Example 1

This example shows how an ordinary change variable updates a flow, in this case, a flow of indirect tax revenue from consumption:

```
(change)(all,c,COM)(all,s,SRC)(all,d,DST)
   TAX(c,s,"hou",d) = delTAXhou(c,s,d);
```
(3.10)

In our current example, the RHS of (3.10) is the change that should be made to the value of the coefficient TAX(c,s,"hou",d), to derive its post-qth-solution value.

The post-qth-solution value of TAX(c,s,I,d) is given by

$$TAX(c,s,\text{"hou"},d)_{post\_q} = TAX(c,s,\text{"hou"})_q + RHS(3.10)_q$$

Because $TAX(c,s,i,d)_q$ is read from the header "TAX" in the BASEDATA file, TABLO's implicit instructions mean that $TAX(c,s,i,d)_{post\_q}$ will be stored in the corresponding position in the header designated "TAX" in the updated BASEDATA file.

Example 2

An example of a percentage change variable is used for updating a coefficient is given by

```
Update LEV_CPI = p3tot  ;    .
```

which means that the post-qth-solution value of LEV_CPI (the level of consumer prices) is given by

$$LEV\_CPI_{post\_q} = LEV\_CPI_q * (1+p3tot_q/100),$$

where p3tot is the percentage change in consumer prices.

Example 3

An example, where two percentage change variables are used to update a coefficient is

```
Update (All,i,IND)   V1CAP_(i) = p1cap(i)*x1cap(i);
```
(3.11)

The absence of either (Change) or (Explicit) means that (3.11) is in short-hand. It implies that the post-qth-solution value of V1CAP(i) is given by

$$V1CAP(i)_{post\_q} = V1CAP(i)_q\ (1 + p1cap(i)_q/100 + x1cap(i)_q/100) \quad .$$

Because the qth-step value of V1cap(i) is read from file BASEDATA Header "1CAP", the post-qth-solution value is stored in the corresponding position in updated file BASEDATA Header "1CAP".

In the economic interpretation of the TABLO code, V1CAP(i) is the rental on capital in industry j. This is the product of the rental price and the quantity of capital in industry i.

3.3.7 Display and Write statements

Display and Write commands can be used to name specific coefficients to be reported. Their values are written to a Display file which is automatically created (no logical name need be specified) and labelled in a user-friendly manner by the GEMPACK programmes. The purpose of the Display file is to provide information for checking and interpreting results. The second list of coefficients are written to files with logical names nominated by the model-builder in the TABLO code. For FINAGE/REFINAGE we have only one Write file with logical name SUMMARY. The labelling in Write files is less user friendly than that in Display files. However Write files are in a suitable form to be processed by other GEMPACK programmes.

In a simulation for year t, the values that appear in Display and Write files are the values of coefficients reflecting the execution of reads and formulas in the first step of the computation up to the point where the Display or Write command occurs. These values are usually those used in forming the first step's $A_{(\overline{V})}$ matrix. An exception occurs when we Display or Write the value of a coefficient and then subsequently alter this value via a formula occurring after the Display or Write command.

3.3.8 Equations

TABLO requires that each equation has a name. Unlike formulas, equations can be listed in any order. Unlike sets, coefficients, reads, variables and updates, equations cannot be listed in an order which is both mechanical (e.g. alphabetical) and useful. FINAGE and REFINAGE equations are arranged in thematic groups, which are:

- producer's demands for produced inputs and primary factors;
- producer’s demands for inputs to capital creation;
- household demands;
- export demands;
- government demands;
- demands for margins;
- market-clearing conditions for commodities and primary factors; and
- zero pure profits in production and distribution;
- indirect taxes;
- macroeconomic variables and price indices.
- investment dynamics
- labour market dynamics
- government accounts
- balance of payments
- income and saving aggregates
- miscellaneous variables
- reporting variables.

Most equations are named following the convention that the name of an equation reflects that of the variable it determines in a standard long run closure. In other words, we use names of the form E_xx...x where xx...x is the name of the variable determined by the equation. While the idea that each equation determines a particular variable is not precise, as in a simultaneous equation system, the value of each endogenous variable is determined by the whole system, the convention is useful in finding a closure to the model. In fact, TABLO offers a very useful facility that can be used to obtain a tentative closure for a model. The facility uses the naming convention to pair variables to the equations that appear to determine them.

At an informal level, we have little difficulty in associating a particular variable with each equation. There are a few cases in which our equation-naming system runs into difficulties because the determination of an endogenous vector variable is spread over more than one vector equation. Another potential difficulty is that some vector variables may be split between the endogenous and exogenous categories.

Each equation in the TABLO model description is linear in the changes (percentage or absolute) of the model's variables. For example, the industry labour demand equations appear as:

```
Equation E_x1lab_o # Industry demands for effective labour #
  (all,i,IND)  x1lab_o(i) - a1lab_o(i) =
   x1prim(i) - SIGMA1PRIM(i)*[p1lab_o(i) + a1lab_o(i) -
p1prim(i)]
   - SIGMA1PRIMEN(i)*[p1prim(i)-p1prim_f(i)];
```

Within the equation, we generally distinguish between change variables and coefficients by using lower-case script for variables and upper-case script for coefficients. In the equation above, the expression (all,i,IND) signifies that the equations are defined over all elements of the set IND (the set of industries) (Note, however, that the gempack solution software ignores case). Thus in the example above, the variables are x1lab_o(i), x1prim(i), a1lab_o(i), p1lab_o(i), p1prim(i) and p1prim_f(i). There are two coefficients, SIGMA1PRIM(i), which is the fixed elasticity of substitution between labour and other primary factors, and SIGMA1PRIMEN(i), which is the fixed elasticity of substitution between an energy aggregate and primary factors. A semi-colon signals the end of the TABLO statement.

FINAGE/REFINAGE equation use the same operators as the formulas above. However, it may be helpful to have an understanding of the derivation of the percentage change form for some common non-linear expressions.

There are three basic rules for deriving the linear equations from the non-linear equations:

the product rule: $X = \beta YZ \Rightarrow x = y + z$, where β is a constant,

the power rule: $X = \beta Y\alpha \Rightarrow x = \alpha y$, where α and β are constants, and

the sum rule: $X = Y + Z \Rightarrow Xx = Yy + Zz$.

The *percentage* change variables x, y and z above represent deviations from the levels values X, Y and Z. The levels values (X, Y and Z) are solutions to the model's underlying levels equations.

Using the product-rule equation as an example, values of 100 for X, 10 for Y and 5 for Z represent an initial solution for a value of 2 for β. Now assume that we perturb our initial solution by increasing the values of Y and Z by 3 per cent and 2 per cent respectively, i.e., we set y and z at 3 and 2. The linear representation of the product-rule equation would give a value of x of 5, with the interpretation that the initial value of X has increased by 5 per cent for a 3 per cent increase in Y and a 2 per cent increase in Z up to a linearization error. Values of 5 for x, 3 for y and 2 for z in the corresponding percentage change equation means that the levels value of X has been perturbed from 100 to 105, Y from 10 to 10.3 and Z from 5 to 5.1.

The theory behind the equations of REFINAGE is the topic of the next chapter.

4. The TABLO code of REFINAGE

```
!################################################################
##############!
!
!
! REFINAGE:  a dynamic, multi-region model of Finland by Juha
Honkatukia    !
!
!
!################################################################
##############!
!Contents
!
!Section 1: Files
!
!Section 2: Sets and subsets
!
!Section 3: Coefficiencts
!
!Section 4: Read insctructions
!
!Section 5: Formulas in thematic order
!
!Section 6: Variables
!
!Section 7: Updates
!
!Section 8: Equations in thematic order
!
!Section 9: Reporting variables
!
!
!
!****************************************************************
*************!
! Section 1: Files
!
!****************************************************************
*************!
!################################################################
##############!

File INFILE;
File (new) SUMMARY;
```

```
File REGSETS # Sets file #;

File  EXTRA      # Input for investments #;
File  EXTRA3     # Alternative for EXTRA in forecast#;
File  EXTRA4     # Lagged version of EXTRA file #;

File  EXTRA5     # Lagged version of EXTRA3 file #;

File PSECDATA #Data on all public sectors#;
File ITER # Iteration number, used in forward-looking expecta-
tions #;
ROREXT # Foward-looking expect.: guess of RORs and parameters
for algorithm#;

File POPUDATA #Data on age structure#;
File VOSDATA #Data on communal sectors#;

File  BOPACC     # Balance of payments accounts #;

!##############################################################
##############!

!**************************************************************
*************!
! Section 2: Sets and subsets
!
!**************************************************************
*************!
!##############################################################
##############!

Set                                          ! subscript !
 SRC (dom,imp);                                  !s!
 COM # Commodities #
    read elements from file REGSETS header "COM"; !c!
 MAR # Margin coms #
    read elements from file REGSETS header "MAR"; !m!
 IND # Industries #
    read elements from file REGSETS header "IND"; !i!
 OCC # Labour skill categories #
    read elements from file REGSETS header "OCC"; !o!
 DST # Regions of use #
    read elements from file REGSETS header "REGD";!d!
 ORG # Regions of origin #
    read elements from file REGSETS header "REGS";!r!
 PRD # Regions of margin production #
    read elements from file REGSETS header "REGP";!p!
```

```
Set REG = DST intersect ORG; ! special set for comparing DST
ORG PRD !
Subset
 MAR is subset of COM;
 REG is subset of PRD;
 PRD is subset of ORG;
Set
 FINDEM # Final demanders #  (HOU, INV, GOV, EXP);!f!
 INT # Intermediate # (INT);
 USR # Users #     = IND + FINDEM;                 !u!
 MAINUSR # Main users #     = INT + FINDEM;
 NONMAR # Non-margin goods # = COM-MAR;

Set PRFS (Labour,Capital);
Set FAC(LND,LAB,CAP);
Set COSTCAT # Cost Categories #
 (IntDom, IntImp, ComTax, LAB, CAP, LND, PRODTAX);
Set HOU # Households # (AllHou);

Set NATREG (National);
Set TOTIND (TotalInds);
Set REGPLUS = REG+NATREG;
Set INDPLUS = IND+TOTIND;
Set INVFACT (Invest,CapRental,Output,InvOverCap,InvOverOut);
Set ELSTRAD # Trade elasticities # (SIGMADOMIMP,SIG-
MADOMDOM,EXP_ELAST);

Set PSEC # Public sectors govt, local, soc sec funds #
(S1311,S1313,S1314);

Set GSEC # sectors collecting commodity taxes # (S1311);
Subset GSEC is subset of PSEC;

Set LSEC # Local municipalities # (S1313);
Subset LSEC is subset of PSEC;

Set FSEC # Soc sec funds # (S1314);
Subset FSEC is subset of PSEC;

Set TIME # Sequence of numbers 0,1,2, ...,25 #
read elements from file ROREXT header "TIME";

Set MAINMACROS # Convenient macros for reporting #
 (RealHou, RealInv, RealGov, ExpVol, ImpVolUsed, ImpsLanded,
RealGDP, AggEmploy,
  realwage_io, p1lab_io, AggCapStock,GDPPI, CPI,ExportPI,
```

```
ImpsLandedPI,
  Population, NomHou, NomGDP);

!Subsets of IND and COM!

Set FUEL (C_02_03,C_19_22,C_35_39);
Subset FUEL is subset of COM;
Set COMLFUEL # Non-energy commodities # = COM - FUEL;
Set ALAND (Ahvenanmaa);
Subset ALAND is subset of REG;
Set MREG = REG-ALAND;

Zerodivide off;

!###############################################################
##############!

!**************************************************************
*************!
! Section 3: Coefficient declaration listed alphabetically
!
!**************************************************************
*************!
!###############################################################
##############!

!Coefficient DEFREGSHR # 1/[No of regions] = default regional
share #;
Formula     DEFREGSHR = 1/[sum{r,ORG,1}];!

! Excerpt 2 of TABLO input file: !
! Values from flows data file !

!Domestic basic prices = Output prices
 Imported basic prices = CIF prices
 Delivered values = Basic + Margins
 Purchasers' values = Basic + Margins + Tax = Delivered + Tax !

Coefficient
(parameter) (all,d,DST)(all,j,IND)
    ADJ_COEFF(d,j) # Rate of disappearance of disequilibrium in
rors RE#;
(parameter)
    ADJDUMYEAR1 # Adjusts DUM_YEAR1, one in first year, then
zero #;
(all,d,DST)(all,s,PSEC)
    AGEBENS(s,d) #Age benefits#;
```

```
    AGGLAB #Labour demand at national level#;
(parameter)
    ALPHA1 #Controls wage response to gaps between labour de-
mand & supply#;
(parameter)
    ALPHA2 #Slope of long-run labour supply curve#;
(all,d,DST)
    AV_PROP_CON(d) #Average propensity to consume#;
(all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
    BASSHR(c,s,r,d) # Share of basic value in all-user deliv-
ered price #;
(all,c,COM)(all,d,DST)(all,h,HOU)
    BLUX(c,d,h) # Ratio, (supernumerary expenditure/total ex-
penditure) #;
(all,c,COM)(all,d,DST)(all,h,HOU)
    BUDGSHR(c,d,h) # Household average budget shares #;
(all,i,IND)(all,d,DST)
    CAP(i,d) # Rentals to capital #;
(all,d,DST)
    CAP_I(d) # Total rentals to capital #;
(all,d,DST)(all,j,IND)
    CHKGR1(d,j)# One if K_GR_MIN(j) >= K_GR(j),else zero Fr#;
(all,d,DST)(all,j,IND)
    CHKGR2(d,j)# One if K_GR_MAX(j) <= K_GR(j),else zero Fr#;
(all,c,COM)(all,d,DST)
    CHKHOUPUR(c,d) # Household demand check #;
(parameter)(all,d,DST)(all,i,IND)
    COEFF_SL(d,i)  # Coefficient in capital supply curve #;
(parameter) (all,t,TIME)
    COEFF_TIME(t) #Vector of consecutive numbers
0,1,2,....,NYEARS R#;
(parameter)
    COEFF_NYEAR # Zero in the last year of a simulation, else
one #;
(all,d,DST)(all,i,IND)(all,s,PSEC)
    COL_PAYROLLS(i,d,s) #Payroll taxes#;
    COL_PAYRTOT # Aggregate collection of payroll taxes F #;
(all,d,DST)(all,s,PSEC)
    COL_PAYRTOTS(d,s)#Payroll taxes#;
(all,i,IND)(all,co,COSTCAT)(all,d,DST)
    COSTMAT(i,co,d) # Cost Matrix #;
    DEFHOUSHR # Default household share #;
(all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
    DELIVRD(c,s,r,d) # Trade + margins #;
(all,c,COM)(all,s,SRC)(all,d,DST)
    DELIVRD_R(c,s,d)
    # Demand in region d for delivered goods from all regions
```

```
#;
(parameter)(all,d,DST)(all,i,IND)
    DEP(d,i) # Rate of depreciation #;
(parameter)
    DIFF # Max. difference from trend rate of growth #;
(parameter)(all,d,DST)(all,i,IND)
    DISEQRE_B(d,i) # Diseq. in rational expect. version of ror
in base year #;
(parameter)(all,d,DST)(all,i,IND)
    DISEQSE_B(d,i) # Diseq. in static expect. version of ror in
base year #;
(parameter)
    DUM_IT1 # One in 1st iter of forecast or policy simulation
#;
(parameter)(all,t,TIME)
    DUM_TIME(t) # Equals 1 if t  = YEAR, 0 otherwise #;
(parameter)(all,t,TIME)
    DUM_TIME_LAG(t) # Equals 1 if t= YEAR-1, else 0 #;
(parameter)
    DUM_YEAR1 # Zero in first year, then one #;
(parameter)
    DUMMY_DEC # Zero in simulations off 1/2-way database, else
one#;
(parameter)(all,d,DST)(all,j,IND)
    EROR_B(d,j) # Expected. ror in init. sol for t, usually
exptd. ror for t-1#;
(parameter)(all,d,DST)(all,j,IND)
    EROR_F(d,j) # Expected ror, imposed in soln. for year t,
beyond iter. one #;
(parameter)(all,d,DST)(all,j,IND)(all,t,TIME)
    EROR_G_B(d,j,t)
    # Matrix for transfer of info on expected rors between it-
erations #;
(parameter)(all,d,DST)(all,j,IND)(all,t,TIME)
    EROR_G(d,j,t)
    # Matrix for transfer of info on expected rors between it-
erations #;
(all,d,DST)
    F_EEQROR_I(d) # Scalar shifter in EEQROR  #;
(all,d,DST)(all,i,IND)
    EEQROR(d,i) # Equilibrium expected rate of return, SE #;
(all,d,DST)(all,i,IND)
    F_EEQROR(d,i) # Industry specific shifter in EEQROR  #;
    NATEMP # Aggregate employment: 1 in init. sol. for yr 1 #;
    NATEMP_OLD # Aggregate employment, f'cast: 1 in init.sol.yr
1#;
(parameter)
```

```
    NATEMP_B # Aggregate employment in year 1, base #;
(parameter)
    NATEMP_L_B # Aggregate employment in year t-1, base #;
(parameter)
    NATEMP_O_B # Aggregate employment in year t, forecast
value, base #;
(parameter)
    NATEMP_O_L_B # Aggregate employment in year t-1, forecast
value, base R#;
(all,d,DST)
    EMPLOYS(d) # Regional employment#;
(all,d,DST)
    EMP_RATE(d) # Employment rate#;
    EMP_RATEN # National employment level#;
(all,d,DST)(all,h,HOU)
    EPSAVE(d,h) # Average EPS: should be 1 #;
(all,c,COM)(all,d,DST)(all,h,HOU)
    EPSH(c,d,h) # Household expenditure elasticities #;
(parameter)(all,c,COM)
    EXP_ELAST(c)   # Export demand elasticities #;
(all,c,COM)(all,r,REG)
    EXPSHR(c,r) # Share of output eventually exported #;
    FEMPADJ # Level of the shift variable in E_d_f_empadj #;
(parameter)
    FEMPADJ_B # Level of the shift variable in E_d_f_empadj in
t-1#;
(parameter)
    FEMPADJ_O # Level of the shift variable in E_d_f_em-
padj,forec#;
(all,d,DST)(all,h,HOU)
    FRISCHH(d,h) # Frisch LES 'parameter'= - (total/luxury) #;
(all,d,DST)(all,s,PSEC)
    GOV_DEFS(d,s) #Public sector deficits#;
(all,d,DST)
    GOVTOMUN(d);
(all,d,DST)
    GOVTOSSF(d);
(all,d,DST)(all,s,PSEC)
    GRANTSS(s,d) #Grants from public sectors#;
(all,c,COM)(all,d,DST)(all,h,HOU)
    HOUPUR(c,d,h) #Household demands#;
(all,d,DST)(all,h,HOU)
    HOUPUR_C(d,h) # Household demand totals #;
(all,c,COM)(all,d,DST)
    HOUPUR_H(c,d) # Household demand totals #;
(all,d,DST)
    HOUS_DIS_INC(d) #Household disposable income#;
```

```
(all,d,DST)
    HOUS_SAV(d) #Household saving#;
(all,c,COM)(all,d,DST)(all,h,HOU)
    HOUSHR(c,d,h) #Household shares#;
(all,r,ORG)
    IMPLANDED_C(r) # Imports landed in r #;
(all,d,DST)
    IMPUSED_C(d) # Imports used in d #;
(all,d,DST)(all,s,PSEC)
    INCTAXS(d,s) #Income taxes#;
    INF    # Rate of inflation measured by CPI #;
    INF_L    # Rate of inflation, lagged #;
    INTR      # Nominal interest rate#;
    INTR_L       # Rate of interest, lagged #;
    INT_PSD # Interest on public sector debt Fs #;
(all,c,COM)(all,i,IND)(all,d,DST)
    INVEST(c,i,d) # Investment at purchasers prices #;
(all,c,COM)(all,d,DST)
    INVEST_I(c,d) # Investment by commodity and region #;
(all,i,IND)(all,d,DST)
    INVEST_C(i,d) # Investment by industry and region #;
(all,r,REGPLUS)(all,i,INDPLUS)(all,z,INVFACT)
    INVFACTS(r,i,z) # Investment ratio summary #;
(all,i,IND)(all,z,INVFACT)
    INVFACTS_r(i,z) # Temp total #;
(all,r,REGPLUS)(all,z,INVFACT)
    INVFACTS_I(r,z) # Temp total #;
(parameter)
    ITER_NUM #Iteration number, used when expectations are for-
ward-looking#;
(parameter)
    ITER_NUM_B # Iteration number, used when expectations are
forward-looking #;
(all,d,DST)(all,i,IND)
    K_GR(d,i)  # Growth rate of capital stock in ind. i#;
(parameter)(all,d,DST)(all,i,IND)
    K_GR_MIN(d,i) # Minimum growth rate for capital stock in
ind. i#;
(parameter)(all,d,DST)(all,i,IND)
    K_GR_MAX(d,i) # Maximum growth rate for capital stock in
ind. i#;
(all,i,IND)(all,o,OCC)(all,d,DST)
    LAB(i,o,d) # Wage matrix #;
(all,i,IND)(all,d,DST)
    LAB_O(i,d) # Total labour bill in industry i #;
(all,o,OCC)(all,d,DST)
    LAB_I(o,d) # Total wages by skill #;
```

```
(all,d,DST)
    LAB_IO(d) # Total wages #;
(all,d,DST)
    LND_I(d) # Total rentals to land #;
(all,o,OCC)
    LAB_ID(o) # Total wages by occupation #;
(all,i,IND)
    LAB_OD(i) # Total national wage cost #;
(all,d,DST)
    LAB_SUP(d) # Labour supply#;
    LAB_SUPN # Labour supply, national#;
    LAB_SUPN_O # Labour supply, forecast run #;
    LEV_PLAB   # Nominal wage level#;
    LEV_PLAB_L  # Nominal wage level, lagged #;
    LEV_PLAB_B  # Nominal wage level, start of the year#;
    LEV_PLAB_L_B # Nominal wage level, lagged start of the
year#;
(all,i,IND)(all,d,DST)
    LND(i,d)     # Rentals to land #;
    LEV_CPI    # Consumer price level  #;
(parameter)
    LEV_CPI_B  # Consumer price level, start of the year, FI#;
    LEV_CPI_L  # Consumer price level, lagged, #;
(parameter)
    LEV_CPI_L_B # Consumer price level, lagged start of the
year#;
    LEV_CPI_2L # CPI double lagged, that is for t-2#;
(parameter)
    LEV_CPI_2L_B # CPI double lagged, base #;
(all,c,COM)(all,s,SRC)(all,d,DST)
    LOCUSE(c,s,d) # Non-export delivered value of regional com-
posite c,s in d #;
(all,c,COM)(all,d,DST)
    LOCUSE_S(c,d) # Non-export delivered value of good c #;
(all,c,COM)
    LOCUSE_SD(c) # Non-export national delivered value of good
c #;
(all,c,COM)(all,i,IND)(all,d,DST)
    MAKE(c,i,d) # MAKE multiproduction matrix #;
(all,i,IND)(all,d,DST)
    MAKE_C(i,d) # All production by industry i #;
(all,c,COM)(all,i,IND)
    MAKE_D(c,i) # National MAKE matrix #;
(all,c,COM)(all,d,DST)
    MAKE_I(c,d) # Total production of commodities #;
(all,c,COM)
    MAKE_IR(c) # National commodity outputs #;
```

```
(all,c,COM)(all,i,IND)(all,d,DST)
    MAKESHR1(c,i,d) # Com share in Ind output #;
(all,c,COM)(all,i,IND)(all,d,DST)
    MAKESHR2(c,i,d) # Ind share in Com supply #;
(all,c,COM)(all,s,SRC)(all,m,MAR)(all,r,ORG)(all,d,DST)
    MARSHR(c,s,m,r,d) # Share of margin m in all-user delivered
price #;
(all,d,DST)
    MUNTOGOV(d);
(all,i,IND)
    NATVTOT(i) # Total national industry cost plus tax #;
(parameter)(all,d,DST)(all,s,PSEC)
    NETINTS_G(s,d);
(all,d,DST)(all,s,PSEC)
    NETINTS_HS(d,s);
(all,d,DST)(all,s,PSEC)
    NET_TAXTOTS(d,s);
(integer,parameter)(all,c,COM)
    NINDPROD(c)# No of industries that make good c#;
(integer,parameter)(all,i,IND)
    NCOMPROD(i)# No of commodities made by ind i #;
(parameter)
    NOFITERS # N of forec. iterations in RE sims #;
(parameter)
    NYEARS # Length in years of the simulation horizon #;
(parameter)
    ONE_IT1_REP # Used in rat. exp.: one in 1st iter of policy,
else zero #;
(parameter)
    ONE_ITER1  # Used in rat. exp.: one in 1st iter of fore-
cast, else zero #;
(all,d,DST)(all,s,PSEC)
    OTHBENS(s,d) #Other public sector benefits#;
(all,d,DST)(all,s,PSEC)
    OTHCAPGOVS_(s,d) #Other public sector investments#;
(all,d,DST)(all,s,PSEC)
    OTHCAPGOVS(s,d) #Other public sector investments#;
(all,d,DST)(all,s,PSEC)
    OTHGOVREVS(s,d) #Other public sector revenues#;
(all,d,DST)(all,i,IND)
    PCAP_AT_T(d,i) # Asset price of capital stocks, start of
forecast year #;
(parameter)(all,d,DST)(all,i,IND)
PCAP_AT_T_B(d,i) # Asset price of capital stocks, start of data
year, base #;
(all,d,DST)(all,i,IND)
    PCAP_AT_T1(d,i) # Asset price of capital stocks, end of
```

```
data year, base #;
(parameter)(all,d,DST)(all,i,IND)
    PCAP_AT_T1_B(d,i) # Asset price of capital stocks, end of
data year, base #;
(all,d,DST)(all,i,IND)
    PCAP_I(d,i) # Asset price of capital by industry, average
in year #;
(parameter)(all,d,DST)(all,i,IND)
    PCAP_I_B(d,i) # Asset price of capital by industry, average
in year, base #;
(all,d,DST)(all,i,IND)
    PCAP_I_L(d,i) # Asset price of capital stocks, average of
year t-1 #;
(parameter)(all,d,DST)(all,i,IND)
PCAP_I_L_B(d,i) # Asset price of capital stocks, average of
year t-1, init sol#;
(all,d,DST)(all,i,IND)
    POW_PAYROLL(i,d) #Power of payroll taxes#;
(all,d,DST)(all,i,IND)(all,s,PSEC)
    POW_PAYROLLS(s,i,d) #Pow payroll taxes#;
(all,d,DST)
    POP(d)         # Population #;
(all,i,IND)(all,d,DST)
    PRIM(i,d) # Total factor input to industry i#;
(all,i,IND)(all,f,FAC)(all,d,DST)
    PRIMCOST(i,f,d) # Total factor inputs #;
(all,d,DST)
    PRIM_I(d) # Regional GDP at factor cost #;
(all,i,IND)
    PRIM_D(i)     # Total factor input to industry i #;
(all,i,IND)(all,d,DST)
    PRIMSHR(i,d) # PRIM(i,d)/PRIM_I(d) #;
(all,i,IND)(all,d,DST)
    PRODTAX(i,d) # Taxes on production #;
(all,d,DST)(all,s,PSEC)
    PSDATT(s,d) # Public sector debt, start of year #;
(parameter) (all,d,DST)(all,s,PSEC)
    PSDATT_1_B(d,s)#Public sector debt, end of year, base #;
(parameter)(all,d,DST)(all,s,PSEC)
    PSDATT_B(d,s) #Publ sector debt, start of year, base #;
(all,d,DST)(all,s,PSEC)
    PSDATTPLUS1(d,s) # Public sector debt, end of year #;
(all,i,IND)(all,d,DST)
    PTXRATE(i,d)   # Rate of production tax #;
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
    PUR(c,s,u,d) # Purchasers values#;
(all,c,COM)(all,u,USR)(all,d,DST)
```

```
    PUR_S(c,u,d) # Purch. values, sum over s #;
(all,u,USR)(all,d,DST)
    PUR_CS(u,d) # Expenditure on goods #;
(parameter)     R_DEFGDP_B
                # Level of the ratio of the government deficit
to GDP  #;
(parameter)     R_PSDGDP_B;

(all,d,DST)(all,i,IND)
    QCAPATT(d,i) # Quantity of capital stocks, start of fore-
cast year, ie K(t)#;
(all,d,DST)(all,i,IND)
QCAPATTPLUS1(d,i)
# Quantity of capital stocks, start of forecast year, ie
K(t+1)#;
(parameter)(all,d,DST)(all,i,IND)
QCAPATT_B(d,i)
# Quantity of capital stocks, start of forecast year, ie K(t),
base#;
(parameter)(all,d,DST)(all,i,IND)
    QINV_BASE(d,i) # Quantity of investments, start of forec
year#;
(all,d,DST)(all,i,IND)
    QINVEST(d,i) # Quantity of investment by industry i in
forec #;
(parameter)
    RALPH # Share of depreciation that is tax deductible R#;
(all,d,DST)(all,h,HOU)
    RATIOCPI(d,h)# (Current/initial) CPI#;
(all,m,MAINMACROS)
    RATIOMMACRO(m) # Initial/final ratio #;
(all,d,DST)
    RATIOPRIM_I(d) # Ratio (current/initial) real GDP at factor
cost #;
(all,i,IND)
    RATIOPRIM_D(i) # (Current/initial) ratio #;
    RINT_PSD #Interest on public sector debt#;
    RINT #Real rate of interest#;
(parameter)
    RINT_B      # Real interest rate, base#;
    RINT_L     # Real interest rate, lagged#;
(parameter)
    RINT_L_B   # Real interest rate, base, lagged #;
    RINT_PT_SE # Post-tax real interest rate, SE#;
(all,d,DST)(all,i,IND)
    ROR_SE(d,i) # Rates of return in year t: static expecta-
tions#;
```

```
(parameter)(all,d,DST)(all,i,IND)
    ROR_SE_BASE(d,i) # SE of rors in init. sol. for year t#;
(parameter)(all,d,DST)(all,i,IND)
    RORN(d,i) # Normal rates of return, given as data #;
(all,d,DST)(all,i,IND)
    ROR_ACT_L(d,i) # Lagged rate of return, ror in t-1 #;
(parameter)(all,d,DST)(all,i,IND)
    ROR_ACT_L_B(d,i) # Lagged rate of return, init. soln., usu-
ally ror in t-2#;
(all,c,COM)(all,r,ORG)(all,d,DST)
    ROWDEM(c,r,d) # Eventually exported goods #;
(all,c,COM)(all,r,ORG)
    ROWDEM_D(c,r) # Eventually exported goods #;
    RWAGE   # Real wage in year t, CPI deflated #;
(parameter)
    RWAGE_B # Real wage in year t, CPI deflated, base #;
(parameter)
    RWAGE_L_B # Real wage in year t-1, CPI deflated,base  #;
    RWAGE_OLD # Real wage in year t, CPI deflated, forecast #;
(parameter)
    RWAGE_OLD_B # Real wage in year t, CPI deflated, forec,
base#;
(parameter)
    RWAGE_O_L_B # Real wage in year t-1, CPI deflated, forec,
base#;
    RWAGE_PT # Real post-tax wage in year t, CPI deflated #;
(parameter)
    RWAGE_PT_B # Real post-tax wage in year t, CPI deflated,
base #;
(parameter)
    RWAGE_PT_L_B # Real post-tax wage, year t-1,CPI de-
flated,base#;
(parameter)
    RWAGE_PT_O_B # Real post-tax wage,year t,CPI
defl.,forec,base#;
    RWAGE_PT_OLD # Real post-tax wage,year t, CPI defl, fore-
cast#;
(parameter)
    RW_PT_O_L_B # Real post-tax wage, t-1, CPI defl, forec,
base#;
(all,d,DST)(all,c,COM)(all,r,SRC)(all,s,PSEC)
    SCRSHR5(d,c,r,s);
(all,i,IND)(all,d,DST)(all,p,PRFS)
    SHRLK(i,d,p)#Primary factor shares#;
(parameter)(all,i,IND)
    SIGMA1LAB(i) # CES substitution between skill types #;
(parameter)(all,i,IND)
```

```
    SIGMAPRIM(i) # CES substitution, primary factors #;
(parameter)(all,c,COM)
    SIGMADOMIMP(c) # Substitution elast between dom/imp #;
(parameter)(all,c,COM)
    SIGMADOMDOM(c) # Substitution elast between origins #;
(parameter)(all,m,MAR)
    SIGMAMAR(m) # Subst elast between margin origins #;
(parameter)(all,i,IND)
    SIGMAOUT(i) # CET transformation elasticities #;
(all,i,IND)(all,o,OCC)(all,d,DST)
    SLAB_I(i,o,d) # Industry shares of wages #;
(all,o,OCC)(all,d,DST)
    SLAB_ID(o,d) # Region shares of wages #;
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
    SRCSHR(c,s,u,d) # Imp/dom shares#;
(all,c,COM)(all,d,DST)(all,h,HOU)
    SLUX(c,d,h) # Marginal household budget shares #;
(parameter)(all,d,DST)(all,i,IND)
    SMURF(d,i) # Recip. of slopes of cap. supply curves at
K_GR(i)=TREND_K(i)#;
(all,d,DST)
    SSFTOGOV(d);
(all,i,IND)(all,d,DST)
    STOCKS(i,d)  # Domestic inventories #;
(all,m,MAR)(all,r,ORG)(all,d,DST)(all,p,PRD)
    SUPPMAR(m,r,d,p) # Margins supplied by p on goods passing
from r to d #;
(all,m,MAR)(all,r,ORG)(all,d,DST)
    SUPPMAR_P(m,r,d)  # Total demand for margin m on goods from
r to d #;
(all,m,MAR)(all,r,ORG)(all,p,PRD)
    SUPPMAR_D(m,r,p)  # Total demand for margin m (from p) on
goods from r #;
(all,m,MAR)(all,p,PRD)
    SUPPMAR_RD(m,p)   # Total demand for margin m produced in p
#;
(all,m,MAR)(all,d,DST)(all,p,PRD)
    SUPPMAR_R(m,d,p) # Margins supplied by p on all goods pass-
ing to d #;
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
    TAX(c,s,u,d) # Commodity taxes #;
(all,d,DST)
    TAX_CSI(d) #Commodity taxes#;
(all,d,DST)
    TAXEXP(d) #Export taxes#;
(all,d,DST)
    TAXGOV(d)#Taxes on govt#;
```

```
(all,d,DST)
    TAXHOU(d)#Taxes on households#;
(all,d,DST)
    TAXINT(d)#Taxes on intermediates#;
(all,d,DST)
    TAXINV(d)#Taxes on investments#;
(all,d,DST)
    TAXPROD(d)#Production taxes#;
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
    TAXRATE(c,s,u,d) # Tax rate #;
(all,d,DST)(all,s,PSEC)
    TAXS_CAP(d,s)#Tax on capital income#;
(all,d,DST)(all,s,PSEC)
    TAXS_AB(d,s) #Tax on age benefits#;
(all,d,DST)(all,s,PSEC)
    TAXS_AB_RATE(s,d) #Tax rate on age benefits#;
(all,d,DST)(all,s,PSEC)
    TAXS_K_RATE(s,d) #Capital income tax rate#;
    TAX_K_RATE  # Rate of tax on capital and land income#;
    TAX_CAP # Tax collected from labour income #;
    TAX_L_RATE # Rate of tax on labour income, year t#;
(parameter)
    TAX_L_RATE_L   # Rate of tax on lab income, year t-1,
base#;
    TAX_L_RATE_O # Rate of tax on labour income, forecast, year
t#;
(parameter)
    TAX_L_R_O_L # Rate of tax on lab income, t-1, forecast,
base #;
(all,d,DST)(all,s,PSEC)
    TAXS_LAB(d,s) #Labour income tax#;
(all,d,DST)(all,s,PSEC)
    TAXS_LND(d,s) #Capital income tax on land#;
(all,d,DST)(all,s,PSEC)
    TAXS_L_RATE(s,d) #Labour income tax rate#;
(all,d,DST)(all,s,PSEC)
    TAXS_OB(d,s) #Tax on other benefits#;
(all,d,DST)(all,s,PSEC)
    TAXS_OB_RATE(s,d)#Tax rate on other benefits#;
(all,d,DST)(all,s,PSEC)
    TAXS_UB(d,s) #Tax on unemployment benefits#;
(all,d,DST)(all,s,PSEC)
    TAXS_UB_RATE(s,d)#Tax rate on unemployment benefits#;
(all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
    TRADE(c,s,r,d) # Sourcing matrix (at basic prices) #;
(all,s,SRC)(all,d,DST)
    TRADE_CR(s,d) # Total direct demands dest d #;
```

```
(all,c,COM)(all,s,SRC)(all,r,ORG)
    TRADE_D(c,s,r) # Total direct demands #;
(all,c,COM)(all,s,SRC)(all,d,DST)
    TRADE_R(c,s,d) # Total direct demands #;
(all,c,COM)(all,s,SRC)
    TRADE_RD(c,s) # Total national direct demands #;
(all,c,COM)(all,e,ELSTRAD)
    TRADELAST(c,e) # Trade elasticities #;
(all,c,COM)(all,s,SRC)(all,m,MAR)(all,r,ORG)(all,d,DST)
    TRADMAR(c,s,m,r,d) # Margins on trade matrix (at basic
prices)#;
(all,m,MAR)(all,r,ORG)(all,d,DST)
    TRADMAR_CS(m,r,d) # Total demand for margin m on goods from
r to d #;
(all,d,DST)(all,s,PSEC)
    TRANSS_G(d,s) #Transfers between public sectors#;
(all,d,DST)(all,s,PSEC)
    TRANSS_H(d,s) #Transfers between public sectors#;
(parameter)(all,d,DST)(all,i,IND)
    TREND_K(d,i) #'Historical' trend gr. rate for capital stock
in i#;
(all,d,DST)(all,s,PSEC)
    UNEMPBENS(s,d) #Unemployment benefits#;
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
    USE(c,s,u,d) # Delivered value of demands: basic + margins
(ex-tax) #;
(all,c,COM)(all,s,SRC)(all,d,DST)
    USE_U(c,s,d) # Total delivered value of regional composite
c,s in d #;
(all,c,COM)(all,s,SRC)(all,d,DST)
USE_I(c,s,d) # All-intermediate delivered value of reg. compo-
site c,s in d #;
(all,d,DST)
    V0GDPINC(d);
(all,d,DST)(all,s,PSEC)
    V0TAX_CSIS(d,s);
(all,d,DST)(all,i,IND)
    V1CAP(d,i)  # Capital rentals #;
    V1CAP_I   # Total payments to capital #;
(all,d,DST)
    V1PRIM_I(d);
(all,d,DST)(all,i,IND)(all,s,PSEC)
    V2SHRSG_(d,i,s);
(all,d,DST)(all,i,IND)(all,s,PSEC)
    V2SHRSG(d,i,s);
(all,d,DST)(all,i,IND)
    V2TOT(d,i)   # Investment #;
```

```
(all,d,DST)(all,s,PSEC)
    V2TOT_G_IS(d,s);
(all,d,DST)(all,i,IND)(all,s,PSEC)
    V2TOTSG_(d,i,s);
(all,d,DST)
    V3TOT(d);
(all,d,DST)(all,c,COM)(all,s,PSEC)
    V5SHRS_(d,c,s);
(all,d,DST)(all,c,COM)(all,s,PSEC)
    V5TOT(d,c,s);
(all,d,DST)(all,c,COM)(all,r,SRC)(all,s,PSEC)
    V5TOTR(d,c,r,s);
(all,d,DST)(all,s,PSEC)
    V5TOTS(d,s);
(parameter)(all,d,DST)(all,c,COM)(all,s,PSEC)
    V5TOTS_(d,c,s);
(all,i,IND)(all,d,DST)
    VARCST(i,d) # Shortrun variable cost of industry i #;
(all,d,DST)(all,i,IND)
VCAP_AT_T(d,i) # Start of year capital stocks valued at start
of yr prices #;
(all,d,DST)(all,i,IND)
    VCAP_AT_TM(d,i) # Val of capital, start of f'cast year in
mid-yr prices #;
(all,i,IND)(all,d,DST)
    VCST(i,d) # Total cost of industry i #;
(all,c,COM)(all,r,REG)
VDOMEXP(c,r)
# Value good c made in r sent to other domestic regions (non-
margin) #;
(all,c,COM)(all,d,REG)
VDOMIMP(c,d)
# Value domestic good c used in d made in other domestic re-
gions (non-margin)#;
(all,r,REG)
VDOMEXP_C(r)
# Value goods made in r sent to other domestic regions (non-
margin) #;
(all,d,REG)
VDOMIMP_C(d)
# Value domestic goods used in d made in other domestic regions
(non-margin)#;
(all,i,IND)(all,d,DST)
    VTOT(i,d) # Total industry cost plus tax #;
(all,m,MAINMACROS)(all,q,REG)
    WMAINMACRO(m,q) # Weights to aggregate macros #;
(all,m,MAINMACROS)
```

```
    WNATMACRO(m) # Total of WMainMacro #;
    YEAR # Year of current solution #;
(parameter)
    YEAR_B # Year of current solution FIt#;
(parameter)
    YR_POLICY # Year in which policy shock is first antici-
pated#;
(parameter)
    ZERO_PYR1 # Zero in 1st yr of a rational-exp. policy sim,
else 1#;

!################################################################
##############!

!***************************************************************
*************!
! Section 4: Read instructions for coefficients listed alpha-
betically       !
!***************************************************************
*************!
!################################################################
##############!

Read ADJ_COEFF      from file EXTRA     header "ADJC";
Read AGEBENS        from file PSECDATA  header "AGES";
Read ALPHA1         from file INFILE    header "ALF1";
Read ALPHA2         from file INFILE    header "ALF2";
Read CAP            from file INFILE    header "1CAP";
Read COEFF_TIME     from file ROREXT    header "TYME";
Read DEP            from file EXTRA     header "DEPR";
Read DUM_YEAR1      from file EXTRA     header "0045";
Read DUMMY_DEC      from file ROREXT    header "DMDC";
Read EMPLOYS        from file PSECDATA  header "REMP";
Read EPSH           from file INFILE    header "XPEL";
Read EROR_G         from file ROREXT    header "RORG";
Read EXP_ELAST      from file INFILE    header "P018";
Read F_EEQROR_I     from file EXTRA     header "FCSE";
Read F_EEQROR       from file EXTRA     header "FSTA";
Read FEMPADJ        from file EXTRA     header "EADJ";
Read FEMPADJ_O      from file EXTRA3    header "EADJ";
Read FRISCHH        from file INFILE    header "P021";
Read GOVTOMUN       from file PSECDATA  header "G2M";
Read GOVTOSSF       from file PSECDATA  header "G2S";
Read GRANTSS        from file PSECDATA  header "GRNS";
Read INVEST         from file INFILE    header "2PUR";
Read ITER_NUM       from file ITER      header "ITNO";
Read LAB            from file INFILE    header "1LAB";
```

```
Read LAB_SUP         from file PSECDATA  header "POPW";
Read LEV_CPI         from file EXTRA     header "LCPI";
Read LEV_CPI_L       from file EXTRA     header "CPIL";
Read LEV_CPI_2L      from file EXTRA     header "LCP2";
Read LEV_PLAB        from file EXTRA     header "PLAB";
Read LEV_PLAB_L      from file EXTRA     header "PLAL";
Read LND             from file INFILE    header "1LND";
Read MAKE            from file INFILE    header "MAKE";
Read MUNTOGOV        from file PSECDATA  header "M2G";
Read NETINTS_G       from file PSECDATA  header "NINS";
Read INT_PSD         from file EXTRA     header "NINT";
Read NOFITERS        from file ROREXT    header "NFIT";
Read NYEARS          from file ROREXT    header "HORZ";
Read OTHBENS         from file PSECDATA  header "OTHS";
Read OTHCAPGOVS_     from file PSECDATA  header "OGIS";
Read OTHGOVREVS      from file PSECDATA  header "OTGS";
Read PCAP_I          from file EXTRA     header "PCAI";
Read PCAP_I_B        from file EXTRA     header "PCAB";
Read PCAP_I_L        from file EXTRA     header "PCAL";
Read PCAP_AT_T       from file EXTRA     header "PCAP";
Read PCAP_AT_T1      from file EXTRA     header "PCAT";
Read POP             from file INFILE    header "P001";
Read POW_PAYROLL     from file PSECDATA  header "POPR";
Read POW_PAYROLLS    from file PSECDATA  header "POPS";
Read PRODTAX         from file INFILE    header "1PTX";
Read PSDATT          from file PSECDATA  header "PSDS";
Read RALPH           from file EXTRA     header "RLPH";
Read RINT            from file EXTRA     header "RINT";
Read RINT_L          from file EXTRA     header "RNTL";
Read RORN            from file EXTRA     header "RORN";
Read RWAGE           from file EXTRA     header "RWAG";
Read RWAGE_L_B       from file EXTRA4    header "RWAG";
Read RWAGE_O_L_B     from file EXTRA5    header "RWAG";
Read RWAGE_OLD       from file EXTRA3    header "RWAG";
Read SIGMA1LAB       from file INFILE    header "SLAB";
Read SIGMAPRIM       from file INFILE    header "P028";
Read SIGMADOMIMP     from file INFILE    header "P015";
Read SIGMADOMDOM     from file INFILE    header "SGDD";
Read SIGMAMAR        from file INFILE    header "SMAR";
Read SIGMAOUT        from file INFILE    header "SCET";
Read SMURF           from file EXTRA     header "SMRF";
Read SSFTOGOV        from file PSECDATA  header "S2G";
Read STOCKS          from file INFILE    header "STOK";
Read SUPPMAR         from file INFILE    header "MARS";
Read TAX             from file INFILE    header "UTAX";
Read TAXS_AB_RATE    from file PSECDATA  header "TLAS";
Read TAXS_K_RATE     from file PSECDATA  header "TKRS";
```

```
Read TAXS_L_RATE    from file PSECDATA  header "TLRS";
Read TAX_L_RATE     from file EXTRA     header "TLRT";
Read TAX_L_RATE_L   from file EXTRA4    header "TLRT";
Read TAX_L_RATE_O   from file EXTRA3    header "TLRT";
Read TAX_L_R_O_L    from file EXTRA5    header "TLRT";
Read TAXS_OB_RATE   from file PSECDATA  header "TLOS";
Read TAXS_UB_RATE   from file PSECDATA  header "TLUS";
Read  TRADE         from file INFILE    header "TRAD";
Read  TRADMAR       from file INFILE    header "TMAR";
Read TREND_K        from file EXTRA     header "TRNK";
Read UNEMPBENS      from file PSECDATA  header "UBES";
Read USE            from file INFILE    header "BSMR";
Read V2TOTSG_       from file PSECDATA  header "RGI";
Read V5TOTS_        from file PSECDATA  header "RGC";
Read VCAP_AT_T      from file EXTRA     header "VCAP";
Read YEAR           from file EXTRA     header "YEAR";
Read YR_POLICY      from file ROREXT    header "YRPL";

Assertion ! various sign checks on data !
(initial) # MAKE>=0 # (all,c,COM)(all,i,IND)(all,d,DST)
    MAKE(c,i,d)>=0;
(initial) # USE>=0 #
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
    USE(c,s,u,d) >=0;
(initial) # USE=0 --> TAX=0 # (all,c,COM)(all,s,SRC)(all,u,USR)
  (all,d,DST:USE(c,s,u,d)=0)
    TAX(c,s,u,d)=0;
(initial) # TRADE>=0 #
(all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
    TRADE(c,s,r,d)>=0;
(initial) # TRADMAR>=0 #
(all,c,COM)(all,s,SRC)(all,m,MAR)(all,r,ORG)(all,d,DST)
    TRADMAR(c,s,m,r,d)>=0;
(initial) # TRADE=0 --> TRADMAR=0 #
(all,c,COM)(all,s,SRC)(all,r,ORG)
   (all,d,DST:TRADE(c,s,r,d)=0)(all,m,MAR)
    TRADMAR(c,s,m,r,d)=0;
(initial) # SUPPMAR>=0 #
(all,m,MAR)(all,r,ORG)(all,d,DST)(all,p,PRD)
    SUPPMAR(m,r,d,p) >=0;
(initial) # INVEST>=0 # (all,c,COM)(all,i,IND)(all,d,DST)
    INVEST(c,i,d)>=0;
(initial) # LAB>=0 # (all,i,IND)(all,o,OCC)(all,d,DST)
    LAB(i,o,d) >=0;
(initial) # CAP>=0 # (all,i,IND)(all,d,DST)
    CAP(i,d)   >=0;
(initial) # LND>=0 # (all,i,IND)(all,d,DST)
```

```
    LND(i,d)   >=0;

(initial) # SIGMA1LAB>=0 #   (all,i,IND)    SIGMA1LAB(i)
>=0;
(initial) # SIGMAPRIM>=0 #   (all,i,IND)    SIGMAPRIM(i)   >=0;
(initial) # SIGMADOMIMP>=0 # (all,c,COM)    SIGMADOMIMP(c) >=0;
(initial) # SIGMADOMDOM>=0 # (all,c,COM)    SIGMADOMDOM(c) >=0;
(initial) # SIGMAMAR>=0 #    (all,m,MAR)    SIGMAMAR(m)    >=0;
(initial) # POP>=0 #         (all,d,DST)    POP(d)         >=0;
(initial) # SIGMAOUT>=0 #    (all,i,IND)    SIGMAOUT(i)    >=0;
(initial) # EXP_ELAST>=0 #   (all,c,COM)    EXP_ELAST(c)   >=0;

Formula
            NATEMP          = sum{d,DST, EMPLOYS(d)};
(initial)   NATEMP_L_B      = NATEMP;
(initial)   NATEMP_O_L_B    = NATEMP;
(initial)   NATEMP_OLD      = NATEMP;


!###############################################################
##############!

!***************************************************************
*************!
! Section 5: Formulas in thematic groups
!
!***************************************************************
*************!
!###############################################################
##############!

!***************************************************************
***********!
!Section 5.1 Formulas used for defining
!
! purchasers prices and imp/dom shares
!
!***************************************************************
***********!

Formula
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
            PUR(c,s,u,d) = USE(c,s,u,d) + TAX(c,s,u,d);
(all,c,COM)(all,u,USR)(all,d,DST)
            PUR_S(c,u,d) = sum{s,SRC,PUR(c,s,u,d)};
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
            SRCSHR(c,s,u,d) = PUR(c,s,u,d)/ID01[PUR_S(c,u,d)];
```

```
(all,u,USR)(all,d,DST)
            PUR_CS(u,d)=sum{c,COM,PUR_S(c,u,d)};
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
            TAXRATE(c,s,u,d) = TAX(c,s,u,d)/ID01[USE(c,s,u,d)];
Write TAXRATE to file SUMMARY header "TRAT";

!**************************************************************
***********!
!Section 5.2 Formulas used for defining factor demands
!
!**************************************************************
***********!

Formula
    (all,i,IND)(all,d,DST) LAB_O(i,d)   = sum{o,OCC,
LAB(i,o,d)};
    (all,i,IND)(all,d,DST) PRIM(i,d)    = LAB_O(i,d)+ CAP(i,d)
+ LND(i,d);
    (all,i,IND)(all,d,DST) SHRLK(i,d,"Labour") =
        LAB_O(i,d)/ID01[LAB_O(i,d)+CAP(i,d)];
    (all,i,IND)(all,d,DST) SHRLK(i,d,"capital") =
        CAP(i,d)/ID01[LAB_O(i,d)+CAP(i,d)];
    (all,i,IND)(all,d,DST) PRIMCOST(i,"Lnd",d) = LND(i,d);
    (all,i,IND)(all,d,DST) PRIMCOST(i,"Lab",d) = LAB_O(i,d);
    (all,i,IND)(all,d,DST) PRIMCOST(i,"Cap",d) = CAP(i,d);

    (all,i,IND)(all,d,DST) VARCST(i,d)  = LAB_O(i,d) +
PUR_CS(i,d);
    (all,i,IND)(all,d,DST) VCST(i,d)    = PRIM(i,d) +
PUR_CS(i,d);
Zerodivide default 1.0;
Formula
    (all,i,IND)(all,d,DST) VTOT(i,d)    = VCST(i,d) +
PRODTAX(i,d);
    (all,i,IND)(all,d,DST) PTXRATE(i,d) =
PRODTAX(i,d)/VCST(i,d);
Zerodivide off;
Formula
    (all,i,IND)(all,d,DST) COSTMAT(i,"IntDom",d) = sum{c,COM,
USE(c,"dom",i,d)};
    (all,i,IND)(all,d,DST) COSTMAT(i,"IntImp",d) = sum{c,COM,
USE(c,"imp",i,d)};
    (all,i,IND)(all,d,DST) COSTMAT(i,"ComTax",d) =
        sum{c,COM, sum{s,SRC, TAX(c,s,i,d)}};
    (all,i,IND)(all,d,DST) COSTMAT(i,"Lab",d)    = LAB_O(i,d);
    (all,i,IND)(all,d,DST) COSTMAT(i,"Cap",d)    = CAP(i,d);
    (all,i,IND)(all,d,DST) COSTMAT(i,"Lnd",d)    = LND(i,d);
```

```
    (all,i,IND)(all,d,DST) COSTMAT(i,"ProdTax",d)=
PRODTAX(i,d);

Write PRIMCOST  to file SUMMARY header "PCST";
Write PTXRATE   to file SUMMARY header "PTXR";
Write COSTMAT   to file SUMMARY header "CSTM";
Write VTOT      to file SUMMARY header "VTOT";

!***************************************************************
***********!
!Section 5.3 Formulas used for defining household demands!
!***************************************************************
***********!

Formula
    (all,c,COM)(all,d,DST)(all,h,HOU)
        HOUPUR(c,d,h) = PUR_S(c,"Hou",d);
    (all,d,DST)(all,h,HOU)
        HOUPUR_C(d,h) = sum{c,COM, HOUPUR(c,d,h)};
    (all,c,COM)(all,d,DST)(all,h,HOU)
        BUDGSHR(c,d,h) = HOUPUR(c,d,h)/ID01[HOUPUR_C(d,h)];
    (all,d,DST)(all,h,HOU)
        EPSAVE(d,h) = sum{c,COM, EPSH(c,d,h)*BUDGSHR(c,d,h)};
    (initial)(all,c,COM)(all,d,DST)(all,h,HOU)
        EPSH(c,d,h) = EPSH(c,d,h)/ID01[EPSAVE(d,h)];
    (all,c,COM)(all,d,DST)(all,h,HOU)
        BLUX(c,d,h) = ABS[EPSH(c,d,h)/ID01[FRISCHH(d,h)]];
    (all,c,COM)(all,d,DST)(all,h,HOU)
        SLUX(c,d,h) = EPSH(c,d,h)*BUDGSHR(c,d,h);

Write  SLUX    to file SUMMARY header "LSHR";
       BUDGSHR to file SUMMARY header "BSHR";
       EPSAVE  to file SUMMARY header "AVEP";

Formula
    (initial)(all,d,DST)(all,h,HOU)
        RATIOCPI(d,h) = 1;
        DEFHOUSHR = 1/sum{h,HOU,1};
Zerodivide default DEFHOUSHR;
Formula
    (all,c,COM)(all,d,DST)
        HOUPUR_H(c,d) = sum{h,HOU, HOUPUR(c,d,h)};
    (all,c,COM)(all,d,DST)(all,h,HOU)
        HOUSHR(c,d,h) = HOUPUR(c,d,h)/HOUPUR_H(c,d);
Zerodivide off;
Formula
    (all,c,COM)(all,d,DST)
```

```
        CHKHOUPUR(c,d) = HOUPUR_H(c,d) - PUR_S(c,"Hou",d);
Write CHKHOUPUR to file SUMMARY header "CHOU";

Formula
    (all,c,COM)(all,d,DST)
        CHKHOUPUR(c,d) =
        200*CHKHOUPUR(c,d)/ID01[HOUPUR_H(c,d) +
PUR_S(c,"Hou",d)];
Write CHKHOUPUR to file SUMMARY header "CHO2" longname "HOUPUR
error as %";

Assertion # Check HOUPUR_H = PUR_S("Hou") #
    (all,c,COM)(all,d,DST) ABS[CHKHOUPUR(c,d)]<0.1;


Coefficient
(all,c,COM)(all,d,DST)     INCELAST(c,d) # Household expendi-
ture elasticities #;

(all,d,DST) AGGCON(d);
(all,i,COM)(all,d,DST) DELTA(i,d);
(all,i,COM)(all,d,DST) EPS(i,d);
(all,i,COM)(all,j,COM)(all,d,DST) ETA(i,j,d);
(all,i,COM)(all,j,COM)(all,d,DST) KD(i,j,d);
(all,i,COM)(all,d,DST) S3CON(i,d);
(all,i,COM)(all,d,DST) SS3CON(i,d);
(all,i,COM)(all,d,DST) TPURCHVAL3(i,d);
(all,d,DST) SUMDELTA(d);
(all,d,DST) FRISCH(d);

Read INCELAST from file INFILE header "XPEL";

Formula
(all,d,DST)                V3TOT(d) = PUR_CS("Hou",d);

(all,d,DST) AGGCON(d)=V3TOT(d);
(all,d,DST) FRISCH(d)=FRISCHH(d,"ALLhou");



(all,i,COM)(all,d,DST) TPURCHVAL3(i,d)=PUR_S(i,"Hou",d);
(all,i,COM)(all,d,DST) S3CON(i,d) = TPURCHVAL3(i,d)/AGGCON(d);


Formula
(initial)(all,i,COM)(all,d,DST)
DELTA(i,d)=INCELAST(i,d)*S3CON(i,d);
```

```
(initial)(all,d,DST) SUMDELTA(d) = sum{i,COM, DELTA(i,d)};
(initial)(all,i,COM)(all,d,DST) DELTA(i,d) = DELTA(i,d)/SUM-
DELTA(d);

Formula
    (all,i,COM)(all,d,DST)
EPS(i,d) =
DELTA(i,d)/{if[S3CON(i,d)>0,S3CON(i,d)]+if[S3CON(i,d)=0,1/.0000
001]};
Formula (all,i,COM)(all,d,DST)
SS3CON(i,d) = S3CON(i,d) + DELTA(i,d)/FRISCH(d);
(all,i,COM)(all,j,COM)(all,d,DST) KD(i,j,d) = 0.0;
(all,i,COM)(all,d,DST) KD(i,i,d) = 1.0;
(all,i,COM)(all,j,COM)(all,d,DST) ETA(i,j,d) =
    KD(i,j,d)*EPS(i,d)/FRISCH(d) - EPS(i,d)*[S3CON(j,d)+
DELTA(j,d)/FRISCH(d)];



!***************************************************************
***********!
!Section 5.4 Formulas used for defining
!
! Investment demands and indices: conditional on industry-spe-
cific investment !
!***************************************************************
***********!

Formula
    (all,c,COM)(all,d,DST) INVEST_I(c,d) = sum{i,IND,IN-
VEST(c,i,d)};
    (all,i,IND)(all,d,DST) INVEST_C(i,d) = sum{c,COM,IN-
VEST(c,i,d)};

!***************************************************************
***********!
!Section 5.5 Formulas used for defining
!
!total regional demands for delivered goods
!
!***************************************************************
***********!

Formula
```

```
    (all,c,COM)(all,s,SRC)(all,d,DST)
        USE_U(c,s,d) = sum{u,USR, USE(c,s,u,d)};
    (all,c,COM)(all,s,SRC)(all,d,DST)
        USE_I(c,s,d) = sum{i,IND, USE(c,s,i,d)};
    (all,c,COM)(all,s,SRC)(all,d,DST)
        LOCUSE(c,s,d) = USE_U(c,s,d) - USE(c,s,"exp",d);
    (all,c,COM)(all,d,DST)
        LOCUSE_S(c,d) = sum{s,SRC, LOCUSE(c,s,d)};
    (all,c,COM)
        LOCUSE_SD(c) = sum{d,DST, LOCUSE_S(c,d)};

    (all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
        DELIVRD(c,s,r,d) = TRADE(c,s,r,d) + sum{m,MAR,
TRADMAR(c,s,m,r,d)};
    (all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
        BASSHR(c,s,r,d) = TRADE(c,s,r,d)/ID01[DE-
LIVRD(c,s,r,d)];
    (all,c,COM)(all,s,SRC)(all,m,MAR)(all,r,ORG)(all,d,DST)
         MARSHR(c,s,m,r,d) = TRADMAR(c,s,m,r,d)/ID01[DE-
LIVRD(c,s,r,d)];

    (all,c,COM)(all,s,SRC)(all,d,DST)
        DELIVRD_R(c,s,d) = sum{r,ORG,DELIVRD(c,s,r,d)};

!***************************************************************
***********!
!Section 5.6 Formulas used for defining margin production and
demands           !
!***************************************************************
***********!

Formula
    (all,m,MAR)(all,r,ORG)(all,d,DST)
        TRADMAR_CS(m,r,d) = sum{c,COM, sum{s,SRC,
TRADMAR(c,s,m,r,d)}};
    (all,m,MAR)(all,r,ORG)(all,d,DST)
        SUPPMAR_P(m,r,d) = sum{p,PRD, SUPPMAR(m,r,d,p)};
    (all,m,MAR)(all,r,ORG)(all,p,PRD)
        SUPPMAR_D(m,r,p) = sum{d,DST, SUPPMAR(m,r,d,p)};
    (all,m,MAR)(all,p,PRD)
        SUPPMAR_RD(m,p) = sum{r,ORG, SUPPMAR_D(m,r,p)};
    (all,m,MAR)(all,d,DST)(all,p,PRD)
        SUPPMAR_R(m,d,p) = sum{r,ORG, SUPPMAR(m,r,d,p)};

!***************************************************************
***********!
!Section 5.7 Formulas used for multi-production (MAKE)
```

```
!
!*************************************************************
***********!

Formula
    (all,i,IND)(all,d,DST)
        MAKE_C(i,d) = sum{c,COM, MAKE(c,i,d)};
    (all,c,COM)(all,d,DST)
        MAKE_I(c,d) = sum{i,IND, MAKE(c,i,d)};

Coefficient RECIPNCOM;
Formula     RECIPNCOM = 1/sum{c,COM,1};
Coefficient RECIPNIND;
Formula     RECIPNIND = 1/sum{i,IND,1};
Zerodivide default RECIPNCOM;
Formula
(all,c,COM)(all,i,IND)(all,d,DST) MAKESHR1(c,i,d) =
MAKE(c,i,d)/MAKE_C(i,d);
Zerodivide default RECIPNIND;
Formula
(all,c,COM)(all,i,IND)(all,d,DST) MAKESHR2(c,i,d) =
MAKE(c,i,d)/MAKE_I(c,d);
Zerodivide off;

Formula
    (all,c,COM)(all,i,IND)
        MAKE_D(c,i) = sum{d,DST, MAKE(c,i,d)};
    (initial) (all,c,COM)
        NINDPROD(c) = sum{i,IND:MAKE_D(c,i)<>0,1};
    (initial) (all,i,IND)
        NCOMPROD(i) = sum{c,COM:MAKE_D(c,i)<>0,1};

Set
 MIND # Multi-product industries #   = (all,i,IND:NCOM-
PROD(i)>1);
 SIND # Single-product industries #  =  IND - MIND;
 MINDCOM # Commodities produced by any industry in MIND #
     = (all,c,COM:sum{i,MIND,ABS[MAKE_D(c,i)]}>0);
Mapping SIND2COM from SIND to COM;
Formula (all,i,SIND) SIND2COM(i) =
sum{c,COM:ABS[MAKE_D(c,i)]>0, $pos(c,COM)};

Set
 MCOM # Commodities made by several industries #   =
(all,c,COM:NINDPROD(c)>1);
 SCOM # Commodities made by only one industry #  =  COM - MCOM;
 MCOMIND # Industries that produce a commodity in MCOM #
```

```
     = (all,i,IND:sum{c,MCOM,ABS[MAKE_D(c,i)]}>0);
Mapping SCOM2IND from SCOM to IND;
Formula (all,c,SCOM) SCOM2IND(c) =
sum{i,IND:ABS[MAKE_D(c,i)]>0, $pos(i,IND)};

Write
 (Set) MIND              to file SUMMARY header "MIND";
 (Set) SIND              to file SUMMARY header "SIND";
 (Set) MCOM              to file SUMMARY header "MCOM";
 (Set) SCOM              to file SUMMARY header "SCOM";
 (Set) MCOMIND           to file SUMMARY header "MCI";
 (Set) MINDCOM           to file SUMMARY header "MIC";
 (by_elements) SCOM2IND to file SUMMARY header "SC2I";
 (by_elements) SIND2COM to file SUMMARY header "SI2C";

Coefficient (all,c,COM)(all,i,IND) ISMADE(c,i);
Formula
    (all,c,COM)(all,i,IND)
        ISMADE(c,i) = 0;
    (all,c,COM)(all,i,IND)
        ISMADE(c,i) = if[MAKE_D(c,i)>0,1];

Coefficient (all,c,COM)(all,i,IND)(ALL,D,dst) ISMADEd(c,i,d);
Formula
    (all,c,COM)(all,i,IND)(ALL,D,dst)
        ISMADED(c,i,D) = 0;
    (all,c,COM)(all,i,IND)(ALL,D,dst)
        ISMADED(c,i,D) = if[MAKE(c,i,d)>0,1];



Coefficient (all,c,COM)(all,i,IND) MAKESHR_i(c,i);
Formula
    (all,c,COM)(all,i,IND)
        MAKESHR_i(c,i) = 0;
    (all,c,COM)(all,i,IND)
        MAKESHR_i(c,i) =
        if[sum{cc,COM,MAKE_D(cc,i)}>0,
MAKE_D(c,i)/sum{cc,COM,MAKE_D(cc,i)}];

Coefficient (all,c,COM)(all,i,IND)(all,d,DST) MAKESHR(c,i,d);
Formula
    (all,c,COM)(all,i,IND)(all,d,DST)
MAKESHR(c,i,d) =
      if[sum{cc,COM,MAKE(cc,i,d)}>0,
MAKE(c,i,d)/sum{cc,COM,MAKE(cc,i,d)}];
```

```
!*************************************************************
****************!
!Section 5.8 Formulas used for defining market equilibrium
!
!Total demand for commodity c produced in r = supply commodity
c produced in r !
!*************************************************************
****************!

Formula
    (all,c,COM)(all,s,SRC)(all,r,ORG)
        TRADE_D(c,s,r) = sum{d,DST, TRADE(c,s,r,d)};
    (all,c,COM)(all,s,SRC)(all,d,DST)
        TRADE_R(c,s,d) = sum{r,ORG, TRADE(c,s,r,d)};
    (all,c,COM)(all,s,SRC)
        TRADE_RD(c,s)  = sum{r,ORG, TRADE_D(c,s,r)};

!*************************************************************
*************!
!Section 5.9 Formulas used for defining
!
!Sectoral contributions to regional GDP at factor cost
!
!*************************************************************
*************!

Formula
    (all,d,DST)
        PRIM_I(d) = sum{i,IND, PRIM(i,d)};
    (initial)(all,d,DST)
        RATIOPRIM_I(d) = 1;
    (all,i,IND)(all,d,DST)
        PRIMSHR(i,d) = PRIM(i,d)/PRIM_I(d);

    (all,o,OCC)(all,d,DST)
        LAB_I(o,d) = sum{i,IND, LAB(i,o,d)};
    (all,d,DST)
        LAB_IO(d) = sum{o,OCC, LAB_I(o,d)};
    (all,d,DST)
        LND_I(d) = sum{i,IND, LND(i,d)};
    (all,d,DST)
        CAP_I(d) = sum{i,IND, CAP(i,d)};
    (all,o,OCC)
        LAB_ID(o) = sum{d,DST, LAB_I(o,d)};
```

```
    (all,i,IND)(all,o,OCC)(all,d,DST)
        SLAB_I(i,o,d) = LAB(i,o,d)/LAB_I(o,d);
    (all,o,OCC)(all,d,DST)
        SLAB_ID(o,d) = LAB_I(o,d)/LAB_ID(o);

!*************************************************************
*************!
!Section 5.10 Formulas for GDP aggregates
!
!*************************************************************
*************!
! Nominal Income-side GDP !

Set GDPINCCAT # GDP income categories # (Land,Labour,Capi-
tal,PRODTAX,ComTax);
Coefficient
    (all,i,GDPINCCAT)(all,d,DST) GDPINCSUM(d,i)# Income GDP
breakdown #;
Formula
    (all,i,GDPINCCAT)(all,d,DST) GDPINCSUM(d,i) = 0;
    (all,d,DST) GDPINCSUM(d,"Land")    = LND_I(d);
    (all,d,DST) GDPINCSUM(d,"Labour")  = LAB_IO(d);
    (all,d,DST) GDPINCSUM(d,"Capital") = CAP_I(d);
    (all,d,DST) GDPINCSUM(d,"ProdTax") =
sum{i,IND,PRODTAX(i,d)};
    (all,d,DST) GDPINCSUM(d,"ComTax")  =
              sum{u,USR, sum{c,COM,sum{s,SRC,TAX(c,s,u,d)}}};
Write GDPINCSUM to file SUMMARY header "GNSM";

Coefficient (all,d,DST) GDPINC(d)# Income GDP #;
Formula     (all,d,DST) GDPINC(d) = sum{i,GDPINCCAT,
GDPINCSUM(d,i)};

Set GDPEXPCAT (HOU, INV, GOV, STOCKS, EXP, Imports, RExports,
RImports, NetMar);
Subset FINDEM is subset of GDPEXPCAT;
Coefficient
    (all,i,GDPEXPCAT)(all,q,DST) GDPEXPSUM(q,i) # Expend GDP
breakdown#;
Formula
    (all,i,GDPEXPCAT)(all,q,DST) GDPEXPSUM(q,i) = 0;
    (all,q,DST)(all,f,FINDEM) GDPEXPSUM(q,f) = sum{c,COM,
PUR_S(c,f,q)};
    (all,q,DST) GDPEXPSUM(q,"Stocks") = sum{i,IND,
STOCKS(i,q)};
    (all,q,REG) GDPEXPSUM(q,"Imports") =
```

```
        - sum{c,COM, sum{d,DST, TRADE(c,"imp",q,d)}};
    (all,q,REG) GDPEXPSUM(q,"NetMar") = sum{m,MAR, sum{r,ORG,
        SUPPMAR_D(m,r,q) - SUPPMAR_P(m,r,q) }};
    (all,q,REG) GDPEXPSUM(q,"Rexports") =
        sum{c,COM,sum{s,SRC, TRADE_D(c,s,q) - TRADE(c,s,q,q)}};
    (all,q,REG) GDPEXPSUM(q,"Rimports") =
        - sum{c,COM,sum{s,SRC, TRADE_R(c,s,q) -
TRADE(c,s,q,q)}};

Write GDPEXPSUM to file SUMMARY header "GESM";

Coefficient (all,d,DST) GDPEXP(d)# Expenditure GDP #;
Formula     (all,d,DST) GDPEXP(d) = sum{i,GDPEXPCAT, GDPEXP-
SUM(d,i)};

!Expenditure side GDP       !

Set NATGDPEXPCAT (HOU, INV, GOV, STOCKS, EXP, Imports);
Subset NATGDPEXPCAT is subset of GDPEXPCAT;
Subset FINDEM is subset of NATGDPEXPCAT;

Coefficient
    (all,i,NATGDPEXPCAT) NATGDPEXPSUM(i) # Expend GDP break-
down#;
Formula
    (all,i,NATGDPEXPCAT) NATGDPEXPSUM(i)=sum{q,DST, GDPEXP-
SUM(q,i)};
Write NATGDPEXPSUM to file SUMMARY header "NGSM";

Coefficient NATGDPEXP # Expenditure GDP #;
Formula     NATGDPEXP = sum{d,DST, GDPEXP(d)};

Coefficient  RATIONGDPEXP# (Current/initial) real expenditure
GDP#;
Formula  (initial) RATIONGDPEXP = 1;

! Investment ratio summary -- identify outlying INV/RENTAL ra-
tios !

Formula
    (all,r,REGPLUS)(all,i,INDPLUS)(all,z,INVFACT)
INVFACTS(r,i,z) = 0;
    (all,r,REG)(all,i,IND) INVFACTS(r,i,"Invest") = IN-
VEST_C(i,r);
    (all,r,REG)(all,i,IND) INVFACTS(r,i,"CapRental") =
CAP(i,r);
    (all,r,REG)(all,i,IND) INVFACTS(r,i,"Output") = VTOT(i,r);
```

```
    (all,i,IND)(all,z,INVFACT) INVFACTS_r(i,z) = sum{r,REG,
INVFACTS(r,i,z)};
    (all,i,IND)(all,z,INVFACT) INVFACTS("National",i,z) =
INVFACTS_r(i,z);
    (all,r,REGPLUS)(all,z,INVFACT) INVFACTS_I(r,z) =
        sum{i,IND, INVFACTS(r,i,z)};
    (all,r,REGPLUS)(all,z,INVFACT) INVFACTS(r,"TotalInds",z) =
INVFACTS_I(r,z);
    (all,r,REGPLUS)(all,i,INDPLUS) INVFACTS(r,i,"InvOverCap") =
        INVFACTS(r,i,"Invest")/ID01[INVFACTS(r,i,"CapRental")];
    (all,r,REGPLUS)(all,i,INDPLUS) INVFACTS(r,i,"InvOverOut") =
        INVFACTS(r,i,"Invest")/ID01[INVFACTS(r,i,"Output")];
 Write INVFACTS to file SUMMARY header "INVF";

! Regional macro reporting variables !

Formula
    (all,s,SRC)(all,d,DST)
        TRADE_CR(s,d) = sum{c,COM, TRADE_R(c,s,d)};
    (all,d,DST)
        IMPUSED_C(d) = TRADE_CR("imp",d);
    (all,r,ORG)
        IMPLANDED_C(r) = sum{c,COM, TRADE_D(c,"imp",r)};

!***********************************************************
***************!
!Section 5.11 Formulas used for defining national aggeragates
!
!Aggregation of regional to national industry output -- value
added weights    !
!***********************************************************
***************!

Formula
    (all,i,IND)
        PRIM_D(i) = sum{d,DST, PRIM(i,d)};
    (initial)(all,i,IND)
        RATIOPRIM_D(i) = 1;
    (all,c,COM)
        MAKE_IR(c) = sum{r,REG, MAKE_I(c,r)};

!National price and employment variables !
    (all,i,IND)
        NATVTOT(i) = sum{d,DST,VTOT(i,d)};
    (all,i,IND)
        LAB_OD(i)  = sum{d,DST,LAB_O(i,d)};
```

```
!*************************************************************
**************!
!Section 5.12 Check of accounting identities
!
!*************************************************************
**************!

Zerodivide default 1;

Coefficient
    EP # Tiny value #;
    (all,i,IND)(all,d,DST) CHECKA(i,d) # Net Output - MAKE_C #;
    (all,i,IND)(all,d,DST) CKRATA(i,d) # Net Output / MAKE_C #;

Formula
    EP=0.00001;
    (all,i,IND)(all,d,DST)
        CHECKA(i,d) = VTOT(i,d) - STOCKS(i,d) - MAKE_C(i,d);
    (all,i,IND)(all,d,DST)
        CKRATA(i,d) = [EP + VTOT(i,d) - STOCKS(i,d)]/[EP +
MAKE_C(i,d)];
Write
    MAKE_C to file SUMMARY header "MAKC";
    STOCKS to file SUMMARY header "STOK";
    CHECKA to file SUMMARY header "CHKA";
    CKRATA to file SUMMARY header "CKRA";

Coefficient
    (all,c,COM)(all,s,SRC)(all,d,DST) CHECKB(c,s,d) # USE_U -
DELIVRD_R #;
    (all,c,COM)(all,s,SRC)(all,d,DST) CKRATB(c,s,d) # USE_U /
DELIVRD_R #;

Formula
    (all,c,COM)(all,s,SRC)(all,d,DST)
        CHECKB(c,s,d) = USE_U(c,s,d) - DELIVRD_R(c,s,d);
    (all,c,COM)(all,s,SRC)(all,d,DST)
        CKRATB(c,s,d) = [EP + USE_U(c,s,d)]/[EP + DE-
LIVRD_R(c,s,d)];
Write
    USE_U  to file SUMMARY header "USEU";
    DELIVRD_R  to file SUMMARY header "DVDR";
    CHECKB to file SUMMARY header "CHKB";
    CKRATB to file SUMMARY header "CKRB";

Coefficient
    (all,c,COM)(all,r,REG) CHECKC(c,r) # MAKE_I - demands #;
```

```
    (all,c,COM)(all,r,REG) CKRATC(c,r) # MAKE_I / demands #;
    (all,c,COM)(all,r,REG) DEMANDS(c,r) # Demands #;
Formula
    (all,c,COM)(all,r,REG)
        DEMANDS(c,r) = TRADE_D(c,"dom",r);
    (all,m,MAR)(all,r,REG)
        DEMANDS(m,r) = DEMANDS(m,r) + SUPPMAR_RD(m,r);
    (all,c,COM)(all,r,REG)
        CHECKC(c,r) = MAKE_I(c,r) - DEMANDS(c,r);
    (all,c,COM)(all,r,REG)
        CKRATC(c,r) = [EP + MAKE_I(c,r)]/[EP + DEMANDS(c,r)];
Write
    CHECKC to file SUMMARY header "CHKC";
    CKRATC to file SUMMARY header "CKRC";
    MAKE_I to file SUMMARY header "MAKI";
    DEMANDS to file SUMMARY header "DMDS";

Coefficient
    (all,m,MAR)(all,r,ORG)(all,d,DST) CHECKD(m,r,d) #
TRADMAR_CS - SUPPMAR_P #;
    (all,m,MAR)(all,r,ORG)(all,d,DST) CKRATD(m,r,d) #
TRADMAR_CS / SUPPMAR_P #;
Formula
    (all,m,MAR)(all,r,ORG)(all,d,DST)
        CHECKD(m,r,d) = TRADMAR_CS(m,r,d) - SUPPMAR_P(m,r,d);
    (all,m,MAR)(all,r,ORG)(all,d,DST)
        CKRATD(m,r,d) = [EP + TRADMAR_CS(m,r,d)]/[EP + SUPP-
MAR_P(m,r,d)];
Write
    TRADMAR_CS to file SUMMARY header "TMCS";
    SUPPMAR_P  to file SUMMARY header "SPMP";
    CHECKD     to file SUMMARY header "CHKD";
    CKRATD     to file SUMMARY header "CKRD";

Coefficient
    (all,c,COM)(all,d,DST) CHECKE(c,d) # INVEST_I - PUR_S(inv)
#;
    (all,c,COM)(all,d,DST) CKRATE(c,d) # INVEST_I / PUR_S(inv)
#;
Formula
    (all,c,COM)(all,d,DST)
        CHECKE(c,d) = INVEST_I(c,d) - PUR_S(c,"Inv",d);
    (all,c,COM)(all,d,DST)
        CKRATE(c,d) = [EP + INVEST_I(c,d)]/[EP +
PUR_S(c,"Inv",d)];
Write
    INVEST_I to file SUMMARY header "INVI";
```

```
    PUR_S     to file SUMMARY header "PURS";
    CHECKE    to file SUMMARY header "CHKE";
    CKRATE    to file SUMMARY header "CKRE";
Zerodivide off;

Set CONSTRAINTS (A,B,c,d,e);
Coefficient
    (all,c,CONSTRAINTS) SUMABS(c) # Sum absolute errors #;
Formula
    SUMABS("A") = sum{i,IND, sum{d,DST,
ABS[CHECKA(i,d)]}};
    SUMABS("B") = sum{c,COM, sum{s,SRC, sum{d,DST,
ABS[CHECKB(c,s,d)]}}};
    SUMABS("C") = sum{c,COM, sum{r,REG,
ABS[CHECKC(c,r)]}};
    SUMABS("D") = sum{m,MAR, sum{r,ORG, sum{d,DST,
ABS[CHECKD(m,r,d)]}}};
    SUMABS("E") = sum{c,COM, sum{d,DST,
ABS[CHECKE(c,d)]}};
Write
    SUMABS to file SUMMARY header "SMAB";

!****************************************************************
***************!
!Section 5.13 Formulas used for defining trade flows!
!****************************************************************
***************!

!Trade elasticities!
Formula
    (all,c,COM)(all,e,ELSTRAD)
        TRADELAST(c,e) = 0;
    (all,c,COM)
        TRADELAST(c,"EXP_ELAST")    = EXP_ELAST(c);
    (all,c,COM)
        TRADELAST(c,"SIGMADOMIMP") = SIGMADOMIMP(c);
    (all,c,COM)
        TRADELAST(c,"SIGMADOMDOM") = SIGMADOMDOM(c);
Write
    TRADELAST to file SUMMARY header "TREL";

!Foreign trade!
Formula
    (all,c,COM)(all,r,ORG)(all,d,DST)
        ROWDEM(c,r,d) =

TRADE(c,"dom",r,d)*USE(c,"dom","Exp",d)/ID01[USE_U(c,"dom",d)];
```

```
    (all,c,COM)(all,r,ORG)
        ROWDEM_D(c,r) = sum{d,DST, ROWDEM(c,r,d)};
    (all,c,COM)(all,r,REG)
        EXPSHR(c,r) = ROWDEM_D(c,r)/ID01[MAKE_I(c,r)];
Write
    ROWDEM to file SUMMARY header "ROWD";
    EXPSHR to file SUMMARY header "SHXP";

!Domestic trade flows!
Formula
    (all,c,COM)(all,r,REG)
        VDOMEXP(c,r) = sum{d,DST, TRADE(c,"dom",r,d)} -
TRADE(c,"dom",r,r);
    (all,c,COM)(all,d,REG)
        VDOMIMP(c,d) = sum{r,ORG, TRADE(c,"dom",r,d)} -
TRADE(c,"dom",d,d);
    (all,r,REG)
        VDOMEXP_C(r) = sum{c,COM,VDOMEXP(c,r)};
    (all,d,REG)
        VDOMIMP_C(d) = sum{c,COM,VDOMIMP(c,d)};
Write
    VDOMEXP to file SUMMARY header "VDEX";
    VDOMIMP to file SUMMARY header "VDIM";

!**************************************************************
***************!
!Section 5.14 Summary files!
!**************************************************************
***************!

! Local use for summary file !
Coefficient
    (all,c,COM)(all,s,SRC)(all,m,MAINUSR)(all,d,DST)
        VMAINUSE(c,s,m,d) # Simplified USE matrix #;
Formula
    (all,c,COM)(all,s,SRC)(all,d,DST)
        VMAINUSE(c,s,"int",d) = sum{i,IND, USE(c,s,i,d)};
    (all,c,COM)(all,s,SRC)(all,m,FINDEM)(all,d,DST)
        VMAINUSE(c,s,m,d) = USE(c,s,m,d);
Write
    VMAINUSE to file SUMMARY header "VMNU";

! Local (and other) sales table for summary file !
Coefficient
    (all,c,COM)(all,s,SRC)(all,r,REG)
        LOCSHR(c,s,r) # Share local-made basic in direct use
(delivered) #;
```

```
Formula
    (all,c,COM)(all,s,SRC)(all,r,REG)
        LOCSHR(c,s,r) = TRADE(c,s,r,r)/ID01[USE_U(c,s,r)];
Write
    LOCSHR to file SUMMARY header "LCSR";

Coefficient
    (all,c,COM)(all,s,SRC)(all,r,REG)
        LOCSHR_R(c,s,r) # Share basic in delivered #;
Formula
    (all,c,COM)(all,s,SRC)(all,r,REG)
        LOCSHR_R(c,s,r) = TRADE_R(c,s,r)/ID01[USE_U(c,s,r)];
Write
    LOCSHR_R to file SUMMARY header "LCRR";

Set
    MAINDEST # Main destinations #  (INT, HOU, INV, GOV, MAR,
OthReg, RowEXP);
    MAINDESTX # Local direct main destinations #  (INT, HOU,
INV, GOV);
Subset  MAINDESTX is subset of MAINDEST;
Subset  MAINDESTX is subset of MAINUSR;

Coefficient
    (all,c,COM)(all,r,REG)(all,d,MAINDEST)
        VMAINDEST(c,r,d) # Main uses of dom com c made in r #;
Formula
    (all,c,COM)(all,r,REG)(all,d,MAINDEST)
        VMAINDEST(c,r,d) = 42;
    (all,c,COM)(all,r,REG)(all,d,MAINDESTX)
        VMAINDEST(c,r,d) = LOC-
SHR(c,"dom",r)*VMAINUSE(c,"dom",d,r);
    (all,c,NONMAR)(all,r,REG)
        VMAINDEST(c,r,"MAR") = 0;
    (all,m,MAR)(all,p,REG)
        VMAINDEST(m,p,"MAR") = sum{r,ORG, sum{d,DST, SUPP-
MAR(m,r,d,p)}};
    (all,c,COM)(all,r,REG)
        VMAINDEST(c,r,"OthReg") = TRADE_D(c,"dom",r) -
TRADE(c,"dom",r,r);
    (all,c,COM)(all,r,REG)
        VMAINDEST(c,r,"RowEXP") = LOC-
SHR(c,"dom",r)*USE(c,"dom","Exp",r);
Write
    VMAINDEST to file SUMMARY header "VMDS";

Coefficient
```

```
    (all,c,COM)(all,d,DST) CHECKDEST(c,d) # Check -- should be
tiny #;
Formula
    (all,c,COM)(all,d,DST)
        CHECKDEST(c,d) = 42;
    (all,c,COM)(all,d,REG)
        CHECKDEST(c,d) = MAKE_I(c,d) - sum{q,MAINDEST,
VMAINDEST(c,d,q)};
Write
    CHECKDEST to file SUMMARY header "CDST";

Coefficient
    (all,c,COM)(all,d,MAINDEST)
        NATMAINDEST(c,d) # Main uses of dom com c nationally #;
Formula
    (all,c,COM)(all,d,MAINDEST)
        NATMAINDEST(c,d) = 42;
    (all,c,COM)(all,d,MAINDESTX)
        NATMAINDEST(c,d) =
        sum{r,REG, LOCSHR_R(c,"dom",r)*VMAINUSE(c,"dom",d,r)};
    (all,c,NONMAR)
        NATMAINDEST(c,"MAR") = 0;
    (all,m,MAR)
        NATMAINDEST(m,"MAR") = sum{p,REG,
VMAINDEST(m,p,"MAR")};
    (all,c,COM)
        NATMAINDEST(c,"OthReg") = 0;
    (all,c,COM)
        NATMAINDEST(c,"RowEXP") =
        sum{r,REG, LOC-
SHR_R(c,"dom",r)*VMAINUSE(c,"dom","EXP",r)};
Write
    NATMAINDEST to file SUMMARY header "NMDS";

Coefficient
    (all,c,COM)(all,d,MAINDEST) DIFFDEST(c,d);
Formula
    (all,c,COM)(all,d,MAINDEST)
        DIFFDEST(c,d) = sum{r, REG,VMAINDEST(c,r,d)} - NAT-
MAINDEST(c,d);
Write
    DIFFDEST to file SUMMARY header "DDST";


Coefficient
    (all,d,DST)(all,f,FINDEM) RATFINPUR(f,d);
Formula
```

```
    (all,d,DST)(all,f,FINDEM)
        RATFINPUR(f,d) = PUR_CS(f,d);
Write
    RATFINPUR to file SUMMARY header "FPUR" longname "final de-
mands, pur value";
Formula
    (all,d,DST)(all,f,FINDEM)
        RATFINPUR(f,d) = RATFINPUR(f,d)/PRIM_I(d);
Write
    RATFINPUR to file SUMMARY header "RPUR"
    longname "[final demands, pur value]/reg gdp";

! Calculation of Macros for broad regions (optional, but useful
for Brazil)
Set AGGREG # Broad regions # read elements from file REGSUPP
header "AREG";
Mapping MAPREG from REG to AGGREG;
Read (by_elements) MAPREG from file REGSUPP header "MREG";
Variable (all,m,MAINMACROS)(all,A,AGGREG) ZoneMacro(m,A) #
Broad region macros#;
Equation E_ZoneMacro (all,m,MAINMACROS)(all,A,AGGREG)
sum{q,REG:MAPREG(q)=A, WMAINMACRO(m,q)*[ZoneMacro(m,A)-Main-
Macro(m,q)]} = 0;!

!*************************************************************
***************!
!Section 5.15 Formulas for public sectors!
!*************************************************************
***************!

Formula

    (all,d,DST)
        EMP_RATE(d) = EMPLOYS(d)/LAB_SUP(d);
    (all,i,IND)(all,d,DST)(all,s,PSEC)
        COL_PAYROLLS(i,d,s) =
        [LAB_O(i,d)/POW_PAYROLL(i,d)]*[POW_PAYROLLS(s,i,d) -
1];
    (all,d,DST)(all,s,PSEC)
        COL_PAYRTOTS(d,s) = sum{i,IND,COL_PAYROLLS(i,d,s)};
    (all,d,DST)(all,s,PSEC)
        TAXS_LAB(d,s) =
        TAXS_L_RATE(s,d)*[LAB_IO(d) -
sum{p,PSEC,COL_PAYRTOTS(d,p)}];
    (all,d,DST)(all,s,PSEC)
        TAXS_CAP(d,s) = TAXS_K_RATE(s,d)*CAP_I(d);
    (all,d,DST)(all,s,PSEC)
```

```
        TAXS_LND(d,s) = TAXS_K_RATE(s,d)*LND_I(d);
    (all,d,DST)(all,s,PSEC)
        TAXS_AB(d,s) = TAXS_AB_RATE(s,d)*sum{z,PSEC,AGE-
BENS(z,d)};
    (all,d,DST)(all,s,PSEC)
        TAXS_OB(d,s) = TAXS_OB_RATE(s,d)*sum{z,PSEC,OTH-
BENS(z,d)};
    (all,d,DST)(all,s,PSEC)
        TAXS_UB(d,s) = TAXS_UB_RATE(s,d)*sum{z,PSEC,UNEMP-
BENS(z,d)};

    (all,d,DST)
        TAXINT(d) = sum{c,COM, sum{s,SRC, sum{i,IND,
TAX(c,s,i,d)}}};
    (all,d,DST)
        TAXHOU(d) = sum{c,COM, sum{s,SRC, TAX(c,s,"hou",d)}};
    (all,d,DST)
        TAXINV(d) = sum{c,COM, sum{s,SRC, TAX(c,s,"inv",d)}};
    (all,d,DST)
        TAXGOV(d) = sum{c,COM, sum{s,SRC, TAX(c,s,"gov",d)}};
    (all,d,DST)
        TAXEXP(d) = sum{c,COM, sum{s,SRC, TAX(c,s,"exp",d)}};
    (all,d,DST)
        TAXPROD(d) = sum{i,IND, PRODTAX(i,d)};

    (all,d,DST)
        TAX_CSI(d) = TAXINT(d) + TAXINV(d) + TAXHOU(d) +
TAXGOV(d) +
        TAXEXP(d) + TAXPROD(d);
    (all,d,DST)(all,s,PSEC)
        V0TAX_CSIS(d,s) = 0;
    (all,d,DST)
        V0TAX_CSIS(d,"S1311") = TAX_CSI(d);

    (all,d,DST)(all,s,PSEC)
        INCTAXS(d,s) =
        TAXS_LAB(d,s) + TAXS_CAP(d,s) + TAXS_LND(d,s) +
TAXS_AB(d,s) +
        TAXS_OB(d,s) + TAXS_UB(d,s);

    (all,d,DST)(all,s,PSEC)
        NET_TAXTOTS(d,s) = V0TAX_CSIS(d,s) + INCTAXS(d,s) +
COL_PAYRTOTS(d,s);

    (initial)
        LEV_CPI_B     = LEV_CPI;
    (initial)
```

```
        LEV_CPI_L_B  = LEV_CPI_L;
        INF = LEV_CPI/LEV_CPI_L -1;
        RINT_PSD = RINT;

    (all,d,DST)
        V1PRIM_I(d)  = LAB_IO(d) + CAP_I(d) + LND_I(d);
    (all,d,DST)
        V0GDPINC(d)  = V1PRIM_I(d) + TAX_CSI(d) !+ V1OCT_I !;

Write
    V0GDPINC to file SUMMARY header "V0GI";



Coefficient
    (all,d,DST)(all,i,IND) V2SHRSG_S_(d,i);
    (all,d,DST)(all,i,IND) V2SHRSG_S(d,i);
Formula
    (all,d,DST)(all,i,IND)
        V2SHRSG_S_(d,i) = sum{s,PSEC, V2TOTSG_(d,i,s)}/
        ID01[sum{c,COM, INVEST(c,i,d)}];
    (all,d,DST)(all,i,IND)
        V2SHRSG_S(d,i) =
        if[V2SHRSG_S_(d,i)<1, V2SHRSG_S_(d,i)] +
        if[V2SHRSG_S_(d,i)>1, 1];
    (all,d,DST)(all,i,IND)(all,s,PSEC)
        V2SHRSG(d,i,s) = V2TOTSG_(d,i,s)/ID01[sum{z,PSEC,
V2TOTSG_(d,i,z)}];
    (all,d,DST)(all,i,IND)(all,s,PSEC)

        V2SHRSG_(d,i,s) = V2SHRSG(d,i,s)*V2SHRSG_S(d,i);
    (all,d,DST)(all,s,PSEC)
        V2TOT_G_IS(d,s) = sum{i,IND, V2SHRSG_(d,i,s)*sum{c,COM,
INVEST(c,i,d)}};
    (initial)(all,d,DST)(all,s,PSEC)
        OTHCAPGOVS(s,d) =
        OTHCAPGOVS_(s,d) + sum{i,IND, V2TOTSG_(d,i,s)} -
V2TOT_G_IS(d,s);


    (all,d,DST)(all,c,COM)(all,s,PSEC)
        V5SHRS_(d,c,s) =
            if[sum{ss,PSEC, V5TOTS_(d,c,ss)}=0,
                sum{cc,COM, V5TOTS_(d,cc,s)}/
                sum{cc,COM, sum{h,PSEC, V5TOTS_(d,cc,h)}}] +
            if[sum{ss,PSEC, V5TOTS_(d,c,ss)}>0,
                V5TOTS_(d,c,s)/sum{h,PSEC, V5TOTS_(d,c,h)}];
```

```
    (all,d,DST)(all,c,COM)(all,s,PSEC)
        V5TOT(d,c,s) = V5SHRS_(d,c,s)*sum{z,SRC,
PUR(c,z,"gov",d)};
    (all,d,DST)(all,s,PSEC)
        V5TOTS(d,s) = sum{c,COM, V5TOT(d,c,s)};
    (all,d,DST)(all,c,COM)(all,r,SRC)(all,s,PSEC)
        V5TOTR(d,c,r,s) = SRCSHR(c,r,"gov",d)*V5TOT(d,c,s);
    (all,d,DST)(all,c,COM)(all,r,SRC)(all,s,PSEC)
        SCRSHR5(d,c,r,s) = V5TOTR(d,c,r,s)/ID01[V5TOT(d,c,s)];
!Zerodivide off;!
    (all,d,DST)(all,s,PSEC)
        PSDATTPLUS1(d,s) =
        [
            PSDATT(s,d)*[1+INT_PSD/2] + V5TOTS(d,s) +
V2TOT_G_IS(d,s) +
            OTHCAPGOVS(s,d) - NET_TAXTOTS(d,s) - OTHGOV-
REVS(s,d) +
            UNEMPBENS(s,d) + AGEBENS(s,d) + OTHBENS(s,d) +
GRANTSS(s,d) +
            if[s eq "S1313", MUNTOGOV(d) - GOVTOMUN(d)] +
            if[s eq "S1311", GOVTOMUN(d) - MUNTOGOV(d) +
GOVTOSSF(d) -
                SSFTOGOV(d)]
        ]/[1-INT_PSD/2];

    (initial)(all,d,DST)(all,s,PSEC)
        NETINTS_G(s,d) = INT_PSD*[PSDATT(s,d) + PSDATT-
PLUS1(d,s)]/2;

Coefficient
    (all,s,PSEC) NETINTS_GD(s);
Formula
    (all,s,PSEC)
        NETINTS_GD(s) = INT_PSD*sum{d,DST, PSDATT(s,d) +
PSDATTPLUS1(d,s)}/2;

Coefficient
    (parameter)(all,d,DST) SHRASS_H(d);
Read
    SHRASS_H from file EXTRA header "SHRA";
Formula
    (all,d,DST)(all,s,PSEC)
        NETINTS_HS(d,s) = SHRASS_H(d)*NETINTS_GD(s);
    (initial)(all,d,DST)(all,s,PSEC)
        PSDATT_B(d,s) = PSDATT(s,d);
    (initial)(all,d,DST)(all,s,PSEC)
        PSDATT_1_B(d,s) = PSDATTPLUS1(d,s);
```

```
!TRANSFERS from public sectors to consumer!
    (all,d,DST)(all,s,PSEC)
        TRANSS_G(d,s) = UNEMPBENS(s,d) + AGEBENS(s,d) + OTH-
BENS(s,d) +
        GRANTSS(s,d) + NETINTS_G(s,d);
    (all,d,DST)(all,s,PSEC)
        TRANSS_H(d,s) = UNEMPBENS(s,d) + AGEBENS(s,d) + OTH-
BENS(s,d) +
        GRANTSS(s,d) + NETINTS_HS(d,s);
    (all,d,DST)(all,s,PSEC)
        GOV_DEFS(d,s) =
            V5TOTS(d,s) + V2TOT_G_IS(d,s) + OTHCAPGOVS(s,d) -
            NET_TAXTOTS(d,s) - OTHGOVREVS(s,d) + TRANSS_G(d,s)
+
            if(s eq "S1313",MUNTOGOV(d)) - if(s eq
"S1313",GOVTOMUN(d)) +
            if(s eq "S1311",GOVTOMUN(d)) + if(s eq
"S1311",GOVTOSSF(d)) -
            if(s eq "S1311",MUNTOGOV(d)) - if(s eq
"S1311",SSFTOGOV(d))
        ;

        TAX_CAP = sum{d,DST, sum{s,PSEC, TAXS_CAP(d,s)}};
        TAX_K_RATE = TAX_CAP/sum{d,DST, CAP_I(d)};
    (initial)
        TAX_L_RATE = sum{s,PSEC, sum{d,DST, TAXS_LAB(d,s)}}/
        sum{d,DST, LAB_IO(d) - sum{s,PSEC, COL_PAYRTOTS(d,s)}};
    (initial)
        TAX_L_RATE_O = TAX_L_RATE;
    (initial)
        TAX_L_RATE_L = TAX_L_RATE;
    (initial)
        TAX_L_RATE_O = TAX_L_RATE;
    (initial)
        TAX_L_R_O_L = TAX_L_RATE;


!************************************************************
***************!
!Section 5.16 Formulas used for defining
 Income and saving aggregates!
!************************************************************
***************!

Coefficient
```

```
            C_A0E  # Foreign assets, equity, start of year #;
            C_A1E  # Foreign assets, equity, end of year #;
(parameter) C_A0E_B  # Foreign assets, equity, start of year,
base #;
(parameter) C_A1E_B  # Foreign assets, equity, end of year,
base #;
            C_A0D  # Foreign assets, debt, start of year #;
            C_A1D  # Foreign assets, debt, end of year #;
(parameter) C_A0D_B   # Foreign assets, debt, start of year,
base  #;
(parameter) C_A1D_B  # Foreign assets, debt, end of year, base
#;
            C_FE # Share of national savings devoted to foreign
equity assets #;
            C_FD # Share of national savings devoted to foreign
debt assets #;
            C_INTAD # Interest on foreign assets, debt #;
            C_INTAE # Interest on foreign assets, equity #;
            C_INTLD # Interest on foreign liabilities, debt #;
            C_INTLE # Interest on foreign liabilities, equity
#;
            C_L0E  # Foreign liabilities, equity, start of year
#;
            C_L1E  # Foreign liabilities, equity, end of year
#;
(parameter) C_L0E_B  # Foreign liabilities, equity, start of
year, base #;
(parameter) C_L1E_B  # Foreign liabilities, equity, end of
year, base #;
            C_L0D  # Foreign liabilities, debt, start of year
#;
            C_L1D  # Foreign liabilities, debt, end of year #;
(parameter) C_L0D_B   # Foreign liabilities, debt, start of
year, base  #;
(parameter) C_L1D_B  # Foreign liabilities, debt, end of year,
base  #;
            C_REVAE # Revaluation factor for foreign equity as-
sets #;
            C_REVAD # Revaluation factor for foreign debt as-
sets #;
            C_REVLE # Revaluation factor for foreign equity li-
abilities #;
            C_REVLD # Revaluation factor for foreign debt lia-
bilities #;

            C_ROIAD # Rate of interest foreign assets, debt #;
            C_ROIAE # Rate of interest foreign assets, equity
```

```
#;
            C_ROILD # Rate of interest foreign liabilities,
debt #;
            C_ROILE # Rate of interest foreign liabilities, eq-
uity #;
            NETTRN # Net transfers, contributes to surplus #;

Read C_A0E      from file BOPACC header "A0E";
Read C_A1E      from file BOPACC header "A1E";
Read C_A0D      from file BOPACC header "A0D";
Read C_A1D      from file BOPACC header "A1D";
Read C_L0E      from file BOPACC header "L0E";
Read C_L1E      from file BOPACC header "L1E";
Read C_L0D      from file BOPACC header "L0D";
Read C_L1D      from file BOPACC header "L1D";
Read C_REVAE    from file BOPACC header "RAE";
Read C_REVAD    from file BOPACC header "RAD";
Read C_REVLD    from file BOPACC header "RLD";
Read C_REVLE    from file BOPACC header "RLE";
Read C_FE       from file BOPACC header "FE";
Read C_FD       from file BOPACC header "FD";

Read C_INTAD    from file BOPACC header "INAD";
Read C_INTAE    from file BOPACC header "INAE";
Read C_INTLD    from file BOPACC header "INLD";
Read C_INTLE    from file BOPACC header "INLE";
Read C_ROIAD    from file BOPACC header "RIAD";
Read C_ROIAE    from file BOPACC header "RIAE";
Read C_ROILD    from file BOPACC header "RILD";
Read C_ROILE    from file BOPACC header "RILE";

Read NETTRN     from file BOPACC header "NTRN";


Formula
(initial) ADJDUMYEAR1 = 0.0 + if[DUM_YEAR1 lt 0.1, 1.0];
(initial) C_ROIAD = [1 - DUM_YEAR1]*C_INTAD/C_A0D +
DUM_YEAR1*C_ROIAD;
(initial) C_ROIAE = [1 - DUM_YEAR1]*C_INTAE/C_A0E +
DUM_YEAR1*C_ROIAE;
(initial) C_ROILD = [1 - DUM_YEAR1]*C_INTLD/C_L0D +
DUM_YEAR1*C_ROILD;
(initial) C_ROILE = [1 - DUM_YEAR1]*C_INTLE/C_L0E +
DUM_YEAR1*C_ROILE;

Formula
    (all,d,DST)
```

```
        HOUS_DIS_INC(d) = GDPEXP(d) +
        sum{s,PSEC,TRANSS_H(d,s) - NET_TAXTOTS(d,s) - OTHGOV-
REVS(s,d)} +
        SHRASS_H(d)*[C_INTAD + C_INTAE - C_INTLD - C_INTLE];
    (all,d,DST)
        V3TOT(d) = PUR_CS("Hou",d);
(all,d,DST)
        HOUS_SAV(d) = HOUS_DIS_INC(d) - V3TOT(d);
(all,d,DST)
    AV_PROP_CON(d) = V3TOT(d)/HOUS_DIS_INC(d);

Coefficient
    HOUS_DISINCD;
    HOUS_SAV_D;
    GOV_DEF_D;
    PSDATT_D;
    TRANS_D;
    NET_TAXTOTGD;
    OTHGOVREVD;
    NAT_SAV;
    NAT_PROP_CON;
    V0GDPEXP;
    V2TOT_G_I_D;
    OTHCAPGOVD;
    V3TOT_D;
    V4TOT_D;
    V0IMP_C_D;
    VCAB;
    VBOT;
    GNP;

Formula
        TRANS_D = sum{d,DST, sum{s,PSEC, TRANSS_G(d,s)}};
        NET_TAXTOTGD = sum{d,DST, sum{s,PSEC, NET_TAX-
TOTS(d,s)}};
        OTHGOVREVD = sum{d,DST, sum{s,PSEC, OTHGOVREVS(s,d)}};
        OTHCAPGOVD = sum{d,DST, sum{s,PSEC, OTHCAPGOVS(s,d)}};
        V2TOT_G_I_D = sum{d,DST, sum{s,PSEC, V2TOT_G_IS(d,s)}};
        GOV_DEF_D = sum{d,DST, sum{s,PSEC, GOV_DEFS(d,s)}};
        PSDATT_D     =sum(d,DST,sum(s,PSEC,PSDATT(s,d)));
        V0GDPEXP = sum{d,DST, GDPEXP(d)};
        V3TOT_D = sum{d,DST, V3TOT(d)};
        HOUS_SAV_D = sum{d,DST, HOUS_SAV(d)};
    (all,d,DST)
        AV_PROP_CON(d) = V3TOT(d)/HOUS_DIS_INC(d);
        V4TOT_D = sum{d,REG, PUR_CS("exp",d)};
        V0IMP_C_D = sum{d,REG, IMPLANDED_C(d)};
```

```
        HOUS_DISINCD = V0GDPEXP + TRANS_D - NET_TAXTOTGD - OTH-
GOVREVD +
            C_INTAD + C_INTAE - C_INTLD - C_INTLE;
        HOUS_SAV_D = HOUS_DISINCD - V3TOT_D;
    (initial)
        NAT_PROP_CON = V3TOT_D/HOUS_DISINCD;
        NAT_SAV = HOUS_SAV_D - GOV_DEF_D + V2TOT_G_I_D +
OTHCAPGOVD;
        NAT_SAV = HOUS_SAV_D - GOV_DEF_D + V2TOT_G_I_D +
OTHCAPGOVD;
        VCAB = V4TOT_D + C_INTAD + C_INTAE - V0IMP_C_D -
C_INTLD - C_INTLE +
            NETTRN;

        VBOT = V4TOT_D  - V0IMP_C_D;


Coefficient
    (parameter) NAT_PROP_C_B;
    (parameter) (all,d,DST) AV_PROP_C_B(d);

Formula
    (initial)
        NAT_PROP_C_B = NAT_PROP_CON;
    (initial)
        (all,d,DST) AV_PROP_C_B(d) = AV_PROP_CON(d);
    (initial)
        C_FE = [1-DUM_YEAR1]*[C_A1E - C_A0E*[1+C_RE-
VAE]]/NAT_SAV +
            DUM_YEAR1*C_FE;
    (initial)
        C_FD = [1-DUM_YEAR1]*[C_A1D - C_A0D*[1+C_RE-
VAD]]/NAT_SAV +
            DUM_YEAR1*C_FD;
    (initial)
        C_REVLE = [1-DUM_YEAR1]*
            [[C_L1E - C_L0E - C_A1E + C_A0E*[1+C_REVAE] - C_A1D
+
                C_A0D*[1+C_REVAD] + C_L1D - C_L0D*[1+C_REVLD] +
VCAB]/C_L0E] +
            DUM_YEAR1*C_REVLE;

    (initial) C_A0E_B = C_A0E;
    (initial) C_A1E_B = C_A1E;
    (initial) C_A0D_B = C_A0D;
    (initial) C_A1D_B = C_A1D;
```

```
    (initial) C_L0E_B = C_L0E;
    (initial) C_L1E_B = C_L1E;
    (initial) C_L0D_B = C_L0D;
    (initial) C_L1D_B = C_L1D;

!National saving!
        GNP = V0GDPEXP + C_INTAD + C_INTAE - C_INTLD - C_INTLE
+ NETTRN;

(initial) R_DEFGDP_B =
sum(d,DST,sum(s,PSEC,GOV_DEFs(d,s)))/V0GDPEXP;
(initial) R_PSDGDP_B =
sum(d,DST,sum(s,PSEC,PSDATT(s,d)))/V0GDPEXP;


!***************************************************************
***************!
!Section 5.17 Formulas used for labour markets!
!***************************************************************
***************!

Formula
        AGGLAB = sum{i,IND, sum{d,DST, LAB_O(i,d)}};
        COL_PAYRTOT = sum{d,DST, sum{s,PSEC,
COL_PAYRTOTS(d,s)}};
    (initial)
        NATEMP_B = NATEMP;
    (initial)
        NATEMP_O_B = NATEMP_OLD;
    (initial)
        FEMPADJ_B = FEMPADJ;
    (initial)
        LAB_SUPN = sum{d,DST, LAB_SUP(d)};
    (initial)
        LAB_SUPN_O = sum{d,DST, LAB_SUP(d)};
        EMP_RATEN = NATEMP/LAB_SUPN;
    (initial)
        RWAGE_B = RWAGE;
    (initial)
        RWAGE_OLD_B = RWAGE_OLD;
        RWAGE_PT = RWAGE*[1 - TAX_L_RATE];
    (initial)
        RWAGE_PT_B = RWAGE_PT;
        RWAGE_PT_OLD = RWAGE_OLD*[1 - TAX_L_RATE_O];
    (initial)
        RWAGE_PT_O_B = RWAGE_PT_OLD;
    (initial)
```

```
        RWAGE_PT_L_B = RWAGE_L_B*[1 - TAX_L_RATE_L];
    (initial)
        RW_PT_O_L_B = RWAGE_O_L_B*[1 - TAX_L_R_O_L];
    (initial)
        FEMPADJ_B = FEMPADJ;

!*****************************************************************
***************!
!Section 5.18 Formulas used for Capital stocks and investment!
!*****************************************************************
***************!

Zerodivide default 0.3333;
Formula
    (initial)
        DIFF = 0.1;
    (all,d,DST)(all,i,IND)
        V2TOT(d,i)=sum{c,COM, INVEST(c,i,d)};
    (all,d,DST)(all,i,IND)
        QCAPATT(d,i) = VCAP_AT_T(d,i)/PCAP_AT_T(d,i);
    (initial)(all,d,DST)(all,i,IND)
        QCAPATT_B(d,i) =  QCAPATT(d,i);
    (all,r,DST)(all,i,IND)
        QINVEST(r,i) =
        sum{d,DST,V2TOT(d,i)}*QCAPATT(r,i)/sum{d,DST,QCA-
PATT(d,i)}/PCAP_I(r,i);
    (initial)(all,d,DST)(all,i,IND)
        QINV_BASE(d,i) = QINVEST(d,i);
    (all,d,DST)(all,i,IND)
        QCAPATTPLUS1(d,i) = QCAPATT(d,i)*[1 - DEP(d,i)] + QIN-
VEST(d,i);
    (all,d,DST)(all,i,IND)
        K_GR(d,i) = QCAPATTPLUS1(d,i)/QCAPATT(d,i) - 1;
    (initial)(all,d,DST)(all,i,IND)
        PCAP_AT_T_B(d,i) = PCAP_AT_T(d,i);
    (initial)(all,d,DST)(all,i,IND)
        PCAP_I_B(d,i) = PCAP_I(d,i);
    (initial)(all,d,DST)(all,i,IND)
        PCAP_I_L_B(d,i) = PCAP_I_L(d,i);
    (initial)(all,d,DST)(all,i,IND)
        PCAP_AT_T1_B(d,i) = PCAP_AT_T1(d,i);
    (initial)(all,d,DST)(all,i,IND)
        PCAP_AT_T_B(d,i) = PCAP_AT_T(d,i);
    (initial)(all,d,DST)(all,i,IND)
        PCAP_I_L_B(d,i) = PCAP_I_L(d,i);
    (initial)(all,d,DST)(all,i,IND)
        PCAP_AT_T1_B(d,i) = PCAP_AT_T1(d,i);
```

```
    (initial)(all,d,DST)(all,i,IND)
        PCAP_I_B(d,i) = DUMMY_DEC*PCAP_I(d,i) + [1 -
DUMMY_DEC]*PCAP_I_B(d,i);
    (all,d,DST)(all,i,IND)
        V1CAP(d,i) = CAP(i,d);
        V1CAP_I = sum{d,DST, sum{i,IND, V1CAP(d,i)}};
Zerodivide off;

Write
    K_GR    to file SUMMARY header "KGR";
    QINVEST to file SUMMARY header "QINV";

!Nominal prices and nominal and real interest rates!
Formula
    (initial)
        ADJDUMYEAR1 = 0.0 + if[DUM_YEAR1 lt 0.1, 1.0];
    (initial)
        LEV_CPI_B = LEV_CPI;
    (initial)
        LEV_CPI_L_B = LEV_CPI_L;
    (initial)
        LEV_PLAB_B = LEV_PLAB;
    (initial)
        LEV_PLAB_L_B = LEV_PLAB_L;
        INF = LEV_CPI/LEV_CPI_L - 1;
        INTR = [1 + RINT]*[1 + INF] - 1;
        RINT_PT_SE = [1 + INTR*[1 - TAX_K_RATE]]/[1 + INF] - 1;
    (all,d,DST)(all,i,IND)
        VCAP_AT_TM(d,i) =
VCAP_AT_T(d,i)*PCAP_I(d,i)/PCAP_AT_T(d,i);
    (all,d,DST)(all,i,IND)
        ROR_SE(d,i) =
        1/[1 + RINT_PT_SE]*
        [[V1CAP(d,i)*[1 - TAX_K_RATE]]/VCAP_AT_TM(d,i) + [1 -
DEP(d,i)] +
        RALPH*TAX_K_RATE*DEP(d,i)] - 1;
    (initial)(all,d,DST)(all,i,IND)
        ROR_SE_BASE(d,i) = ROR_SE(d,i);

!Coefficiencts in investment equations!
Formula
    (initial)(all,d,DST)(all,i,IND)
        K_GR_MIN(d,i) = - DEP(d,i);
    (initial)(all,d,DST)(all,i,IND)
        K_GR_MAX(d,i) = TREND_K(d,i) + DIFF + if[QCAPATT(d,i)
<= 0.00001, 1.0];
    (initial)(all,d,DST)(all,i,IND)
```

```
        COEFF_SL(d,i) = SMURF(d,i)*[K_GR_MAX(d,i) -
K_GR_MIN(d,i)]/
        [[K_GR_MAX(d,i) - TREND_K(d,i)]*[TREND_K(d,i) -
K_GR_MIN(d,i)]];
    (all,d,DST)(all,i,IND)
        CHKGR1(d,i)= 0.0 + if[K_GR_MIN(d,i) >= K_GR(d,i),1.0];
    (all,d,DST)(all,i,IND)
        CHKGR2(d,i)= 0.0 + if[K_GR_MAX(d,i) <= K_GR(d,i),1.0];
    (all,d,DST)(all,i,IND)
        K_GR(d,i) = K_GR(d,i) +
            if[K_GR_MIN(d,i)>=K_GR(d,i), K_GR_MIN(d,i) -
K_GR(d,i) + 0.005] +
            if[K_GR_MAX(d,i)<=K_GR(d,i), K_GR_MAX(d,i) -
K_GR(d,i) - 0.005];

    (initial)
        YEAR_B = YEAR;
    (initial)
        ITER_NUM_B = ITER_NUM;
    (initial)
        ONE_ITER1 = if[ITER_NUM_B=1, 1];
    (initial)
        ONE_IT1_REP = if[ITER_NUM_B=NOFITERS + 2, 1];
    (initial)
        ZERO_PYR1 = 1 + if[ITER_NUM_B>=NOFITERS + 2 and
YEAR_B=YR_POLICY, -1];
    (initial)(all,t,TIME)
        DUM_TIME(t) = 0 + if[YEAR_B=COEFF_TIME(t), 1];
    (initial)(all,t,TIME)
        DUM_TIME_LAG(t) = 0 + if[YEAR_B=COEFF_TIME(t) + 1, 1];
    (initial)
        DUM_IT1 = 0 + if[ITER_NUM_B=1 or ITER_NUM_B=NOFITERS +
2, 1];
    (initial)
        COEFF_NYEAR = 0 + if[YEAR_B<NYEARS, 1];
        INF_L = LEV_CPI_L/LEV_CPI_2L - 1;
        INTR_L = [1+INF_L]*[1+RINT_L] - 1;
    (initial)
        RINT_B = RINT;
    (initial)
        RINT_L_B = RINT_L;
    (initial)
        LEV_CPI_2L_B = LEV_CPI_2L;
    (all,d,DST)(all,i,IND)
        ROR_ACT_L(d,i) = [1/[PCAP_I_L(d,i)*[1+INTR_L*[1-
TAX_K_RATE]]]]*
        [[1-TAX_K_RATE]*[V1CAP(d,i)/QCAPATT(d,i)] + [1-
```

```
DEP(d,i)]*PCAP_I(d,i) +
            RALPH*TAX_K_RATE*DEP(d,i)*PCAP_I(d,i)] - 1;
    (initial)(all,d,DST)(all,j,IND)
        ROR_ACT_L_B(d,j) = ROR_ACT_L(d,j);
    (initial)(all,d,DST)(all,j,IND)(all,t,TIME)
        EROR_G_B(d,j,t) = EROR_G(d,j,t) +
        ZERO_PYR1*DUM_IT1*DUM_TIME_LAG(t)*[ROR_ACT_L_B(d,j) -
EROR_G(d,j,t)];
    (initial)(all,d,DST)(all,j,IND)
        EROR_F(d,j) = sum{t,TIME,DUM_TIME(t)*EROR_G_B(d,j,t)};
    (initial)(all,d,DST)(all,j,IND)
        EROR_B(d,j) =
sum{t,TIME,DUM_TIME_LAG(t)*EROR_G_B(d,j,t)};
    (all,i,IND)(all,d,DST)
        EEQROR(d,i) = RORN(d,i) + F_EEQROR_I(d) + F_EEQROR(d,i)
+
        [1/COEFF_SL(d,i)]*
        [
        [Loge[K_GR(d,i)-K_GR_MIN(d,i)] - Loge[K_GR_MAX(d,i) -
K_GR(d,i)]] -
        [Loge[TREND_K(d,i)-K_GR_MIN(d,i)] - Loge[K_GR_MAX(d,i)
- TREND_K(d,i)]]
        ];
    (initial)(all,d,DST)(all,j,IND)
        DISEQRE_B(d,j) = EROR_B(d,j) - EEQROR(d,j);
    (initial)(all,d,DST)(all,j,IND)
        DISEQSE_B(d,j) = ROR_SE_BASE(d,j) - EEQROR(d,j);
    (initial)(all,d,DST)(all,i,IND)
        K_GR_MIN(d,i) = - DEP(d,i);
    (initial)(all,d,DST)(all,i,IND)
        K_GR_MAX(d,i) = TREND_K(d,i) + DIFF + if[QCAPATT(d,i)
<= 0.00001, 1.0];
    (initial)(all,d,DST)(all,i,IND)
        COEFF_SL(d,i) = SMURF(d,i)*[K_GR_MAX(d,i) -
K_GR_MIN(d,i)]/
        [[K_GR_MAX(d,i) - TREND_K(d,i)]*[TREND_K(d,i) -
K_GR_MIN(d,i)]];
    (all,i,IND)(all,d,DST)
        CHKGR1(d,i) = 0.0 + if[K_GR_MIN(d,i)>=K_GR(d,i), 1.0];
    (all,i,IND)(all,d,DST)
        CHKGR2(d,i) = 0.0 + if[K_GR_MAX(d,i)<=K_GR(d,i), 1.0];
    (all,i,IND)(all,d,DST)
        K_GR(d,i) = K_GR(d,i) +
        if[K_GR_MIN(d,i)>=K_GR(d,i), K_GR_MIN(d,i) - K_GR(d,i)
+ 0.005] +
        if[K_GR_MAX(d,i)<=K_GR(d,i), K_GR_MAX(d,i) - K_GR(d,i)
- 0.005];
```

```
!***************************************************************
***************!
!Section 5.19 Aggregation of regional macro variables to natl
macro variables !
!***************************************************************
***************!

Formula
 (all,q,REG)          WMAINMACRO("RealHou",q)      =
PUR_CS("Hou",q);
 (all,q,REG)          WMAINMACRO("RealInv",q)      =
PUR_CS("Inv",q);
 (all,q,REG)          WMAINMACRO("RealGov",q)      =
PUR_CS("Gov",q);
 (all,q,REG)          WMAINMACRO("ExpVol",q)       =
PUR_CS("Exp",q);
 (all,q,REG)          WMAINMACRO("ImpVolUsed",q)   = IMPUSED_C(q);
 (all,q,REG)          WMAINMACRO("ImpsLanded",q)   = IM-
PLANDED_C(q);
 (all,q,REG)          WMAINMACRO("RealGDP",q)      = GDPEXP(q);
 (all,q,REG)          WMAINMACRO("AggEmploy",q)    = LAB_IO(q);
 (all,q,REG)          WMAINMACRO("realwage_io",q) = LAB_IO(q);
 (all,q,REG)          WMAINMACRO("p1lab_io",q)     = LAB_IO(q);
 (all,q,REG)          WMAINMACRO("AggCapStock",q) = CAP_I(q);
 (all,q,REG)          WMAINMACRO("CPI",q)          =
PUR_CS("Hou",q);
 (all,q,REG)          WMAINMACRO("GDPPI",q)        = GDPEXP(q);
 (all,q,REG)          WMAINMACRO("ExportPI",q)     =
PUR_CS("Exp",q);
 (all,q,REG)          WMAINMACRO("ImpsLandedPI",q)= IM-
PLANDED_C(q);
 (all,q,REG)          WMAINMACRO("Population",q)   = POP(q);
 (all,q,REG)          WMAINMACRO("NomHou",q)       =
PUR_CS("Hou",q);
 (all,q,REG)          WMAINMACRO("NomGDP",q)       = GDPEXP(q);
 (all,m,MAINMACROS) WNATMACRO(m)                   = sum{q,REG,
WMAINMACRO(m,q)};

 (initial)(all,m,MAINMACROS) RATIOMMACRO(m) = 1;

!###############################################################
##############!

!***************************************************************
*************!
! Section 6: Variable declarations in alphabetical order
```

```
!
!*************************************************************
*************!
!#############################################################
##############!

Variable

    a0e  # Foreign assets, equity, start of year #;
    a1e  # Foreign assets, equity, end of year #;
    a0d  # Foreign assets, debt, start of year #;
    a1d # Foreign assets, debt, end of year #;
(all,c,COM)(all,i,IND)(all,d,DST)
    a1q(c,i,d) # Shifter for industry structure of c#;
(all,i,IND)(all,d,DST)
    a1qsum(i,d) # Shifter for industry structure of c#;
(all,i,IND)(all,d,DST)
    a1cap(i,d) # Capital-augmenting technical change #;
(all,d,DST)(all,s,PSEC)
    age_bens(d,s) # Age benefits#;
(all,c,COM)(all,d,DST)(all,h,HOU)
    ahou_s(c,d,h) # Taste change,household imp/dom compsite#;
(all,c,COM)(all,i,IND)(all,d,DST)
    a1int_s(c,i,d) # Intermediate tech change #;
(all,i,IND)(all,d,DST)
    a1lab_o(i,d) # Labor-augmenting technical change #;
(all,i,IND)
    a1lab_od(i) # Labor-augmenting technical change #;
(all,i,IND)(all,d,DST)
    a1lnd(i,d)   # Land-augmenting technical change #;
(all,i,IND)(all,d,DST)
    a1primsum(i,d);
(all,i,IND)(all,d,DST)
    a1prim(i,d) # Primary-factor-augmenting tech change #;
(all,m,MAR)(all,r,ORG)(all,d,DST)(all,p,PRD)
    asuppmar(m,r,d,p)
# Tech change, Margin m supplied by p on goods passing from r
to d #;
(all,i,IND)(all,d,DST)
    a1tot(i,d) # All-input-augmenting technical change #;
(all,c,COM)(all,s,SRC)(all,m,MAR)(all,r,ORG)(all,d,DST)
    atradmar(c,s,m,r,d) # Tech change: margin m on good c,s go-
ing from r to d #;
(all,m,MAR)(all,r,ORG)(all,d,DST)
    atradmar_cs(m,r,d) # Tech change: margin m on goods going
from r to d #;
(all,c,COM)(all,d,DST)
```

```
    aveqsum(c,d) #All output augmenting tech change#;
(all,i,IND)
    bint_scd(i) # Driver: intermediate tech change #;
(all,c,COM)(all,i,IND)(all,d,DST)
    bint_s(c,i,d) # Intermediate tech change #;
(all,i,IND)(all,d,DST)
    caplab(i,d);
(all,d,DST)(all,j,IND)
    ch_kgr1(d,j) # CHKGR1:checks if K_GR_MIN(j) >= K_GR(j) #;
(all,d,DST)(all,j,IND)
    ch_kgr2(d,j) # CHKGR2:checks if K_GR_MAX(j) <= K_GR(j) #;
(change)(all,c,COM)(all,d,DST)(all,h,HOU)
    contCPI(c,d,h) # Contributions by commodity to % regional
CPI #;
(change)(all,i,GDPEXPCAT)(all,d,REG)
    contxgdpexp(i,d) # Contributions to % regional real GDP ex-
penditure #;
(change)(all,i,NATGDPEXPCAT)
    contxnatgdpexp(i) # Contributions to % regional real GDP
expenditure #;
(change)(all,i,IND)(all,d,DST)
    contnatxtot(i,d) # Regional contributions to national in-
dustry output #;
(change)(all,i,IND)(all,d,DST)
    contxprim_i(i,d) # Sector contributions to regional GDP at
factor cost #;
(change)
    d_bot;
(change)
    d_cab;
(change)
    d_empadj # Determines speed of direct employment adjust-
ment#;
(change)
    d_emp_sh # Set at one to zero out shift in E_d_f_empadj #;
(change)
    del_f_wage_c # Shift in labour supply, pre-tax #;
(change)
    del_f_wage_pt # Shifter in post-tax stick-wage equation #;
(change)
    d_ff_empadj # Exogenized to zero out shift in E_d_f_empadj
#;
(change)
    d_f_empadj # Exogenized to cause direct adjustment of agg
empl#;
(change)(all,d,DST)(all,i,IND)
    d_diseq(d,i) # Disequilibrium in expected ror, SE #;
```

```
(change)
    d_dum_year1 # One in year one, zero in later years #;
(change)(all,d,DST)(all,i,IND)
    d_eeqror(d,i) # Equilibrium expected ror, SE #;
(change)
    d_inf_l    # Inflation rate, lagged #;
(change)
    d_int_l    # Nominal rate of interest, lagged #;
(change)(all,d,DST)(all,j,IND)
    del_ror_se_o(d,j) # Ror for industry j in forecast, SE #;
(change)(all,d,DST)(all,j,IND)
    d_f_ror_se_o(d,j) # Shift in eqn. that records SE. rate of
return #;
(change)
    d_f_p1lab_io_l # Shifter in lagged wage equation #;
(change)
    d_f_p3tot_l # Shifter in lagged CPI equation #;
(change)
d_f_p3tot_2l # Turns off 2 lag inflation equ, if init. soln is
not from t-1 #;
(change)
    d_f_rint_l # Shifter in real rate of interest, lagged #;
(change)(all,d,DST)(all,i,IND)
    d_eror(d,i) # Percentage point changes in expected ror #;
(change)(all,d,DST)
    d_eror_ave(d) # Average expected rate of return #;
(change)(all,d,DST)(all,i,IND)
    d_eror_o(d,i) # Expected ror in forecast #;
(change)(all,d,DST)(all,i,IND)
    d_f_diseq(d,i) # Shifter in d_diseq under SE #;
(change)(all,d,DST)(all,j,IND)
    d_f_diseqre(d,j) # Shifter in d_diseq under RE #;
(change)(all,d,DST)
    d_f_eeqror_i(d) # General capital growth shifter, in yr-to-
yr #;
(change,ORIG_LEVEL = F_EEQROR)
(all,d,DST)(all,i,IND)
    d_f_eeqror(d,i) # Industry-specific cap. growth shifter,
yr-to-yr, RE#;
(change)(all,d,DST)(all,j,IND)
    d_f_eror_o(d,j) # Shift in equation that records forecast
of expected ror #;
(change)(all,d,DST)(all,i,IND)
    d_f(d,i) # Exog. in all iters with rational expect., endo
for static exp #;
(change)(all,d,DST)(all,i,IND)
    d_ff(d,i) # Exog. simulations with SE, endog for RE #;
```

```
(change)(all,d,DST)(all,i,IND)
d_f_p2tot_l(d,i)
# Turns off lag cap. price equ, if initial soln is not from t-1
#;
(change)(all,d,DST)(all,i,IND)
d_f_ac_p_y(d,i) # Shifter in cap. accum. eq'n for year t-1 in
yr-to-yr f'cast #;
(change)(all,d,DST)(all,i,IND)
d_f_pcapatt(d,i)
# Shifter for pcapatt; Endogenous if initial solution is not
from t-1 #;
(change)(all,d,DST)(all,i,IND)
d_ff_pcapatt1(d,i)
# Shifter for pcapatt1; Endogenous if initial solution is not
from t-1 #;
(change)
    d_f_trn;
(change)
    d_govsav_nat;
(change)
    d_natsav;


(change)(all,d,DST)(all,j,IND)
    d_k_gr(d,j)  # Capital growth thru forecast year #;
(change)
    d_nettrn;
(change)
    d_newle # New foreign equity liabilities #;
(change)
    d_newld # New foreign debt liabilities #;
(change)
    d_revae # Revaluation factor for foreign equity assets #;
(change)
    d_revad # Revaluation factor for foreign debt assets #;
(change)
    d_revle # Revaluation factor for foreign equity liabilities
#;
(change)
    d_revld # Revaluation factor for foreign debt liabilities
#;
(change)
    d_rint_l   # Real rate of interest, lagged #;
(change)
    d_rint_pt_se # Real post-tax interest rate, SE #;
(change)(all,d,DST)(all,i,IND)
    d_ror_act_l(d,i) # Lagged actual rate of return #;
```

```
(change)(all,d,DST)(all,j,IND)
    d_ror_se(d,j) # Percentage point changes in ror: static ex-
pect#;
(change)(all,d,DST)(all,s,PSEC)
    d_col_payrs(d,s) #Collection of payroll taxes #;
(change)(all,d,DST)(all,s,PSEC)
    d_gov_def(d,s) # Public sector deficits #;
(change)(all,s,PSEC)
    d_gov_def_d(s) # Public sector deficits #;
(all,d,DST)
    d_f_govtomun(d) #Shifter for transfers from govt to muns#;
(all,d,DST)
    d_f_govtossf(d) #Shifter for transfers from govt to soc sec
funds#;
(all,d,DST)
    d_f_muntogov(d) #Shifter for transfers from muns to govt#;
(all,d,DST)
    d_f_ssftogov(d) #Shifter for soc sec funds to govt#;
(change)(all,d,DST)(all,s,PSEC)
    d_f_othcapgovs(d,s) # Shift oth pub cap expd#;
(change)(all,d,DST)(all,s,PSEC)
    d_f_psd_ts(d,s);
(change)(all,d,DST)(all,s,PSEC)
    d_f_psd_t1s(d,s);
(change)
    d_f_rint_psd;
(all,d,DST)(all,c,COM)(all,s,PSEC)
    d_f5totr(d,c,s);
(all,d,DST)(all,s,PSEC)
    d_f5totrc(d,s);
(all,c,COM)
    d_f5totrds(c);
(all,c,COM)(all,d,DST)
    d_f5totrs(d,c);
(all,s,PSEC)
    d_f5totrcd(s);
(Change)(all,c,COM)(all,d,DST)(all,h,HOU)
    d_gamma(c,d,h);
(change)
    d_gov_def_nat;
(change)
    d_othcapgov_nat;
(change)
    d_inf # Nominal rate of interest #;
(change)
    d_int # Nominal rate of interest #;
(change)
```

```
    d_rint # Nominal rate of interest #;
(change)
    d_int_psd # Nominal rate of interest #;
(change)
    d_rint_psd # Real rate of interest #;
(change)(all,d,DST)(all,s,PSEC)
    d_net_int_gs(d,s);
(change)(all,s,PSEC)
    d_net_int_gd(s);
(change)(all,d,DST)(all,s,PSEC)
    d_nettaxtot(d,s);
(change)(all,p,PSEC)
    d_nettaxtot_d(p);
(change)(all,d,DST)(all,s,PSEC)
    d_othgovrev(d,s);
(change)(all,s,PSEC)
    d_othgovrev_d(s);
(change)(all,d,DST)(all,s,PSEC)
    d_psd_t1s(d,s);
(change)(all,d,DST)(all,s,PSEC)
    d_psd_ts(d,s);
(change)(all,s,PSEC)
    d_psd_ts_d(s);
(change)(all,s,PSEC)
    d_psd_t1s_d(s);
(change)
    d_psd_ts_nat;
(change)(all,d,DST)(all,s,PSEC)
    d_transfs(d,s) # Public sector transfers #;
(change)(all,d,DST)(all,s,PSEC)
    d_transfs_h(d,s);
(change)(all,d,DST)(all,s,PSEC)
    d_othcapgovs(d,s) # Oth pub sec cap expd#;
(change)
    d_unity # Homothopy variable#;
(change)(all,d,DST)(all,s,PSEC)
    d_w5tots(d,s);
(change)(all,s,PSEC)
    d_w5tots_d(s);
(change)
    d_w5tots_ds;
(change)
    delB;
(change)(all,i,GDPEXPCAT)(all,d,DST)
    delPGDPEXP(d,i)# Ordinary change in price expenditure GDP
component #;
(change)(all,i,GDPEXPCAT)(all,d,DST)
```

```
    delXGDPEXP(d,i)# Ordinary change in quantity expenditure
GDP component #;
(change)(all,i,GDPINCCAT)(all,d,DST)
    delGDPINC(d,i)# Ordinary change in nominal income GDP com-
ponent #;
(change)(all,i,NATGDPEXPCAT)
    delNatXGDPEXP(i)# Ordinary change in quantity expenditure
GDP component #;
(change)(all,i,NATGDPEXPCAT)
    delNatPGDPEXP(i)# Ordinary change in price expenditure GDP
component #;
(change)(all,i,IND)(all,d,DST)
    delPRIM(i,d)# Ordinary change in cost of primary factors #;
(change)(all,i,IND)(all,d,DST)
    delPTX(i,d) # Ordinary change in production tax revenue #;
 (change)(all,i,IND)(all,d,DST)
    delPTXRATE(i,d) # Change in rate of production tax #;
(change)(all,c,COM)(all,s,SRC)(all,d,DST)(all,i,IND)
    delTAXint(c,s,i,d)# Ordinary change in intermediate commod-
ity tax revenue #;
(change)(all,c,COM)(all,s,SRC)(all,d,DST)
    delTAXhou(c,s,d)# Ordinary change in household commodity
tax revenue #;
(change)(all,c,COM)(all,s,SRC)(all,d,DST)
    delTAXinv(c,s,d)# Ordinary change in investment commodity
tax revenue #;
(change)(all,c,COM)(all,s,SRC)(all,d,DST)
    delTAXgov(c,s,d)# Ordinary change in government commodity
tax revenue #;
(change)(all,c,COM)(all,s,SRC)(all,d,DST)
    delTAXexp(c,s,d)# Ordinary change in export commodity tax
revenue #;
(change)(all,d,DST)(all,s,PSEC)
    delV0tax_csis(d,s);
(change)(all,d,DST)
    delV0tax_csi(d);
(change)(all,d,DST)
    d_UR(d) #Ordinary change in unemployment rate#;
(change)
    d_URN #Ordinary change in unemployment rate, national#;
    employ_i   # Aggregate employment: wage bill weights #;
    employ_i_o # Aggregate employment in forecast simulation #;
    f_aprim_id #General primary factor productivity shifter#;
(all,i,IND)
    f_atot_d(i) #Intermediate improving tech change#;
(all,i,IND)(all,d,DST)
    f_atot(i,d) #Intermediate improving tech change#;
```

```
(all,c,COM)(all,i,IND)(all,d,DST)
    f_a1q(c,i,d)#Shifter for ind structure of c#;
(all,c,COM)(all,d,DST)
    f_a1q_i(c,d)#Shifter for ind structure of c#;
(all,i,IND)
    f_a1q_dc(i) #Shifter for ind structure of c#;
    f_age_ben_nat;
(all,s,PSEC)
    f_age_bens_d(s);
(all,d,DST)(all,s,PSEC)
    f_age_bens(d,s) #Shifter for agebens#;
(all,i,IND)(all,d,DST)
    f_aprim(i,d) #Primary factor augmenting tech change#;
(all,i,IND)
    f_aprim_d(i) #Industry specific prim fact tech change #;
(all,d,DST)
    f_aprim_i(d)#Region specific tech change#;
    f_employ_o # Shift for the value of emp_hours_o #;
    f_employ_i # Shift for the value of national employment #;
    f_labsupn_o;
    f_rwage_o # Shift for the value of real_wage_c_o #;
    f_rwage_pt_o # Shift for the value of real_wage_pt_o #;
(all,i,IND)(all,o,OCC)(all,d,DST)
    f_x1lab(i,o,d);
    ftax_l_rds_o;
(all,d,DST)
    f_govtomun(d);
(all,d,DST)
    f_govtossf(d);
    f_grants_nat;
(all,s,PSEC)
    f_grants_d(s);
(all,d,DST)(all,s,PSEC)
    f_grants(d,s);
(all,d,DST)
    f_labsup(d)#Labour supply shifter#;
    f_labsupn #Labour supply shifter, national#;
(all,d,DST)
    f_muntogov(d);
    f_oth_ben_nat;
(all,s,PSEC)
    f_oth_bens_d(s);
(all,d,DST)(all,s,PSEC)
    f_oth_bens(d,s);
(all,d,DST)(all,s,PSEC)
    f_othcapgovs(d,s);
(all,d,DST)(all,s,PSEC)
```

```
    f_othcapgov(d,s);
(all,s,PSEC)
    f_othcapgov_d(s);
(all,d,DST)(all,s,PSEC)
    f_oth_grevs(d,s) #Shifter for oth pub sec revenue#;
(all,d,DST)
    f_ssftogov(d);
(all,c,COM)
    f_pimp_d(c)#Foreign currency import price shifter#;
    f_pimp_dc;
(all,d,DST)(all,s,PSEC)
    f_tax_k_r(d,s);
(all,d,DST)(all,s,PSEC)
    f_tax_ab_r(d,s);
(all,d,DST)(all,s,PSEC)
    f_tax_l_r(d,s);
(all,s,PSEC)
    f_tax_l_rd(s);
(all,d,DST)(all,s,PSEC)
    f_tax_ob_r(d,s);
(all,d,DST)(all,s,PSEC)
    f_tax_ub_r(d,s);
(all,d,DST)(all,s,PSEC)
    f_unempben_rats(d,s);
(all,d,DST)(all,s,PSEC)
    f_unemp_bens(d,s) #Shifter for unempbens#;
(all,s,PSEC)
    f_unemp_bens_d(s);
(all,c,COM)(all,d,DST)
    f_x0com(c,d) #Shifter for turning off sum-up of x0com#;
(all,i,IND)(all,d,DST)
    f_x2tot(i,d);
(all,i,IND)
    f_x2tot_d(i);
    f_x2tot_id;
    fd # Shr of national savings devoted to foreign debt as-
sets#;
    fe # Shr of national savings devoted to foreign equity as-
sets#;
(all,i,IND)(all,o,OCC)(all,d,DST)
    flab(i,o,d) # Wage shifter #;
(all,o,OCC)
    flab_id(o) # Wage shifter #;
(all,d,DST)
    flab_io(d) # Wage shifter #;
(all,i,IND)(all,d,DST)
    flab_o(i,d) #Wage shifter#;
```

```
(all,i,IND)
    flab_od(i) #Industry soecific wage shifter#;
    flab_iod #Wage shifter, national#;
(all,c,COM)(all,s,SRC)
    fqexp(c,s)  # Export quantity shift variable #;
(all,c,COM)(all,s,SRC)
    fpexp(c,s)  # Export price shift variable #;
(all,c,COM)
    f_pexp_d(c);
    f_pexp_dc;
(all,c,COM)(all,d,DST)
    f_qexp(c,d);
(all,c,COM)(all,d,DST)
    fff_qexp(c,d);
(all,i,IND)(all,d,DST)
    ff_qexp(i,d);
(all,d,DST)
    f_qexp_c(d);
(all,c,COM)
    f_qexp_d(c);
(all,c,COM)
    ff_qexp_d(c);
(all,i,IND)
    ff_qexp_i(i);
    f_qexp_dc;
(all,i,IND)(all,d,DST)
    f_stocks(i,d);
(all,i,IND)
    f_stocks_d(i);
(all,d,DST)
    f_f3tot(d);
    f_f3tot_d;
(all,d,DST)
    f3tot(d);
    f3tot_d;
(all,d,DST)(all,c,COM)(all,s,PSEC)
    f5totr(d,c,s);
    gnpnom # Nominal gnp #;
(all,d,DST)(all,s,PSEC)
    grants_s(d,s);
(all,d,DST)
    hdispinc(d);
    hdispinc_d;
(all,d,DST)
    housav(d);
    housav_d # Household savings #;
    intad # %-Change in Interest on foreign assets, debt #;
```

```
    intae # %- Change in Interest foreign assets, equity #;
    intld # %- Change in Interest foreign liabilities, debt #;
    intle # %- Change in Interest foreign liabilities, equity
#;
    l0e  # Foreign liabilities, equity, start of year #;
    l1e  # Foreign liabilities, equity, end of year #;
    l0d  # Foreign liabilities, debt, start of year #;
    l1d # Foreign liabilities, debt, end of year #;
(all,d,DST)
    labsup(d);
    labsupn;
    labsupn_o # Labour supply in forecast simulation #;
(change)(all,d,DST)(all,i,IND)
    lev_eror(d,i) # Levels of expected rors in year t #;
(change)(all,d,DST)(all,i,IND)
lev_eror_l(d,i) # Lagged levels of expect. rors, usually ex-
pect. rors for t-1 #;
(change)(all,d,DST)(all,i,IND)
   lev_ror_act_l(d,i) # Level of actual ror in year t-1 #;
(all,m,MAINMACROS)(all,q,REG)
    MainMacro(m,q) # Convenient macros for reporting#;
(all,m,MAINMACROS)
    NatMacro(m) # National macros for reporting #;
(change)(all,m,MAINMACROS)(all,q,REG)
    contMainMacro(m,q) # Regional contributions to national
macro results #;
(all,h,HOU)
    natp3tot(h) # National CPI by household #;
(all,i,IND)
    natptot(i) # National output price average #;
    natsav # National savings #;
(all,c,COM)
    natxcom(c) # National commodity outputs #;
(all,d,DST)(all,s,PSEC)
    nettaxtots(d,s) # Net tax revenue#;
(all,h,HOU)
    natx3tot(h) # National real consumption by household #;
(all,c,COM)
    natximp(c) # National imports #;
(all,i,IND)
    natxtot(i) # National industry output -- value added
weights #;
(all,i,IND)
    natwprim(i) # National nominal factor payments #;
(all,d,DST)
    nhou(d) # Number of households #;
(all,d,DST)(all,h,HOU)
```

```
    nhouh(d,h) # Number of households #;
(all,d,DST)(all,s,PSEC)
    oth_bens(d,s)# Oth benefits#;
(all,d,DST)(all,s,PSEC)
    oth_govrevs(d,s) # Oth pub sector revenue#;
    p0gdpexp;
    p0imp_c;
    p0realdev;
    p0toft;
    p3tot;
    p1lab_iod;
    p1lab_io_l # Lagged nominal wage #;
(all,d,DST)(all,i,IND)
    p2tot(d,i) # Cost of unit of capital #;
(all,d,DST)(all,i,IND)
    p2tot_l(d,i) # Cost of unit of capital, lagged #;
   p3tot_l # Consumer price index lagged #;
   p3tot_2l # Consumer price index lagged #;
(all,i,IND)
    p2tot_d(i);
(all,d,DST)
    p2tot_i(d);
    p4tot;
(all,d,DST)(all,s,PSEC)
    p5tots(d,s);
(all,c,COM)(all,s,SRC)(all,r,ORG)
    pbasic(c,s,r) # Basic prices #;
(all,d,DST)(all,i,IND)
    pcapatt(d,i) #Asset price of capital by ind, start of year
#;
(all,d,DST)(all,i,IND)
    pcapatt1(d,i) # Asset price of capital by ind, end of year
#;
(all,i,IND)(all,d,DST)
    p1cap(i,d) # Rental price of capital #;
(all,i,IND)(all,d,DST)
    pcst(i,d) # Ex-tax cost of production #;
(all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
    pdelivrd(c,s,r,d) # All-user delivered price of good c,s
from r to d #;
(all,c,COM)(all,r,ORG)
    pdom(c,r) # Output prices = basic prices of domestic goods
#;
(all,c,COM)(all,r,ORG)
    pfimp(c,r) # Import prices, foreign currency #;
(all,u,FINDEM)(all,d,DST)
    pfin(u,d) # Final user price indices #;
```

```
(all,d,DST)
    pgdpexp(d) # Price index expenditure GDP #;
    phi # Exchange rate, local currency/$world #;
(all,d,DST)(all,h,HOU)
    p3tot_c(d,h) # CPI #;
(all,c,COM)(all,d,DST)
    p3_s(c,d) # Household price of composites #;
(all,c,COM)(all,r,ORG)
    pimp(c,r)  # Import prices, local currency #;
(all,d,DST)
    pimpused(d) # Price index, imports used in d #;
(all,r,ORG)
    pimplanded(r) # Price index, imports landed in d #;
(all,i,IND)(all,d,DST)
    pint(i,d) # Intermediate effective price indices #;
(all,c,COM)(all,d,DST)
    pinvest(c,d) # Purchaser's price of good c for investment
in d #;
(all,i,IND)(all,d,DST)
    pinvitot(i,d) # Investment price index by industry #;
(all,i,IND)(all,o,OCC)(all,d,DST)
    p1lab(i,o,d) # Wage rates #;
(all,o,OCC)(all,d,DST)
    p1lab_i(o,d) # Average wage by occ and reg #;
(all,o,OCC)
    p1lab_id(o) # Average wage by occ and reg #;
(all,d,DST)
    p1lab_io(d) # Ave wage by region #;
(all,i,IND)(all,d,DST)
    p1lab_o(i,d) # Price of labour composite #;
(all,i,IND)(all,d,DST)
    p1lnd(i,d) # Rental price of land #;
(all,c,COM)(all,i,IND)(all,d,REG)
    pmake(c,i,d) # Price received by industries #;
    pnatgdpexp # Price index expenditure national GDP #;
    popagednat # Population over 65#;
    popnat # Population, national#;
(all,d,DST)
    pops(d);
(all,d,DST)
    popaged(d);
(all,d,DST)(all,i,IND)
    powpayroll(d,i);
(all,d,DST)(all,i,IND)(all,s,PSEC)
    powpayrolls(d,i,s)#Pow of payroll taxes#;
(all,i,IND)(all,d,DST)
    p1prim(i,d)  # Effective price of primary factor composite
```

```
#;
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
    ppur(c,s,u,d) # User (purchasers) prices, inc margins and
taxes #;
(all,c,COM)(all,u,USR)(all,d,DST)
    ppur_s(c,u,d) # User prices, average over s#;
(all,c,COM)(all,s,SRC)(all,d,DST)
    puse(c,s,d) # Delivered price of regional composite good
c,s to d #;
(all,i,IND)(all,d,DST)
    p1tot(i,d) # Industry output prices #;
(all,i,IND)(all,d,DST)
    pvar(i,d)   # Shortrun variable cost of production #;
    ratio_led # Ratio, fgn equity liab. to fgn debt
liab.,endofyr #;
(all,d,DST)(all,i,IND)
    r_inv_cap_i(d,i) # Investment capital ratio by  industry #;
    r_inv_cap_u # Uniform shifter in investment capital ratio
#;
(all,d,DST)
    r_inv_cap(d);
(all,i,IND)
    r_inv_cap_d(i);
(all,i,IND)(all,o,OCC)(all,d,DST)
    realwage(i,o,d) # Wages deflated by CPI #;
    real_wage_c # Real wage for consumers #;
    real_wage_c_o # Pre-Tax real wage in forecast simulation #;
(all,o,OCC)(all,d,DST)
    realwage_i(o,d) # Average real wages #;
(all,o,OCC)
    realwage_id(o) # Average real wages #;
(all,d,DST)
    realwage_io(d) # Average real wage by region #;
    realwage_iod;
    real_wage_pt # Economy-wide CPI-deflated wage rate, post
tax #;
    real_wage_pt_o # Post-Tax real wage in forecast simulation
#;
(all,o,OCC)(all,d,DST)
    rlab_i(o,d) # Total real wage bill #;
(all,o,OCC)
    rlab_id(o) # Total real wage bill #;
(all,d,DST)
    rlab_io(d) # Total real wage bill by region #;
    roiad # %- Change in Rate of interest fgn assets, debt #;
    roiae # %- Change in Rate of interest fgn assets, debt #;
    roild # %- Change in Rate of interest fgn liabilities, debt
```

```
#;
    roile # %- Change in Rate of interest fgn liabilities, eq-
uity #;
(all,i,IND)
    s2gov(i);
(all,d,DST)(all,s,PSEC)
    tax_ab_r(d,s);
(all,d,DST)(all,s,PSEC)
    tax_k_r(d,s);
    tax_k_rr;
(all,d,DST)(all,s,PSEC)
    tax_l_r(d,s);
    tax_l_rds;
    tax_l_rds_o;
(all,d,DST)(all,s,PSEC)
    tax_ob_r(d,s);
(all,d,DST)(all,s,PSEC)
    tax_ub_r(d,s);
(all,d,DST)(all,s,PSEC)
    taxrev_incs(d,s) #Value of income tax revenue #;
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
    tuser(c,s,u,d) # Powers of commodity taxes #;
(all,c,COM)(all,u,USR)
    tuser_sd(c,u);
(all,c,COM)(all,s,SRC)
    tuser_ud(c,s) # Tax shifter by commodity #;
(all,i,COM)(all,s,SRC)(all,k,ORG)
    twistsrc(i,s,k) # Sourcing twist towards origin (k) for
good (i,s) #;
(all,i,IND)(all,d,DST)
    twistlk(i,d) # Twist towards labour away from capital #;
(all,i,IND)(all,d,DST)
    f_twistlk(i,d) # Twist towards labour away from capital #;
(all,i,IND)
    f_twistlk_d(i) # Twist towards labour away from capital #;
(all,d,DST)(all,s,PSEC)
    unemp_bens(d,s);
(all,d,DST)(all,s,PSEC)
    unempben_rats(d,s);
    x0gdpexp;
    x0imp_c;
    x1cap_id # Aggregate capital stock, rental weights #;
(all,i,IND)(all,d,DST)
    x1cap_tplus1(i,d) # Capital stock at t+1 (end of forecast
year) #;
(all,i,IND)(all,d,DST)
    x2tot(i,d) # Investment by using industry #;
```

```
(all,i,IND)
    x2tot_d(i);
(all,d,DST)
    x2tot_i(d);
    x4tot;
(all,c,COM)(all,s,SRC)(all,d,DST)(all,z,PSEC)
    x5totr(c,s,d,z);
(all,d,DST)(all,s,PSEC)
    x5tots(d,s);
(all,i,IND)(all,d,DST)
    x1cap(i,d) # Capital usage #;
(all,d,DST)
    x1cap_i(d)  # Aggregate capital, rental-weighted #;
(all,c,COM)(all,d,DST)
    xcom(c,d) # Total output of commodities #;
(all,c,COM)(all,r,REG)
    xdomexp(c,r)
    # Amount good c made in r sent to other domestic regions
(non-margin) #;
(all,c,COM)(all,d,REG)
    xdomimp(c,d)
# Amount domestic good c used in d made in other domestic re-
gions (non-margin)#;
(all,r,REG)
    xdomexp_c(r)
    # Amount goods made in r sent to other domestic regions
(non-margin) #;
(all,d,REG)
    xdomimp_c(d)
# Amount domestic goods used in d made in other domestic re-
gions (non-margin)#;
(all,c,COM)(all,r,REG)
    xdomloc(c,r) # Amount good c made in r and used in r #;
(all,c,COM)(all,s,SRC)(all,d,DST)
    xexp(c,s,d) # Export of all-region composite leaving port
at d #;
(all,c,COM)(all,d,DST)
    xexp_s(c,d) # Export demands, dom+imp #;
(all,u,FINDEM)(all,d,DST)
    xfin(u,d) # Final user quantity indices #;
(all,d,DST)
    xgdpexp(d) # Real expenditure GDP #;
(all,c,COM)(all,s,SRC)(all,d,DST)
    xgov(c,s,d) # Government demands for all-region composite
#;
(all,c,COM)(all,d,DST)
    xgov_s(c,d) # Government demands, dom+imp #;
```

```
(all,c,COM)(all,s,SRC)(all,d,DST)
    x3(c,s,d) # Household demands for all-region composite #;
(all,c,COM)(all,d,DST)(all,h,HOU)
    x3_s(c,d,h) # Household demands #;
(all,c,COM)(all,d,DST)
    x3_sh(c,d) # Household demands for dom/imp composite #;
(all,d,DST)(all,h,HOU)
    x3tot(d,h) # Total real household consumption #;
(all,d,DST)
    xhoutot(d) # Total real household consumption #;
(all,c,COM)(all,d,DST)
    ximps(c,d) # Volume of imports used in d #;
(all,d,DST)
    ximpused(d) # Volume of imports used in d #;
(all,r,ORG)
    ximplanded(r) # Volume of imports landed in d #;
(all,c,COM)(all,s,SRC)(all,d,DST)
    x2(c,s,d) # Investment demands for all-region composite #;
(all,c,COM)(all,i,IND)(all,d,DST)
    x2i(c,i,d) # Amount of good c for investment, industry i in
d #;
(all,c,COM)(all,d,DST)
    x2_s(c,d) # Investment demands for dom/imp composite #;
(all,c,COM)(all,s,SRC)(all,i,IND)(all,d,DST)
    x1(c,s,i,d) # Intermediate demands for all-region composite
#;
(all,c,COM)(all,s,SRC)(all,d,DST)
    x1_i(c,s,d) # Total intermediate demand for regional compo-
site c,s in d #;
 (all,c,COM)(all,i,IND)(all,d,DST)
    x1_s(c,i,d) # Industry demands for dom/imp composite #;
(all,i,IND)(all,o,OCC)(all,d,DST)
    x1lab(i,o,d) # Labour demands #;
(all,o,OCC)(all,d,DST)
    x1lab_i(o,d) # Aggregate labour, wage-weighted #;
(all,i,IND)
    x1lab_od(i)# Aggregate employment in forecast simulation #;
(all,o,OCC)
    x1lab_id(o) # Aggregate labour, wage-weighted #;
(all,d,DST)
    x1lab_io(d) # Labour by region, wage-weighted #;
(all,i,IND)(all,d,DST)
    x1lab_o(i,d) # Effective labour input #;
(all,i,IND)(all,d,DST)
    x1lnd(i,d) # Land usage #;
(all,d,DST)
    x1lnd_i(d) # Aggregate land, rental-weighted #;
```

```
(all,c,COM)(all,s,SRC)(all,d,DST)
    xlocuse(c,s,d) # Total non-export demand for regional com-
posite c,s in d#;
(all,c,COM)(all,d,DST)
    xlocuse_s(c,d) # Total non-export demand for good c in d #;
(all,c,COM)
    xlocuse_sd(c) # National non-export demand for good c #;
(all,c,COM)(all,i,IND)(all,d,REG)
    xmake(c,i,d) # Output of good c by industry i in d #;
(all,i,NATGDPEXPCAT)
    xNatXGDPEXP(i) # Percent change in quantity expenditure GDP
component #;
    xnatgdpexp # Real expenditure GDP #;
(all,i,IND)(all,d,DST)
    x1prim(i,d)  # Primary factor composite #;
(all,d,DST)
    xprim_i(d)   # Regional GDP at factor cost (% change) #;
(all,c,COM)(all,r,ORG)(all,d,DST)
    xrowdem(c,r,d) # Eventually exported goods #;
(all,c,COM)(all,r,ORG)
    xrowdem_d(c,r) # Eventually exported goods made in r #;
(all,i,IND)(all,d,DST)
    xstocks(i,d) # Inventories #;
(all,m,MAR)(all,r,ORG)(all,p,PRD)
    xsuppmar_d(m,r,p) # Total margins on goods from r, produced
in p #;
(all,m,MAR)(all,r,ORG)(all,d,DST)(all,p,PRD)
    xsuppmar(m,r,d,p) # Demand for margin m (made in p) on
goods from r to d #;
(all,m,MAR)(all,r,ORG)(all,d,DST)
    psuppmar_p(m,r,d) # Price of composite margin m on goods
from r to d #;
(all,m,MAR)(all,r,ORG)(all,d,DST)
    xsuppmar_p(m,r,d) # Quantity of composite margin m on goods
from r to d #;
(all,m,MAR)(all,p,PRD)
    xsuppmar_rd(m,p) # Total demand for margins produced in p
#;
(all,i,IND)(all,d,DST)
    x1tot(i,d) # Industry outputs #;
(all,c,COM)(all,s,SRC)(all,d,DST)
    xtrad_r(c,s,d) # Total demand for regional composite c,s in
d #;
(all,c,COM)(all,s,SRC)(all,m,MAR)(all,r,ORG)(all,d,DST)
    xtradmar(c,s,m,r,d) # Margin m on good c,s going from r to
d #;
(all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
```

```
    xtrad(c,s,r,d) # Quantity of good c,s from r to d #;
(all,c,COM)(all,s,SRC)(all,r,ORG)
xtrad_d(c,s,r)
# Total direct demands for goods produced(dom) or landed(imp)
in r #;
(all,c,COM)(all,s,SRC)
    xtrad_rd(c,s)  # National direct use of goods #;
(all,d,DST)(all,i,GDPEXPCAT)
    xXGDPEXP(d,i)# Percent change in quantity expenditure GDP
component #;
    w0gdpexp;
    w0imp_c;
(all,d,DST)(all,s,PSEC)
    w0tax_csis(d,s) #Value of indirect tax collection#;
(all,d,DST)(all,i,IND)(all,s,PSEC) w2totg_s(d,i,s);
(all,d,DST)(all,s,PSEC)
    w2totg_is(d,s);
    w2totg_is_ds;
    w3tot_d;
(all,d,DST)(all,s,PSEC)
    w5tots(d,s);
(all,d,DST)
    wcap_i(d) # Total rentals to capital #;
(all,u,FINDEM)(all,d,DST)
    wfin(u,d) # Final user expenditures #;
(all,d,DST)
    wgdpexp(d) # Nominal expenditure GDP #;
(all,d,DST)
    wgdpdiff(d) # SHOULD=0: nominal (income - expend) GDP #;
(all,d,DST)
    wgdpinc(d) # Nominal income GDP #;
(all,d,DST)(all,h,HOU)
    w3tot(d,h) # Total nominal household consumption #;
    w4tot;
(all,o,OCC)(all,d,DST)
    wlab_i(o,d) # Wage bill #;
(all,o,OCC)
    wlab_id(o) # Total wage bill by occupation#;
(all,d,DST)
    wlab_io(d) # Total wage bill by region #;
(all,i,IND)(all,d,DST)
    wlab_o(i,d) # Wage bills by occupation#;
    wlabnat # Wage bill at national level#;
(all,d,DST)
    wlnd_i(d) # Total rentals to land #;
    wnatgdpexp # Nominal expenditure GDP #;
    wnatgdpinc # Nominal income GDP #;
```

```
    wnatgdpdiff # SHOULD=0: nominal (income - expend) GDP #;
(all,d,DST)
    wprim_i(d) # Total factor payments #;
(all,i,IND)(all,d,DST)
    wprim(i,d) # Primary factor payments #;

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!****************************************************************
*************!
! Section 7: Updates in alphabetical order
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!################################################################
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Update
(all,d,DST)(all,s,PSEC)
    AGEBENS(s,d) = age_bens(d,s);
(all,i,IND)(all,d,DST)
    CAP(i,d) = p1cap(i,d)*x1cap(i,d);
    C_A0E = a0e;
    C_A1E = a1e;
    C_A0D = a0d;
    C_A1D = a1d;
    C_L0E = l0e;
    C_L1E = l1e;
    C_L0D = l0d;
    C_L1D = l1d;
    C_INTAD = intad;
    C_INTAE = intae;
    C_INTLD = intld;
    C_INTLE = intle;
    C_ROIAD = roiad;
    C_ROIAE = roiae;
    C_ROILD = roild;
    C_ROILE = roile;
(change)
    C_REVAE = d_revae;
(change)
    C_REVAD = d_revad;
(change)
    C_REVLD = d_revld;
(change)
```

```
    C_REVLE = d_revle;
    C_FE = fe;
    C_FD = fd;

    NATEMP_OLD = employ_i_o;
(all,d,DST)
    EMPLOYS(d) = x1lab_io(d);

(change)
    FEMPADJ = d_f_empadj;
(change)(all,d,DST)
    F_EEQROR_I(d) = d_f_eeqror_i(d);
(change)(all,d,DST)(all,i,IND)
    F_EEQROR(d,i) = d_f_eeqror(d,i);

(Explicit)(all,d,DST)(all,h,HOU) FRISCHH(d,h) =
-100/[100 - sum{i,COM,SS3CON(i,d)*
[100+p3_s(i,d)-
w3tot(d,h)+nhouh(d,h)]+S3CON(i,d)*d_gamma(i,d,h)}];


(all,d,DST)
    GOVTOMUN(d) = f_govtomun(d);
(all,d,DST)
    GOVTOSSF(d) = f_govtossf(d);
(all,d,DST)(all,s,PSEC)
    GRANTSS(s,d) = grants_s(d,s);
(all,c,COM)(all,i,IND)(all,d,DST)
    INVEST(c,i,d) = pinvest(c,d)*x2i(c,i,d);
(all,d,DST)(all,i,IND)(all,s,PSEC)
    V2TOTSG_(d,i,s)= w2totg_s(d,i,s);
(all,i,IND)(all,o,OCC)(all,d,DST)
    LAB(i,o,d) = p1lab(i,o,d)*x1lab(i,o,d);

    LAB_SUPN = labsupn;
    LAB_SUPN_O = labsupn_o;
    LEV_CPI = p3tot;
    LEV_CPI_L = p3tot_l;
    LEV_CPI_2L = p3tot_2l;
    LEV_PLAB = p1lab_iod;
    LEV_PLAB_L = p1lab_io_l;
(all,i,IND)(all,d,DST)
    LND(i,d) = p1lnd(i,d)*x1lnd(i,d);
(all,c,COM)(all,i,IND)(all,d,REG)
    MAKE(c,i,d) = xmake(c,i,d)*pmake(c,i,d);
(all,d,DST)
    MUNTOGOV(d) = f_muntogov(d);
```

```
    NAT_PROP_CON = f_f3tot_d;
(change)
    NETTRN = d_nettrn;
(all,d,DST)(all,s,PSEC)
    OTHBENS(s,d) = oth_bens(d,s);
(all,d,DST)(all,s,PSEC)
    OTHGOVREVS(s,d) = oth_govrevs(d,s);
(change)(all,d,DST)(all,s,PSEC)
    OTHCAPGOVS_(s,d) = d_othcapgovs(d,s);
(change)(all,d,DST)(all,s,PSEC)
    OTHCAPGOVS(s,d) = d_othcapgovs(d,s);
(all,d,DST)(all,i,IND)
    PCAP_AT_T(d,i) = pcapatt(d,i);
(all,d,DST)(all,i,IND)
    PCAP_I(d,i) = p2tot(d,i);
(all,d,DST)(all,i,IND)
    PCAP_I_L(d,i) = p2tot_l(d,i);
(all,d,DST)(all,i,IND)
    PCAP_AT_T1(d,i) = pcapatt1(d,i);
(all,d,DST)(all,i,IND)
    POW_PAYROLL(i,d) = powpayroll(d,i);
(all,d,DST)(all,i,IND)(all,s,PSEC)
    POW_PAYROLLS(s,i,d) = powpayrolls(d,i,s);
(change)(all,i,IND)(all,d,DST)
    PRODTAX(i,d) = delPTX(i,d);
(change)(all,d,DST)(all,s,PSEC)
    PSDATT(s,d) = d_psd_ts(d,s);
(all,d,DST)(all,h,HOU)
    RATIOCPI(d,h) = p3tot_c(d,h);
(all,d,DST)
    RATIOPRIM_I(d)= xprim_i(d);
(all,m,MAINMACROS)
    RATIOMMACRO(m) = NatMacro(m);
    RATIONGDPEXP = xnatgdpexp;
(all,i,IND)
    RATIOPRIM_D(i) =  natxtot(i);
(change)
    RINT_L = d_rint_l;
(change)
    RINT = d_rint;
(change)
    INT_PSD = d_int_psd;
    RWAGE = real_wage_c;
    RWAGE_OLD = real_wage_c_o;
(all,d,DST)
    SSFTOGOV(d) = f_ssftogov(d);
(all,i,IND)(all,d,DST)
```

```
    STOCKS(i,d) = p1tot(i,d)*xstocks(i,d);
(change)(all,c,COM)(all,s,SRC)(all,i,IND)(all,d,DST)
    TAX(c,s,i,d) = delTAXint(c,s,i,d);
(change)(all,c,COM)(all,s,SRC)(all,d,DST)
    TAX(c,s,"hou",d) = delTAXhou(c,s,d);
(change)(all,c,COM)(all,s,SRC)(all,d,DST)
    TAX(c,s,"inv",d) = delTAXinv(c,s,d);
(change)(all,c,COM)(all,s,SRC)(all,d,DST)
    TAX(c,s,"gov",d) = delTAXgov(c,s,d);
(change)(all,c,COM)(all,s,SRC)(all,d,DST)
    TAX(c,s,"exp",d) = delTAXexp(c,s,d);
(all,d,DST)(all,s,PSEC)
    TAXS_AB_RATE(s,d)=tax_ab_r(d,s);
(all,d,DST)(all,s,PSEC)
    TAXS_K_RATE(s,d)=tax_k_r(d,s);
(all,d,DST)(all,s,PSEC)
    TAXS_L_RATE(s,d)=tax_l_r(d,s);
    TAX_L_RATE = tax_l_rds;
    TAX_L_RATE_O = tax_l_rds_o;
(all,d,DST)(all,s,PSEC)
    TAXS_OB_RATE(s,d) = tax_ob_r(d,s);
(all,d,DST)(all,s,PSEC)
    TAXS_UB_RATE(s,d) = tax_ub_r(d,s);
(all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
    TRADE(c,s,r,d) = pbasic(c,s,r)*xtrad(c,s,r,d);
(all,m,MAR)(all,r,ORG)(all,d,DST)(all,p,PRD)
    SUPPMAR(m,r,d,p) = xsuppmar(m,r,d,p)*pdom(m,p);
(all,c,COM)(all,s,SRC)(all,m,MAR)(all,r,ORG)(all,d,DST)
    TRADMAR(c,s,m,r,d) =  xtradmar(c,s,m,r,d)*psupp-
mar_p(m,r,d);
(all,d,DST)(all,s,PSEC)
    UNEMPBENS(s,d)=unemp_bens(d,s);
(all,c,COM)(all,s,SRC)(all,i,IND)(all,d,DST)
    USE(c,s,i,d) = x1(c,s,i,d)*puse(c,s,d);
(all,c,COM)(all,s,SRC)(all,d,DST)
    USE(c,s,"hou",d) = x3(c,s,d)*puse(c,s,d);
(all,c,COM)(all,s,SRC)(all,d,DST)
    USE(c,s,"inv",d) = x2(c,s,d)*puse(c,s,d);
(all,c,COM)(all,s,SRC)(all,d,DST)
    USE(c,s,"gov",d) = xgov(c,s,d)*puse(c,s,d);
(all,c,COM)(all,s,SRC)(all,d,DST)
    USE(c,s,"exp",d) = xexp(c,s,d)*puse(c,s,d);
(all,d,DST)(all,i,IND)
    VCAP_AT_T(d,i) = x1cap(i,d)*pcapatt(d,i);
(change)
    YEAR = d_unity;
```

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!################################################################
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!****************************************************************
**************!
! Section 8: Equations in thematic order
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!****************************************************************
**************!
! Section 8.1. Demand for goods and primary factors
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!****************************************************************
**************!
! Section 8.1.1 Intermediate demands
!
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Coefficient
(parameter) (all,i,IND) SIGMAFUELS(i) #CES substitution btw.
energy composites#;
(parameter) (all,i,IND) SIGMAGREEN(i)
    #CES subst.el. btw. primary factors and energy#;

Read SIGMAGREEN from file INFILE header "SIGR";
Read SIGMAFUELS from file INFILE header "SIFU";

Equation
    E_x1 #Dom/imp substitution in intermediate demands#
    (all,c,COM)(all,s,SRC)(all,i,IND)(all,d,DST)
        x1(c,s,i,d) =
        x1_s(c,i,d) - SIGMADOMIMP(c)*[ppur(c,s,i,d) -
ppur_s(c,i,d)];

    E_a1int_s #Intermediate-augmenting technical change#
    (all,c,COM)(all,i,IND)(all,d,DST)
        a1int_s(c,i,d) = bint_scd(i) + bint_s(c,i,d);
```

```
    E_x1_i # Total intermediate demand for regional composite
c,s in d #
    (all,c,COM)(all,s,SRC)(all,d,DST)
        ID01[USE_I(c,s,d)]*x1_i(c,s,d) = sum{i,IND,
USE(c,s,i,d)*x1(c,s,i,d)};

    E_pint #Price index for composite intermediates #
    (all,i,IND)(all,d,DST)
        ID01[PUR_CS(i,d)]*pint(i,d) =
        sum{c,COM,PUR_S(c,i,d)*[ppur_s(c,i,d) +
a1int_s(c,i,d)]};


!*************************************************************
**************!
! Section 8.1.2. Primary factor demand
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!*************************************************************
**************!

!Formula TINY=0.00000001;!



Equation
    E_a1primsum # Primary factor saving tech change at the K-L-
Land nest #
    (all,i,IND)(all,d,DST)
        ID01[PRIM(i,d)]*a1primsum(i,d) =
        LAB_O(i,d)*[a1lab_o(i,d) + a1lab_od(i)] +
        CAP(i,d)*a1cap(i,d) +
        LND(i,d)*a1lnd(i,d);

! Occupational composition of Labour demand !

    E_x1lab # Demand for Labour by industry and skill group #
    (all,i,IND)(all,o,OCC)(all,d,DST)
        x1lab(i,o,d) = x1lab_o(i,d) -
        SIGMA1LAB(i)*[p1lab(i,o,d) - p1lab_o(i,d)] +
f_x1lab(i,o,d);

    E_p1lab_o # Price to each industry of Labour composite #
    (all,i,IND)(all,d,DST)
        ID01[LAB_O(i,d)]*p1lab_o(i,d) = sum{o,OCC,
LAB(i,o,d)*p1lab(i,o,d)};
```

```
    E_wlab_o # Wage bills #
    (all,i,IND)(all,d,DST)
        ID01[LAB_O(i,d)]*wlab_o(i,d) =
        sum{o,OCC,LAB(i,o,d)*[p1lab(i,o,d) + x1lab(i,o,d)]};

    E_x1lab_o  # Industry demands for effective labour #
    (all,i,IND)(all,d,DST)
        x1lab_o(i,d) - [a1lab_o(i,d) + a1lab_od(i)] =
        x1prim(i,d) -
        SIGMAPRIM(i)*[p1lab_o(i,d) + a1lab_o(i,d) + a1lab_od(i)
- p1prim(i,d)] -
        SIGMAPRIM(i)*[a1lab_o(i,d) + a1lab_od(i) -
a1primsum(i,d)] +
        SHRLK(i,d,"capital")*twistlk(i,d);


    E_p1cap # Industry demands for capital #
    (all,i,IND)(all,d,DST)
        x1cap(i,d) - a1cap(i,d) =
        x1prim(i,d) -
        SIGMAPRIM(i)*[p1cap(i,d) + a1cap(i,d) - p1prim(i,d)] -
        SIGMAPRIM(i)*[a1cap(i,d) - a1primsum(i,d)] -
        SHRLK(i,d,"labour")*twistlk(i,d);

    E_twistlk (all,i,IND)(all,d,DST)
        twistlk(i,d) = f_twistlk(i,d) + f_twistlk_d(i);

    E_caplab # Equation for cap lab ratio #
    (all,i,IND)(all,d,DST)
        x1cap(i,d) - x1lab_o(i,d) = caplab(i,d);

    E_p1lnd # Industry demands for land #
    (all,i,IND)(all,d,DST)
        x1lnd(i,d) - a1lnd(i,d) =
        x1prim(i,d) -
        SIGMAPRIM(i)*[p1lnd(i,d) + a1lnd(i,d) - p1prim(i,d)] -
        SIGMAPRIM(i)*[a1lnd(i,d) - a1primsum(i,d)];

    E_p1prim # Effective price term for factor demand equations
#
    (all,i,IND)(all,d,DST)
        ID01[PRIM(i,d)]*p1prim(i,d) =
        LAB_O(i,d)*[p1lab_o(i,d) + a1lab_o(i,d) + a1lab_od(i)]
+
        CAP(i,d)*[p1cap(i,d) + a1cap(i,d)] +
        LND(i,d)*[p1lnd(i,d) + a1lnd(i,d)];
```

```
!
Equation E_xprim  # Use of composite primary factor #
  (all,i,IND)(all,d,DST) x1prim(i,d) =
x1tot(i,d)+a1tot(i,d)+a1prim(i,d);
!

    E_f_atot (all,i,IND)(all,d,DST)
        a1tot(i,d) = f_atot(i,d) + f_atot_d(i);

    E_a1prim # Total primary factor productivity #
    (all,i,IND)(all,d,DST)
        a1prim(i,d) = f_aprim(i,d) + f_aprim_d(i) +
f_aprim_i(d) + f_aprim_id;

    E_wprim # Primary factor payments #
    (all,i,IND)(all,d,DST)
        ID01[PRIM(i,d)]*wprim(i,d) =
        CAP(i,d)*[p1cap(i,d) + x1cap(i,d)] +
        LND(i,d)*[p1lnd(i,d) + x1lnd(i,d)] +
        sum{o,OCC, LAB(i,o,d)*[p1lab(i,o,d) + x1lab(i,o,d)]};

    E_delPRIM # Ordinary change in total cost of primary fac-
tors #
    (all,i,IND)(all,d,DST)
        100*delPRIM(i,d) = PRIM(i,d)*wprim(i,d);

!***************************************************************
**************!
!subsection 8.1.3. demands for energy carriers!
!***************************************************************
**************!

!$  Problem: for each industry i, minimize cost of energy
!
!$          sum{c,FUEL, P1_S(c,i)*X1_S(c,i)}
!
!$  such that $  X1FUEL(i) = CES(All,c,FUEL:
X1_S(c,i)/A1_s(c,i) )  !

Coefficient
(all,i,IND)(all,d,DST) V1FUEL(i,d) # Aggregate use of alterna-
tive fuels #;
(all,i,IND)(all,d,DST) V1PRIM_F(i,d)# Total primary factor and
energy inputs#;

Formula
    (all,i,IND)(all,d,DST)
```

```
        V1FUEL(i,d) = sum{f,FUEL, sum{s,SRC, PUR(f,s,i,d)}};
    (all,i,IND)(all,d,DST)
        V1PRIM_F(i,d) = PRIM(i,d) + V1FUEL(i,d);

Variable
(all,i,IND)(all,d,DST) x1fuel(i,d);
(all,i,IND)(all,d,DST) p1fuel(i,d);
(all,i,IND)(all,d,DST) a1_sfuel(i,d);
(all,i,IND)(all,d,DST) a1prim_f(i,d);

Equation
    E_x1_sA  # Demands for fuels composites #
    (all,c,FUEL)(all,i,IND)(all,d,DST)
        x1_s(c,i,d) - a1int_s(c,i,d) =
        x1fuel(i,d) -
        SIGMAFUELS(i)*{ppur_s(c,i,d)-p1fuel(i,d)} -
        SIGMAFUELS(i)*{a1int_s(c,i,d)-a1_sfuel(i,d)};

    E_p1fuel # Price of fuel composite #
    (all,i,IND)(all,d,DST)
        ID01[V1FUEL(i,d)]*p1fuel(i,d) =
        sum{c,FUEL, sum{s,SRC, PUR(c,s,i,d)}*ppur_s(c,i,d)};

    E_a1_sfuel # Fuel saving tech change at the fuel nest #
    (all,i,IND)(all,d,DST)
        ID01[V1FUEL(i,d)]*a1_sfuel(i,d) =
        sum{c,FUEL, sum{s,SRC, PUR(c,s,i,d)}*a1int_s(c,i,d)};

!***************************************************************
**************!
!subsection 8.1.4. demand for primary-factor and energy compo-
sites!
!***************************************************************
**************!

!$  Problem: for each industry i, minimize cost of primary fac-
tors and energy !
!$          P1PRIM(i)*X1PRIM(i)+P1FUEL(i)*X1FUEL(i) such that
!
!$  X1PRIM_F(i) = CES(X1PRIM(i)/A1PRIM(i),X1FUEL(i)/A1_FUEL(i))
!

Variable
(all,i,IND)(all,d,DST) x1prim_f(i,d);
(all,i,IND)(all,d,DST) p1prim_f(i,d);
(all,i,IND)(all,d,DST) a1prim_fsum(i,d);
(all,i,IND)(all,d,DST) a1_fuel(i,d);
```

```
Equation
    E_x1prim # Demands for primary factor composite #
    (all,i,IND)(all,d,DST)
        x1prim(i,d) - a1prim(i,d) =
        x1prim_f(i,d) -
        SIGMAGREEN(i)*[p1prim(i,d) - p1prim_f(i,d)] -
        SIGMAGREEN(i)*[a1prim(i,d) - a1prim_fsum(i,d)];

    E_x1fuel # Demands for energy composite #
    (all,i,IND)(all,d,DST)
        x1fuel(i,d) - a1_fuel(i,d) =
        x1prim_f(i,d) -
        SIGMAGREEN(i)*[p1fuel(i,d) - p1prim_f(i,d)] -
        SIGMAGREEN(i)*[a1_fuel(i,d) - a1prim_fsum(i,d)];

    E_p1prim_f # Price of energy-primary composite #
    (all,i,IND)(all,d,DST)
        ID01[V1PRIM_F(i,d)]*p1prim_f(i,d) =
        PRIM(i,d)*p1prim(i,d) +
        V1FUEL(i,d)*p1fuel(i,d);

    E_a1prim_fsum # Energy-primary-saving tech change at energy
primary nest #
    (all,i,IND)(all,d,DST)
        ID01[V1PRIM_F(i,d)]*a1prim_fsum(i,d) =
        PRIM(i,d)*a1prim(i,d) +
        V1FUEL(i,d)*a1_fuel(i,d);

!**************************************************************
**************!
! section 8.1.5. Demand for intermediate and primary-energy
cost composites!
!**************************************************************
**************!

!$  Problem: for each industry i, minimize cost
!
!$
sum(c,COM,P1_s(c,i)*x1_s(c,i))+P1PRIM_F(i)*X1PRIM_F(i)+P1OCT(i)
*X1OCT(i) !
!$  such that
!
!   X1TOT(i) = MIN( All,c,COM:
X1_S(c,i)/[A1_S(c,s,i)*A1TOT(i)],             !
!$
X1PRIM_F(i)/[A1PRIM_F(i)*A1TOT(i)],            !
```

```
!$                              X1OCT(i)/[A1OCT(i)*A1TOT(i)] )
!

Equation
    E_x1prim_f (all,i,IND)(all,d,DST)
        x1prim_f(i,d) - a1prim_f(i,d) - a1tot(i,d) =
x1tot(i,d);

    E_x1_sB #Demand for composite intermediate goods#
    (all,c,COMLFUEL)(all,i,IND)(all,d,DST)
        x1_s(c,i,d) = a1tot(i,d) + a1int_s(c,i,d) + x1tot(i,d)
-
        0.15*[ppur_s(c,i,d) + a1int_s(c,i,d) - pint(i,d)];

!***************************************************************
**************!
! Subsection 8.1.6.  Output cost inclusive of production tax!
!***************************************************************
**************!

! Output prices !

    E_pvar #Variable cost#
    (all,i,IND)(all,d,DST)
        ID01[VARCST(i,d)]*[pvar(i,d) - a1tot(i,d)] =
        LAB_O(i,d)*[p1lab_o(i,d) + a1lab_o(i,d) + a1lab_od(i)]
+
        PUR_CS(i,d)*pint(i,d);

    E_pcst #Total cost of production excluding taxes#
    (all,i,IND)(all,d,DST)
        ID01[VCST(i,d)]*[pcst(i,d) - a1tot(i,d)] =
        PRIM(i,d)*[a1prim(i,d)+p1prim(i,d)] +
        PUR_CS(i,d)*pint(i,d);

    E_delPTX #Change in production taxes#
    (all,i,IND)(all,d,DST)
        delPTX(i,d) = 0.01*PRODTAX(i,d)*[x1tot(i,d)+pcst(i,d)]
+
        VCST(i,d)*delPTXRATE(i,d);

    E_x1tot #Total cost#
    (all,i,IND)(all,d,DST)
        ID01[VTOT(i,d)]*[p1tot(i,d) + x1tot(i,d)] =
        VCST(i,d)*[pcst(i,d) + x1tot(i,d)] + 100*delPTX(i,d);

Variable    (all,i,IND)(all,d,DST) w1tot(i,d);
```

```
Equation
    E_w1tot #Total cost#
    (all,i,IND)(all,d,DST)
        ID01[VTOT(i,d)]*[w1tot(i,d)] =
 ID01[VTOT(i,d)]*[p1tot(i,d) + x1tot(i,d)];


!zero profit!
    E_p1totA # Average price received by multi-product indus-
tries #
    (all,i, MIND)(all,d,REG)
        p1tot(i,d) = sum{c,MINDCOM, MAKE-
SHR1(c,i,d)*pmake(c,i,d)};
    E_p1totB # Price received by single-product industries #
    (all,i,SIND)(all,d,REG)
        p1tot(i,d) = pdom(SIND2COM(i),d);

! Next equation says that
 users of good c do not regard c made different industries as
perfect
 substitutes. Rather they CES (sigma=1/0.05) between the dif-
ferent industry
 products. This would be needed, for example, if 2 industries
produced only
 electricity, with all inputs available elastically. The divi-
sion of output
 between the two industries would not be well defined. Replace
0.05 by 0 to
 restore perfect substitute idea. !

    E_pmake  # Demands for commodities from industries #
    (all,c,COM)(all,i,IND)(all,d,REG)
        pmake(c,i,d) = pdom(c,d) - 0.5*[xmake(c,i,d) -
xcom(c,d)];

!***************************************************************
*************!
! section 8.2  Supply of commodities
!
!***************************************************************
*************!

! subsection 8.2.1.  Choice of commodity mix of output !

! CET between outputs of different commodities
!
```

```
!$  Problem: for each industry i and commodity c, maximize rev-
enue          !
!$          sum{all,c,COM: P0com(c,i)*Q1(c,i)}
!
!$ such that
!
!$  X1TOT(i) = CET( All,c,COM: Q1(c,i)/A1(c,s,i) )
!

Equation
    E_xmake  # Supplies of commodities by industries #
    (all,c,COM)(all,i,IND)(all,d,REG)
        xmake(c,i,d) + a1q(c,i,d) = x1tot(i,d) +
        SIGMAOUT(i)*[pmake(c,i,d)- p1tot(i,d)] +
        SIGMAOUT(i)*[-a1q(c,i,d) + a1qsum(i,d)];

    E_a1qsum #All output-augmenting technical change#
    (all,i,IND)(all,d,DST)
        sum{c,COM, MAKE(c,i,d)}*a1qsum(i,d) =
        sum{c,COM, MAKE(c,i,d)*a1q(c,i,d)};

    E_aveqsum #Average output-augmenting technical change#
    (all,c,COM)(all,d,DST)
        sum{i,IND, MAKE(c,i,d)}*aveqsum(c,d) =
        sum{i,IND, MAKE(c,i,d)*a1q(c,i,d)};

    E_f_a1q #Fixes industry structure of producion of c #
    (all,c,COM)(all,i,IND)(all,d,REG)
        xmake(c,i,d) = xcom(c,d) + f_a1q(c,i,d)+ f_a1q_i(c,d) +
f_a1q_dc(i);

    E_xcom # Total output of commodities made by several indus-
tries #
    (all,c,COM)(all,d,REG)
        xcom(c,d) = sum{i,IND, MAKESHR2(c,i,d)*xmake(c,i,d)} +
f_x0com(c,d);


!**************************************************************
***************!
! Section 8.3.   Investment demands
!
!**************************************************************
***************!

Equation
    E_x2 # Dom/imp substitution #
```

```
    (all,c,COM)(all,s,SRC)(all,d,DST)
        x2(c,s,d) = x2_s(c,d) -
        SIGMADOMIMP(c)*[ppur(c,s,"inv",d) - pinvest(c,d)];

    E_x2i # Leontief technology for new capital creation #
    (all,c,COM)(all,i,IND)(all,d,DST)
        x2i(c,i,d) = x2tot(i,d);

    E_pinvest # Alias #
    (all,c,COM)(all,d,DST)
        pinvest(c,d) = ppur_s(c,"Inv",d);

    E_pinvitot # Price index of investment goods #
    (all,i,IND)(all,d,DST)
        ID01[INVEST_C(i,d)]*pinvitot(i,d) =
        sum{c,COM, INVEST(c,i,d)*pinvest(c,d)};

    E_x2_s # Add up industry demands for investment goods #
    (all,c,COM)(all,d,DST)
        ID01[INVEST_I(c,d)]*x2_s(c,d)= sum{i,IND,IN-
VEST(c,i,d)*x2i(c,i,d)};

!**************************************************************
**************!
! Section 8.4. Household demands
!
! follows LES/Stone-Geary/Klein-Rubin scheme
!
!**************************************************************
**************!

! Multiple households version
Set HOU # Households # read elements from file REGSETS header
"HOU";
Coefficient (all,c,COM)(all,d,DST)(all,h,HOU) HOUPUR(c,d,h)
#Household demands#;
Read HOUPUR from file INFILE header "3PUR";  !
! end single households section !
! scale EPS so they average to 1: else they tend to drift off
in recursive sims!

! Dom/imp substitution !

Equation
    E_x3 # Dom/imp substitution in consumption#
    (all,c,COM)(all,s,SRC)(all,d,DST)
```

```
        x3(c,s,d) = x3_sh(c,d) - SIGMADO-
MIMP(c)*[ppur(c,s,"hou",d) - p3_s(c,d)];

    E_p3 # Alias for consumer prices #
    (all,c,COM)(all,d,DST)
        p3_s(c,d) = ppur_s(c,"hou",d);

    E_p3tot_c #Regional household price baskets#
    (all,d,DST)(all,h,HOU)
        p3tot_c(d,h) = sum{c,COM,BUDGSHR(c,d,h)*p3_s(c,d)};


    E_w3tot #Value of regional household consumption#
    (all,d,DST)(all,h,HOU)
        w3tot(d,h) = p3tot_c(d,h) + x3tot(d,h);


Variable
(all,c,COM)(all,d,DST)(all,h,HOU) a3con(c,d,h);
(all,d,DST)(all,h,HOU) ave_a3con(d,h);
  (all,c,COM)(all,d,DST)(all,h,HOU) deltapc(c,d,h);

Equation  E_x3_s # Household demands for composite commodities
#
  (all,c,COM)(all,d,DST)(all,h,HOU)
  x3_s(c,d,h) - nhouh(d,h) =
EPS(c,d)*[w3tot(d,h)-nhouh(d,h)] +
sum{k,COM,ETA(c,k,d)*p3_s(k,d)}
                + a3con(c,d,h) - ave_a3con(d,h);




E_x3_sh # All-household demand for composite commodities #
    (all,c,COM)(all,d,DST)
        x3_sh(c,d)= sum{h,HOU, HOUSHR(c,d,h)*x3_s(c,d,h)};


Equation E_ave_a3con # Average value of a3com #
(all,d,DST)(all,h,HOU)
  ave_a3con(d,h) = sum{k,COM, S3CON(k,d)*a3con(k,d,h)};

Equation E_deltapc # Movements in marginal budget shares in LES
#
  (all,c,COM)(all,d,DST)(all,h,HOU)
deltapc(c,d,h) = a3con(c,d,h) - sum{k,COM,
DELTA(k,d)*a3con(k,d,h)};
```

```
Equation E_d_gamma # Movements in subsistence variables in LES
#
  (all,c,COM)(all,d,DST)(all,h,HOU)
d_gamma(c,d,h) = [1 + EPS(c,d)/FRISCH(d)]*[a3con(c,d,h)-
ave_a3con(d,h)];


E_contCPI #Household contributions to CPI #
    (all,c,COM)(all,d,DST)(all,h,HOU)
        contCPI(c,d,h)  = RATI-
OCPI(d,h)*BUDGSHR(c,d,h)*p3_s(c,d);


E_xhoutot # All-household demand #
    (all,d,DST)
        sum{h,HOU, ID01[HOUPUR_C(d,h)]*[xhoutot(d) -
x3tot(d,h)]} = 0;

E_nhouh # Number of households #
    (all,d,DST)(all,h,HOU)
        nhouh(d,h) = nhou(d);

! national addup of HOU-length variables !
    E_natx3tot # National real consumption by household #
    (all,h,HOU)
        sum{d,DST, ID01[HOUPUR_C(d,h)]*[natx3tot(h) -
x3tot(d,h)]} = 0;

    E_natp3tot # National CPI by household #
    (all,h,HOU)
        sum{d,DST, ID01[HOUPUR_C(d,h)]*[natp3tot(h) -
p3tot_c(d,h)]} = 0;



!*************************************************************
**************!
! Section 8.5.  Export, inventory, and margin demands
!
!*************************************************************
**************!


Equation
    E_ff_qexp_d #Links export demands to industry outputs#
    (all,c,COM)
```

```
        f_qexp_d(c) = ff_qexp_d(c) +
        sum{i,IND, ISMADE(c,i)*MAKESHR_i(c,i)*ff_qexp_i(i)};

    E_f_qexp #Links export demands to industry outputs#
    (all,c,COM)(all,d,DST)
        f_qexp(c,d) = fff_qexp(c,d) +
        sum{i,IND, ISMADED(c,i,d)*MAKESHR(c,i,d)*ff_qexp(i,d)};

    E_xexp #Export demands #
    (all,c,COM)(all,s,SRC)(all,d,DST)
    xexp(c,s,d) = f_qexp_dc + f_qexp_d(c) + f_qexp_c(d) +
f_qexp(c,d) +

    fqexp(c,s) - abs[EXP_ELAST(c)]*
        [ppur(c,s,"Exp",d) - f_pexp_dc - fpexp(c,s) -
f_pexp_d(c) - phi];

    E_xexp_s #Export demands for composite commodities #
    (all,c,COM)(all,d,DST)
        xexp_s(c,d) = sum{s,SRC,
SRCSHR(c,s,"exp",d)*xexp(c,s,d)};

Variable (all,c,COM) xexp_sd(c);

Equation    E_xexp_sd #Export demands for composite commodities
#
    (all,c,COM)

sum{d,DST,(PUR_S(c,"exp",d)+EP)}*xexp_sd(c)=
sum{d,DST,(PUR_S(c,"exp",d)+EP)*xexp_s(c,d)};


!****************************************************************
*************!
! section 8.6 Government and inventory demands !
!****************************************************************
*************!

    E_xgov #Public sector demands #
    (all,c,COM)(all,s,SRC)(all,d,DST)
        xgov(c,s,d) = sum{p,PSEC,
V5SHRS_(d,c,p)*f5totr(d,c,p)};

    E_xgov_s # Public demand for composite goods #
    (all,c,COM)(all,d,DST)
        xgov_s(c,d) = sum{s,SRC,
SRCSHR(c,s,"Gov",d)*xgov(c,s,d)};
```

```
    E_f5totr #Shifter for govt consumption#
    (all,d,DST)(all,c,COM)(all,s,PSEC)
        f5totr(d,c,s) = d_f5totr(d,c,s) + d_f5totrc(d,s) +
d_f5totrcd(s) +
        d_f5totrds(c)  + d_f5totrs(d,c);

    E_x5totr #Shifter for govt consumption#
    (all,c,COM)(all,s,SRC)(all,d,DST)(all,z,PSEC)
        x5totr(c,s,d,z) = SCRSHR5(d,c,s,z)*f5totr(d,c,z);

    E_x5tots (all,d,DST)(all,s,PSEC)
        V5TOTS(d,s)*x5tots(d,s) = sum{c,COM,
V5TOT(d,c,s)*xgov_s(c,d)};

    E_p5tots (all,d,DST)(all,s,PSEC)
        V5TOTS(d,s)*p5tots(d,s) =
sum{c,COM,V5TOT(d,c,s)*ppur_s(c,"gov",d)};

    E_w5tots (all,d,DST)(all,s,PSEC)
        w5tots(d,s) = x5tots(d,s) + p5tots(d,s);

    E_d_w5tots (all,d,DST)(all,s,PSEC)
        100*d_w5tots(d,s) = V5TOTS(d,s)*w5tots(d,s);

    E_d_w5tots_d (all,s,PSEC)
        d_w5tots_d(s) = sum{d,DST,d_w5tots(d,s)};

    E_d_w5tots_ds
        d_w5tots_ds = sum{s,PSEC,d_w5tots_d(s)};



    E_xstocks #Inventory demands #
    (all,i,IND)(all,d,DST)
        xstocks(i,d) = x1tot(i,d) + f_stocks(i,d) +
f_stocks_d(i);



!**************************************************************
**************!
! Section 8.7. Demand for margins
!
!**************************************************************
**************!
```

```
!Demand for margins!

Equation
    E_xtradmar # Leontief demand for margins #
    (all,c,COM)(all,s,SRC)(all,m,MAR)(all,r,ORG)(all,d,DST)
        xtradmar(c,s,m,r,d) = xtrad(c,s,r,d) + at-
radmar(c,s,m,r,d);

    E_atradmar # Driver for margin tech change #
    (all,c,COM)(all,s,SRC)(all,m,MAR)(all,r,ORG)(all,d,DST)
        atradmar(c,s,m,r,d) = atradmar_cs(m,r,d);
Substitute atradmar using E_atradmar;

Equation
    E_pdelivrd # Delivered price of good c,s from r to d #
    (all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
        pdelivrd(c,s,r,d) = BASSHR(c,s,r,d)*pbasic(c,s,r) +
        sum{m,MAR, MARSHR(c,s,m,r,d)*[psuppmar_p(m,r,d) + at-
radmar(c,s,m,r,d)]};

! Excerpt 18 of TABLO input file: !
! For each good and destination region, an average user chooses
region sourcing!
! based on delivered (margin-paid, but ex-tax) prices and val-
ues !

    E_puse # Delivered price of regional composite good c,s to
d #
    (all,c,COM)(all,s,SRC)(all,d,DST)
        ID01[DELIVRD_R(c,s,d)]*puse(c,s,d) =
        sum{r,ORG,DELIVRD(c,s,r,d)*pdelivrd(c,s,r,d)};


    E_xtrad # CES between goods from different regions #
    (all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
        xtrad(c,s,r,d) = xtrad_r(c,s,d) -
        SIGMADOMDOM(c)*[pdelivrd(c,s,r,d)-puse(c,s,d)] +
        sum{k,ORG,
            [if[k eq r, 1] - DELIVRD(c,s,k,d)/ID01[DE-
LIVRD_R(c,s,d)]]*
            twistsrc(c,s,k)};

!Supply of margins!
    E_xsuppmar_p # Composite margin m on goods passing from r
to d #
```

```
    (all,m,MAR)(all,r,ORG)(all,d,DST) ! add up demands !
        ID01[TRADMAR_CS(m,r,d)]*xsuppmar_p(m,r,d) =
        sum{c,COM, sum{s,SRC,
TRADMAR(c,s,m,r,d)*xtradmar(c,s,m,r,d)}};

    E_psuppmar_p # Price of composite margin m on goods from r
to d #
    (all,m,MAR)(all,r,ORG)(all,d,DST) ! CES price index !
        ID01[SUPPMAR_P(m,r,d)]*psuppmar_p(m,r,d) =
        sum{p,PRD, SUPPMAR(m,r,d,p)*[pdom(m,p) + asupp-
mar(m,r,d,p)]};

    E_xsuppmar # Margin m supplied by p on goods passing from r
to d #
    (all,m,MAR)(all,r,ORG)(all,d,DST)(all,p,PRD) ! CES demands
!
        xsuppmar(m,r,d,p) = xsuppmar_p(m,r,d) + asupp-
mar(m,r,d,p) -
        SIGMAMAR(m)*[pdom(m,p) + asuppmar(m,r,d,p) - psupp-
mar_p(m,r,d)];

    E_xsuppmar_d # Total margins on goods from r, produced in p
#
    (all,m,MAR)(all,r,ORG)(all,p,PRD)
        ID01[SUPPMAR_D(m,r,p)]*xsuppmar_d(m,r,p) =
        sum{d,DST, SUPPMAR(m,r,d,p)*xsuppmar(m,r,d,p)};

    E_xsuppmar_rd # Total demand for margins produced in p #
    (all,m,MAR)(all,p,PRD)
        ID01[SUPPMAR_RD(m,p)]*xsuppmar_rd(m,p) =
        sum{r,ORG, SUPPMAR_D(m,r,p)*xsuppmar_d(m,r,p)};


!**************************************************************
**************!
! section 8.8 Product market equilibrium !
!**************************************************************
**************!

!**************************************************************
**************!
! subsection 8.8.1  Market clearing equations !
!**************************************************************
**************!

Equation
    E_xtrad_r # Total demand for regional composite c,s in d #
```

```
    (all,c,COM)(all,s,SRC)(all,d,DST)
        ID01[USE_U(c,s,d)]*xtrad_r(c,s,d) =
        USE_I(c,s,d)*x1_i(c,s,d) +
        USE(c,s,"hou",d)*x3(c,s,d) +
        USE(c,s,"inv",d)*x2(c,s,d) +
        USE(c,s,"gov",d)*xgov(c,s,d) +
        USE(c,s,"exp",d)*xexp(c,s,d);

    E_xlocuse # Total non-export demand for regional composite
c,s in d#
    (all,c,COM)(all,s,SRC)(all,d,DST)
        ID01[USE_U(c,s,d)]*xtrad_r(c,s,d) =
        ID01[LOCUSE(c,s,d)]*xlocuse(c,s,d) +
        USE(c,s,"exp",d)*xexp(c,s,d);

    E_xlocuse_s # Total non-export demand for good c in d #
    (all,c,COM)(all,d,DST)
        ID01[LOCUSE_S(c,d)]*xlocuse_s(c,d) =
        sum{s,SRC, LOCUSE(c,s,d)*xlocuse(c,s,d)};

    E_xlocuse_sd # National non-export demand for good c #
    (all,c,COM)
        ID01[LOCUSE_SD(c)]*xlocuse_sd(c) =
        sum{d,DST, LOCUSE_S(c,d)*xlocuse_s(c,d)};

Backsolve xlocuse using E_xlocuse;
Backsolve xlocuse_s using E_xlocuse_s;
Backsolve xlocuse_sd using E_xlocuse_sd;


Equation
    E_xtrad_d (all,c,COM)(all,s,SRC)(all,r,ORG)
        ID01[TRADE_D(c,s,r)]*xtrad_d(c,s,r) =
        sum{d,DST, TRADE(c,s,r,d)*xtrad(c,s,r,d)};

    E_pdomA # Demand = supply for non-margins #
    (all,c,NONMAR)(all,r,REG)
        xcom(c,r) = xtrad_d(c,"dom",r);

    E_pdomB # Demand = supply for margins #
    (all,m,MAR)(all,p,REG)
        MAKE_I(m,p)*xcom(m,p) =
        TRADE_D(m,"dom",p)*xtrad_d(m,"dom",p) +
        SUPPMAR_RD(m,p)*xsuppmar_rd(m,p);

!*************************************************************
**************!
```

```
! Section 8.8.2 Definitions of purchasers prices and
!
! final demand price and quantity indices
!
!*************************************************************
*************!

!               Definition purchasers prices               !

Coefficient
    (all,s,SRC) ISDOM(s) # binary dummy #;
Formula
    ISDOM("dom") = 1;
    ISDOM("imp") = 0;

Equation
    E_pimp (all,c,COM)(all,r,ORG)
        pimp(c,r) = pfimp(c,r) + f_pimp_d(c) + f_pimp_dc + phi;
    E_pbasic (all,c,COM)(all,s,SRC)(all,r,ORG)
        pbasic(c,s,r) = ISDOM(s)*pdom(c,r) + [1-IS-
DOM(s)]*pimp(c,r);
    E_ppur # Purchasers prices #
    (all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
        ppur(c,s,u,d) = puse(c,s,d) + tuser(c,s,u,d);
    E_ppur_s
    (all,c,COM)(all,u,USR)(all,d,DST)
        ppur_s(c,u,d) =
sum{s,SRC,SRCSHR(c,s,u,d)*ppur(c,s,u,d)};
    E_tuser # Usr x Dst taxes driven by commodity specific
shifter #
    (all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
        tuser(c,s,u,d) = tuser_ud(c,s) + tuser_sd(c,u);

Substitute tuser using E_tuser;

!Definition of final demand price and quantity indices
!

Equation
    E_pfin (all,u,FINDEM)(all,d,DST)
        ID01[PUR_CS(u,d)]*pfin(u,d) =
sum{c,COM,PUR_S(c,u,d)*ppur_s(c,u,d)};
    E_xfinA (all,d,DST)
        xfin("hou",d) = xhoutot(d);
    E_xfinB (all,d,DST)
        ID01[PUR_CS("inv",d)]*xfin("inv",d) =
        sum{c,COM, PUR_S(c,"inv",d)*x2_s(c,d)};
```

```
    E_xfinC (all,d,DST)
        ID01[PUR_CS("gov",d)]*xfin("gov",d) =
        sum{c,COM, PUR_S(c,"gov",d)*xgov_s(c,d)};
    E_xfinD (all,d,DST)
        ID01[PUR_CS("exp",d)]*xfin("exp",d) =
        sum{c,COM,sum{s,SRC, PUR(c,s,"exp",d)*xexp(c,s,d)}};
    E_wfin (all,u,FINDEM)(all,d,DST)
        wfin(u,d) = xfin(u,d) + pfin(u,d);


!*************************************************************
**************!
! Section 8.9. Indirect tax revenues !
!*************************************************************
**************!

Equation
    E_delTAXint (all,c,COM)(all,s,SRC)(all,i,IND)(all,d,DST)
        delTAXint(c,s,i,d) =
        0.01*TAX(c,s,i,d)*[x1(c,s,i,d) + puse(c,s,d)] +
        0.01*PUR(c,s,i,d)*tuser(c,s,i,d);

    E_delTAXhou (all,c,COM)(all,s,SRC)(all,d,DST)
        delTAXhou(c,s,d) =
        0.01*TAX(c,s,"hou",d)*[x3(c,s,d) + puse(c,s,d)] +
        0.01*PUR(c,s,"hou",d)*tuser(c,s,"hou",d);

    E_delTAXinv (all,c,COM)(all,s,SRC)(all,d,DST)
        delTAXinv(c,s,d) =
        0.01*TAX(c,s,"inv",d)*[x2(c,s,d) + puse(c,s,d)] +
        0.01*PUR(c,s,"inv",d)*tuser(c,s,"inv",d);

    E_delTAXgov (all,c,COM)(all,s,SRC)(all,d,DST)
        delTAXgov(c,s,d) =
        0.01*TAX(c,s,"gov",d)*[xgov(c,s,d) + puse(c,s,d)] +
        0.01*PUR(c,s,"gov",d)*tuser(c,s,"gov",d);

    E_delTAXexp (all,c,COM)(all,s,SRC)(all,d,DST)
        delTAXexp(c,s,d) =
        0.01*TAX(c,s,"exp",d)*[xexp(c,s,d) + puse(c,s,d)] +
        0.01*PUR(c,s,"exp",d)*tuser(c,s,"exp",d);

!*************************************************************
**************!
! Section 8.10. Nominal Income-side GDP !
!*************************************************************
**************!
```

```
!Primary factor aggregates!

Equation
    E_wlnd_i (all,d,DST)
        LND_I(d)*wlnd_i(d) = sum{i,IND,LND(i,d)*[p1lnd(i,d) +
x1lnd(i,d)]};
    E_wcap_i (all,d,DST)
        CAP_I(d)*wcap_i(d) = sum{i,IND,CAP(i,d)*[p1cap(i,d) +
x1cap(i,d)]};
    E_wprim_i (all,d,DST)
        PRIM_I(d)*wprim_i(d) = sum{i,IND,PRIM(i,d)*wprim(i,d)};
    E_x1lnd_i (all,d,DST)
        LND_I(d)*x1lnd_i(d) = sum{i,IND,LND(i,d)*x1lnd(i,d)};
    E_x1cap_i (all,d,DST)
        CAP_I(d)*x1cap_i(d) = sum{i,IND,CAP(i,d)*x1cap(i,d)};

    E_delGDPINCa (all,d,DST)
        delGDPINC(d,"Land") = 0.01*LND_I(d)*wlnd_i(d);
    E_delGDPINCb (all,d,DST)
        delGDPINC(d,"Capital") = 0.01*CAP_I(d)*wcap_i(d);
    E_delGDPINCc (all,d,DST)
        delGDPINC(d,"Labour") = 0.01*LAB_IO(d)*wlab_io(d);
    E_delGDPINCd (all,d,DST)
        delGDPINC(d,"ProdTax") = sum{i,IND,delPTX(i,d)};
    E_delGDPINCe (all,d,DST)
        delGDPINC(d,"ComTax") =
        sum{c,COM, sum{s,SRC, sum{i,IND,
            delTAXint(c,s,i,d)} +
            delTAXhou(c,s,d) + delTAXinv(c,s,d) + del-
TAXgov(c,s,d) +
        delTAXexp(c,s,d)}};

    E_wgdpinc (all,d,DST)
        GDPINC(d)*wgdpinc(d) = 100*sum{i,GDPINCCAT,
delGDPINC(d,i)};

!**************************************************************
**************!
! Section 8.11. Real and nominal expenditure side GDP !
!**************************************************************
**************!

Equation
    E_delXGDPEXPa (all,d,DST)(all,u,FINDEM)
        delXGDPEXP(d,u) = 0.01*PUR_CS(u,d)*xfin(u,d);
    E_delXGDPEXPb (all,d,DST)
```

```
        delXGDPEXP(d,"Stocks") =
0.01*sum{i,IND,STOCKS(i,d)*xstocks(i,d)};
    E_delXGDPEXPc (all,r,REG)
        delXGDPEXP(r,"Imports") =
        -0.01*sum{c,COM,
TRADE_D(c,"imp",r)*xtrad_d(c,"imp",r)};
    E_delXGDPEXPd (all,r,REG)
        delXGDPEXP(r,"NetMar") =
        0.01*sum{m,MAR, sum{o,ORG, sum{d,DST,
            SUPPMAR(m,o,d,r)*xsuppmar(m,o,d,r)} -
            sum{p,PRD, SUPPMAR(m,o,r,p)*xsuppmar(m,o,r,p)}
        }};
    E_delXGDPEXPe (all,r,REG)
        delXGDPEXP(r,"Rexports") =
        0.01*sum{c,COM, sum{s,SRC,
            TRADE_D(c,s,r)*xtrad_d(c,s,r) -
TRADE(c,s,r,r)*xtrad(c,s,r,r)
        }};
    E_delXGDPEXPf (all,r,REG)
        delXGDPEXP(r,"Rimports") =
        -0.01*sum{c,COM, sum{s,SRC,
            TRADE_R(c,s,r)*xtrad_r(c,s,r) -
TRADE(c,s,r,r)*xtrad(c,s,r,r)
        }};

    E_xXGDPEXP (all,d,DST)(all,i,GDPEXPCAT)
        ID01[GDPEXPSUM(d,i)]*xXGDPEXP(d,i) =
100*delXGDPEXP(d,i);
    E_xgdpexp (all,d,DST)
        GDPEXP(d)*xgdpexp(d) = 100*sum{i,GDPEXPCAT,
delXGDPEXP(d,i)};

    E_delPGDPEXPa (all,d,DST)(all,u,FINDEM)
        delPGDPEXP(d,u) = 0.01*PUR_CS(u,d)*pfin(u,d);
    E_delPGDPEXPb (all,d,DST)
        delPGDPEXP(d,"Stocks") = 0.01*sum{i,IND,
STOCKS(i,d)*p1tot(i,d)};
    E_delPGDPEXPc (all,q,REG)
        delPGDPEXP(q,"Imports") = -0.01*sum{c,COM,
        TRADE_D(c,"imp",q)*pimp(c,q)};
    E_delPGDPEXPd (all,q,REG)
        delPGDPEXP(q,"NetMar") = 0.01*
            sum{m,MAR, SUPPMAR_RD(m,q)*pdom(m,q) -
            sum{p,PRD, SUPPMAR_R(m,q,p)*pdom(m,p)}};
    E_delPGDPEXPe (all,q,REG)
        delPGDPEXP(q,"Rexports") = 0.01*sum{c,COM, sum{s,SRC,
        [TRADE_D(c,s,q) - TRADE(c,s,q,q)]*pbasic(c,s,q)}};
```

```
    E_delPGDPEXPf (all,q,REG)
        delPGDPEXP(q,"Rimports") = -0.01*
        sum{c,COM, sum{s,SRC,
            sum{r,ORG, TRADE(c,s,r,q)*pbasic(c,s,r)} -
        TRADE(c,s,q,q)*pbasic(c,s,q)}};

    E_pgdpexp (all,d,DST)
        GDPEXP(d)*pgdpexp(d) = 100*sum{i,GDPEXPCAT,
delPGDPEXP(d,i)};
    E_wgdpexp (all,d,DST)
        wgdpexp(d) = xgdpexp(d) + pgdpexp(d);
    E_wgdpdiff (all,d,DST)
        wgdpdiff(d) = wgdpinc(d)- wgdpexp(d);

Coefficient (all,d,REG)
    RATIOGDPEXP(d)# (Current/initial) real expenditure GDP#;
Formula
    (initial)(all,d,REG) RATIOGDPEXP(d) = 1;
Update
    (all,d,REG) RATIOGDPEXP(d) = xgdpexp(d);

Equation
    E_contxgdpexp (all,i,GDPEXPCAT)(all,d,REG)
        GDPEXP(d)*contxgdpexp(i,d) = 100*RATIOG-
DPEXP(d)*delXGDPEXP(d,i);

! Indices and components of national expenditure side GDP !
    E_delNatXGDPEXP (all,i,NATGDPEXPCAT)
        delNatXGDPEXP(i) = sum{d,DST, delXGDPEXP(d,i)};
    E_xNatXGDPEXP (all,i,NATGDPEXPCAT)
        ID01[NATGDPEXPSUM(i)]*xNatXGDPEXP(i)=
100*delNatXGDPEXP(i);
    E_xnatgdpexp
        NATGDPEXP*xnatgdpexp = 100*sum{i,NATGDPEXPCAT,
delNatXGDPEXP(i)};
    E_delNatPGDPEXP (all,i,NATGDPEXPCAT)
        delNatPGDPEXP(i) = sum{d,DST, delPGDPEXP(d,i)};
    E_pnatgdpexp
        NATGDPEXP*pnatgdpexp = 100*sum{i,NATGDPEXPCAT,
delNatPGDPEXP(i)};
    E_wnatgdpexp
        wnatgdpexp = xnatgdpexp+pnatgdpexp;
    E_wnatgdpinc
        sum{d,DST, GDPINC(d)*[wgdpinc(d)-wnatgdpinc]} = 0;
    E_wnatgdpdiff
        wnatgdpdiff  = wnatgdpinc - wnatgdpexp;
    E_contxnatgdpexp (all,i,NATGDPEXPCAT)
```

```
        NATGDPEXP*contxnatgdpexp(i) = 100*RATIONG-
DPEXP*delNatXGDPEXP(i);

!Regional macro reporting variables !
    E_ximps (all,c,COM)(all,d,DST)
        ximps(c,d) = xtrad_r(c,"imp",d);
    E_ximpused (all,d,DST)
        IMPUSED_C(d)*ximpused(d) = sum{c,COM,
TRADE_R(c,"imp",d)*ximps(c,d)};
    E_pimpused (all,d,DST)
        IMPUSED_C(d)*pimpused(d) =
        sum{c,COM, sum{r,ORG, TRADE(c,"imp",r,d)*pimp(c,r)}};
    E_ximplanded (all,r,ORG)
        ID01[IMPLANDED_C(r)]*ximplanded(r) =
        sum{c,COM, TRADE_D(c,"imp",r)*xtrad_d(c,"imp",r)};
    E_pimplanded (all,r,ORG)
        ID01[IMPLANDED_C(r)]*pimplanded(r) =
        sum{c,COM, TRADE_D(c,"imp",r)*pimp(c,r)};

!*************************************************************
**************!
! Section 8.12. National price and quantity indices
!
!*************************************************************
**************!

Equation
    E_natxtot (all,i,IND)
        PRIM_D(i)*natxtot(i) = sum{d,DST,PRIM(i,d)*x1tot(i,d)};
    E_contnatxtot (all,i,IND)(all,d,DST)
        PRIM_D(i)*contnatxtot(i,d) = RATI-
OPRIM_D(i)*PRIM(i,d)*x1tot(i,d);
    E_xtrad_rd (all,c,COM)(all,s,SRC)
        ID01[TRADE_RD(c,s)]*xtrad_rd(c,s) =
        sum{d,DST, TRADE_R(c,s,d)*xtrad_r(c,s,d)};
    E_natximp (all,c,COM)
        natximp(c) = xtrad_rd(c,"imp");
    E_natxcom (all,c,COM)
        natxcom(c) = sum{r,REG,
[MAKE_I(c,r)/MAKE_IR(c)]*xcom(c,r)};
    E_natptot (all,i,IND)
        ID01[NATVTOT(i)]*natptot(i) = sum{d,DST,
VTOT(i,d)*p1tot(i,d)};
    E_natwprim (all,i,IND)
        ID01[PRIM_D(i)]*natwprim(i) =
sum{d,DST,PRIM(i,d)*wprim(i,d)};
```

```
Backsolve natwprim using E_natwprim;

!!
!*************************************************************
*************!
! section 8.13. Investment over time!
!*************************************************************
*************!

! Subsection 8.13.1.  Capital stocks and investment          !

! Capital investment accumulation relationship
!
! The underlying levels equation is:
!
! QCAPATT(i) = QCAPATT_B(i)*(1-DEP(i)) + QINV_BASE(i)
!

!Equation E_d_dum_year1 # One in year one, zero in later years
#
d_dum_year1 = ADJDUMYEAR1*d_unity;!

Equation
    E_d_f_ac_p_y
    # Gives shock in yr-to-yr forecasting to capital at begin-
ning of year t #
    (all,d,DST)(all,i,IND)
        ID01[QCAPATT(d,i)]*x1cap(i,d) =
        100*[QINV_BASE(d,i) - DEP(d,i)*QCAPATT_B(d,i)]*d_unity
+
        100*d_f_ac_p_y(d,i);

    E_x1cap_tplus1
    # Capital accum thru the fcst year (t) related to invest-
ment in the year #
    (all,i,IND)(all,d,DST)
        ID01[QCAPATTPLUS1(d,i)]*x1cap_tplus1(i,d) =
        [1-DEP(d,i)]*QCAPATT(d,i)*x1cap(i,d) + QIN-
VEST(d,i)*x2tot(i,d);

! this equation defines the q'ty of investments needed to sat-
isfy the
  growth rate of capital stock in period (t+1) spesified by in-
verse
  logistic relatioship !
    E_x1cap_id
        V1CAP_I*x1cap_id = sum{d,DST, sum{i,IND,
```

```
V1CAP(d,i)*x1cap(i,d)}};

    E_x2tot # Investment/capital ratios by industry #
    (all,i,IND)(all,d,DST)
        x2tot(i,d) =
        x1cap(i,d) + r_inv_cap_i(d,i) + r_inv_cap_d(i) +
r_inv_cap(d) +
        r_inv_cap_u;


    E_p2tot #Alias p2tot price of investment#
    (all,d,DST)(all,i,IND)
        p2tot(d,i)=pinvitot(i,d);

    E_x2tot_i (all,d,DST)
        sum{i,IND, INVEST_C(i,d)}*x2tot_i(d) =
        sum{i,IND, INVEST_C(i,d)*x2tot(i,d)};

    E_p2tot_i (all,d,DST)
        sum{i,IND, INVEST_C(i,d)}*p2tot_i(d) =
        sum{i,IND, INVEST_C(i,d)*p2tot(d,i)};

    E_x2tot_d (all,i,IND)
        sum{d,DST, INVEST_C(i,d)}*x2tot_d(i) =
        sum{d,DST, INVEST_C(i,d)*x2tot(i,d)};

    E_p2tot_d (all,i,IND)
        sum{d,DST, INVEST_C(i,d)}*p2tot_d(i) =
        sum{d,DST, INVEST_C(i,d)*p2tot(d,i)};

    E_f_x2tot (all,i,IND)(all,d,DST)
        x2tot(i,d) = f_x2tot(i,d) + f_x2tot_d(i) + f_x2tot_id;

    E_f_x2tot_d (all,i,IND)
        x2tot_d(i) = f_x2tot_d(i) + f_x2tot_id;

    E_pcapatt
    # Gives shock to start-of-year asset prices in year-to-year
simulations #
    (all,d,DST)(all,i,IND)
        PCAP_AT_T(d,i)*pcapatt(d,i) =
        100*[PCAP_AT_T1_B(d,i) - PCAP_AT_T_B(d,i)]*d_unity +
        100*d_f_pcapatt(d,i);

    E_pcapatt1 # End-of-year asset prices in year-to-year sims
#
    (all,d,DST)(all,i,IND)
```

```
        PCAP_AT_T1(d,i)*pcapatt1(d,i) =
        [1 +
0.5]*[PCAP_I(d,i)*[PCAP_I(d,i)/PCAP_I_B(d,i)]^(0.5)]*p2tot(d,i)
+
        100*[PCAP_I_B(d,i) - PCAP_AT_T1_B(d,i)]*d_unity +
        100*d_ff_pcapatt1(d,i);

! section 8.13.2. The inverse logistic relationships between
expected rates of
  return and rates of capital growth !

Variable
    (change)(all,i,IND) d_f_eeqror_d(i);


Equation
    E_d_f_eeqror
    # Change in equilibrium expected rate of return in forecast
year #
    (all,d,DST)(all,i,IND)
        d_eeqror(d,i) = [1/COEFF_SL(d,i)]*[1/[K_GR(d,i) -
K_GR_MIN(d,i)] +
        1/[K_GR_MAX(d,i) - K_GR(d,i)]]*d_k_gr(d,i) +
        d_f_eeqror(d,i) + d_f_eeqror_i(d) + d_f_eeqror_d(i);

    E_d_k_gr # Capital growth thru forecast year #
    (all,d,DST)(all,i,IND)
        d_k_gr(d,i) =
        [QCAPATTPLUS1(d,i)/QCAPATT(d,i)/100]*[x1cap_tplus1(i,d)
- x1cap(i,d)];

    E_ch_kgr1 # Provides convenient method for viewing the val-
ues of CHKGR1 #
    (all,d,DST)(all,j,IND)
        ch_kgr1(d,j) = CHKGR1(d,j)*d_unity;

    E_ch_kgr2 # Provides convenient method for viewing the val-
ues of CHKGR2 #
    (all,d,DST)(all,j,IND)
        ch_kgr2(d,j) = CHKGR2(d,j)*d_unity;

! section 8.16.4 Expected and actual rates of return, and the
algorithm for
  imposing forward-looking expectations  parameter!

    E_d_ror_se # Changes in expected rors by industry: static
exp. #
```

```
    (all,d,DST)(all,i,IND)
        100*d_ror_se(d,i) = [1/[1 + RINT_PT_SE]]*
        {
        [V1CAP(d,i)*[1 -
TAX_K_RATE]/VCAP_AT_TM(d,i)]*[p1cap(i,d) - p2tot(d,i)]
       - TAX_K_RATE*{[V1CAP(d,i)/VCAP_AT_TM(d,i)] -
RALPH*DEP(d,i)}*tax_k_rr
    -[V1CAP(d,i)*[1-TAX_K_RATE]/VCAP_AT_TM(d,i)
    +1-DEP(d,i)+RALPH*TAX_K_RATE*DEP(d,i)]*
            (1/[[1 + RINT_PT_SE]])*100*d_rint_pt_se
};

Equation E_d_rint_pt_se
      # Changes in real post-tax rate of interest, static ex-
pectations #
100*d_rint_pt_se = [1/[1+INF]]*{100*[1-TAX_K_RATE]*d_int
      -INTR*TAX_K_RATE*tax_k_rr-100*[1/[1+INF]]*[1+INTR*[1-
TAX_K_RATE]]*d_inf };

Equation E_p3tot_l
# Lagged value of the CPI if initial sol for year t is sol for
year t-1 #
  LEV_CPI_L*p3tot_l = 100*[LEV_CPI_B - LEV_CPI_L_B]*d_unity +
100*d_f_p3tot_l;

E_p1lab_iod
  [sum{d,DST,LAB_IO(d)}]*p1lab_iod =
sum{d,DST,LAB_IO(d)*p1lab_io(d)};

Equation E_p1lab_io_l
# Lagged value of the CPI if initial sol for year t is sol for
year t-1 #
  LEV_PLAB_L*p1lab_io_l = 100*[LEV_PLAB_B -
LEV_PLAB_L_B]*d_unity
                          + 100*d_f_p1lab_io_l;

Equation E_d_int # Nominal rate of interest #
  d_int = [1+INF]*d_rint + [1+RINT]*d_inf;

Equation E_d_inf # Rate of inflation #
  100*d_inf =[1+INF]*[p3tot - p3tot_l];

Equation E_d_eeqror
  # Expected ror equals equil. expec. ror plus disequilibrium
in expec. ror #
(all,d,DST)(all,i,IND) d_eror(d,i) = d_eeqror(d,i) +
d_diseq(d,i);
```

```
Equation E_d_diseq
  # Gives shock to disequil. in s.e. rors, moves them towards
zero #
(all,d,DST)(all,i,IND) d_diseq(d,i) =
    - ADJ_COEFF(d,i)*DISEQSE_B(d,i)*d_unity + d_f_diseq(d,i);

Equation E_d_f_diseqre
  # Gives shock to disequil. in r.e. rors, moves them towards
zero #
(all,d,DST)(all,j,IND) d_diseq(d,j) = - ADJ_COEFF(d,j)*DISE-
QRE_B(d,j)*d_unity
                              + d_f_diseqre(d,j);

Equation E_d_eror # Expected rate of return, static expecta-
tions #
(all,d,DST)(all,i,IND) d_eror(d,i) =  d_ror_se(d,i) +
d_ff(d,i);


Variable del_r_tot;

Variable (all,i,IND)(all,d,DST)
d_ff_eror(d,i);

Equation E_d_ff_eror # Allows for equalization of changes in
rates of return #
 (all,d,DST)(all,i,IND) d_eror(d,i) = del_r_tot +
d_ff_eror(d,i);

Coefficient QCAPATT_DI;
Formula
QCAPATT_DI=sum{d,DST,sum{i,IND,QCAPATT(d,i)}};

Variable capatt_di;

Equation E_capatt_di
QCAPATT_DI*capatt_di=sum{d,DST,sum{i,IND,QCA-
PATT(d,i)*x1cap(i,d)}};

Coefficient (all,d,DST) QCAPATT_I(d);
Formula
(all,d,DST) QCAPATT_I(d)=sum{i,IND,QCAPATT(d,i)};

Variable (all,d,DST) capatt_i(d);

Equation E_capatt_i
```

```
(all,d,DST) QCAPATT_I(d)*capatt_i(d)=sum{i,IND,QCA-
PATT(d,i)*x1cap(i,d)};

Equation E_d_eror_ave # Average expected rate of return #
(all,d,DST) d_eror_ave(d)=

1/ID01[sum{i,IND,V1CAP(d,i)}]*sum{i,IND,[V1CAP(d,i)]*d_eror(d,i
)};

Equation E_del_ror_se_o
  # Used in 1st rat. expect. policy iteration to introduce
forecast s.e. rors #
(all,d,DST)(all,i,IND) del_ror_se_o(d,i) = d_ror_se(d,i) +
d_f_ror_se_o(d,i);

Equation E_d_eror_o
  # Used in 1st rat. expect. policy iteration to introduce
forecast r.e. rors #
(all,d,DST)(all,i,IND) d_eror_o(d,i) = d_eror(d,i) +
d_f_eror_o(d,i);

Equation E_d_f # Expected rate of return, rational expectations
#
(all,d,DST)(all,i,IND) d_eror(d,i) =  ONE_ITER1*d_ror_se(d,i)
  + ONE_IT1_REP*COEFF_NYEAR*[ d_eror_o(d,i) + d_ror_se(d,i)-
del_ror_se_o(d,i)]
+[1-ONE_IT1_REP]*[1-ONE_ITER1]*COEFF_NYEAR*{EROR_F(d,i) -
EROR_B(d,i)}*d_unity
                                + d_f(d,i);

Equation  E_p2tot_l
  # Lag value of cap. asset price if init. sol for year t is
sol for year t-1 #
(all,d,DST)(all,i,IND)
    PCAP_I_L(d,i)*p2tot_l(d,i) = 100*[PCAP_I_B(d,i) -
PCAP_I_L_B(d,i)]*d_unity
                                      + 100*d_f_p2tot_l(d,i);

Equation E_d_int_l # Lagged nominal interest rate #
  d_int_l =  [1+RINT_L]*d_inf_l +[1+INF_L]*d_rint_l;

Equation E_d_inf_l # Lagged rate of inflation #
  100*d_inf_l =[1+INF_L]*[p3tot_l - p3tot_2l];

Equation E_d_f_rint_l
  # Lagged real interest rate, if init. sol for year t is sol
for year t-1 #
```

```
  d_rint_l =[RINT_B - RINT_L_B]*d_unity + d_f_rint_l;

 Equation  E_d_f_p3tot_2l
  # Double lagged value of the CPI if init. sol for year t is
sol for year t-1 #
  LEV_CPI_2L*p3tot_2l = 100*[LEV_CPI_L_B -
LEV_CPI_2L_B]*d_unity
                                      + 100*d_f_p3tot_2l;

Equation E_lev_eror # Level of the expected ror in year t #
(all,d,DST)(all,i,IND) lev_eror(d,i) = EROR_B(d,i)*d_unity +
d_eror(d,i);

Equation E_lev_eror_l # Level of the expected ror in year t-1 #
(all,d,DST)(all,i,IND) lev_eror_l(d,i) = EROR_B(d,i)*d_unity;

Equation E_lev_ror_act_l # Actual ror in year t-1 #
(all,d,DST)(all,i,IND)
    lev_ror_act_l(d,i) = ROR_ACT_L_B(d,i)*d_unity
+d_ror_act_l(d,i);

Equation E_d_ror_act_l # Actual rate of return for year t-1 #
(all,d,DST)(all,j,IND) 100*d_ror_act_l(d,j) =
        (1/{[1 + INTR_L*[1-TAX_K_RATE]]*PCAP_I_L(d,j)})*
        {  - [V1CAP(d,j)/QCAPATT(d,j)]*TAX_K_RATE*tax_k_rr
      + [1-TAX_K_RATE]*[V1CAP(d,j)/QCAPATT(d,j)]*[p1cap(j,d) -
p2tot_l(d,j)]
      + [1-DEP(d,j)]*PCAP_I(d,j)*[p2tot(d,j) - p2tot_l(d,j)]
  + RALPH*TAX_K_RATE*DEP(d,j)*PCAP_I(d,j)*[tax_k_rr +
p2tot(d,j)- p2tot_l(d,j)]}
       - {[1+ROR_ACT_L(d,j)]/[1 + INTR_L*[1-TAX_K_RATE]]}*
               {    100*[1-TAX_K_RATE]*d_int_l
                  - INTR_L*TAX_K_RATE*tax_k_rr
};

!****************************************************************
*************!
! section 8.14. Labour markets !
!****************************************************************
*************!

! definition of real wages !

Equation
E_p1lab (all,i,IND)(all,o,OCC)(all,d,DST)
  realwage(i,o,d) = p1lab(i,o,d) - pfin("Hou",d);
```

```
!####### sum-over-industry labour aggregates ##########!

Equation
E_p1lab_i (all,o,OCC)(all,d,DST)
  p1lab_i(o,d) = sum{i,IND, SLAB_I(i,o,d)*p1lab(i,o,d)};

E_realwage_i (all,o,OCC)(all,d,DST)
  realwage_i(o,d) = sum{i,IND, SLAB_I(i,o,d)*realwage(i,o,d)};

E_x1lab_i (all,o,OCC)(all,d,DST)
  x1lab_i(o,d) = sum{i,IND, SLAB_I(i,o,d)*x1lab(i,o,d)};

E_wlab_i  (all,o,OCC)(all,d,DST)
  wlab_i(o,d) = x1lab_i(o,d) + p1lab_i(o,d);

E_rlab_i  (all,o,OCC)(all,d,DST)
  rlab_i(o,d) = x1lab_i(o,d) + realwage_i(o,d);

!####### sum-over-industry-and-region labour aggregates
##########!
Equation
E_p1lab_id (all,o,OCC)
  p1lab_id(o) = sum{d,DST, SLAB_ID(o,d)*p1lab_i(o,d)};

E_realwage_id (all,o,OCC)
  realwage_id(o) = sum{d,DST, SLAB_ID(o,d)*realwage_i(o,d)};

E_x1lab_id (all,o,OCC)
  x1lab_id(o) = sum{d,DST, SLAB_ID(o,d)*x1lab_i(o,d)};

E_wlab_id  (all,o,OCC)
  wlab_id(o) = x1lab_id(o) + p1lab_id(o);

E_rlab_id  (all,o,OCC)
  rlab_id(o) = x1lab_id(o) + realwage_id(o);

!####### sum-over-occupation-and-industry labour aggregates
##########!
Equation
E_p1lab_io  (all,d,DST)
  ID01[LAB_IO(d)]*p1lab_io(d) =
sum{o,OCC,LAB_I(o,d)*p1lab_i(o,d)};
E_x1lab_io  (all,d,DST)
  ID01[LAB_IO(d)]*x1lab_io(d) =
sum{o,OCC,LAB_I(o,d)*x1lab_i(o,d)};
E_realwage_io  (all,d,DST)
```

```
  ID01[LAB_IO(d)]*realwage_io(d) = sum{o,OCC,LAB_I(o,d)*real-
wage_i(o,d)};
E_wlab_io  (all,d,DST)
  wlab_io(d) = x1lab_io(d) + p1lab_io(d);
E_rlab_io  (all,d,DST)
  rlab_io(d) = x1lab_io(d) + realwage_io(d);


!############# wage dynamics
#########################################!

Equation E_del_f_wage_c
# Relates deviation in CPI-deflated pre-tax wage to deviation
in employment #
[RWAGE/RWAGE_OLD]*[real_wage_c - real_wage_c_o]
    =    100*[[RWAGE_B/RWAGE_OLD_B]
    -   [RWAGE_L_B/RWAGE_O_L_B]]*d_unity
    +    ALPHA1*[NATEMP/NATEMP_OLD]*[employ_i - employ_i_o]
    -    100*ALPHA1*[[RWAGE_B/RWAGE_OLD_B]^ALPHA2
    -   [RWAGE_L_B/RWAGE_O_L_B]^ALPHA2]*d_unity
    +    del_f_wage_c;

Equation E_del_f_wage_pt
# Relates deviation in CPI-deflated post-tax wage to deviat. in
employment #
[RWAGE_PT/RWAGE_PT_OLD]*[real_wage_pt - real_wage_pt_o]
    =    100 * [[RWAGE_PT_B/RWAGE_PT_O_B]
    -   [RWAGE_PT_L_B/RW_PT_O_L_B]]*d_unity
    +    ALPHA1*[NATEMP/NATEMP_OLD]*[employ_i - employ_i_o]
    -    100*ALPHA1*[[RWAGE_PT_B/RWAGE_PT_O_B]^ALPHA2
    -   [RWAGE_PT_L_B/RW_PT_O_L_B]^ALPHA2]*d_unity
    +    del_f_wage_pt;

Equation E_real_wage_pt # Economy-wide CPI-deflated wage rate,
post tax #
real_wage_pt
    = real_wage_c
    - TAX_L_RATE/[1 - TAX_L_RATE]*tax_l_rds;

Equation E_d_f_empadj
  # Direct adjustment of employment back to basecase forecast #
[NATEMP/NATEMP_OLD]*[employ_i - employ_i_o]
    =    100*{[NATEMP_B/NATEMP_O_B]
    -   [NATEMP_L_B/NATEMP_O_L_B]}*d_empadj
    +    d_f_empadj;

Equation E_d_ff_empadj
```

```
  # Equation for moving level of shift variable in E_d_f_empadj
back to zero #
d_f_empadj
    =   {-FEMPADJ_B+ FEMPADJ_O}*d_emp_sh
    +    d_ff_empadj;

Equation E_real_wage_c # Economy-wide real wage rate for con-
sumers #
[AGGLAB-COL_PAYRTOT]*[real_wage_c + p3tot]
    =   sum{d,DST, sum{i,IND,[LAB_O(i,d)/POW_PAY-
ROLL(i,d)]*p1lab_o(i,d)}};

Equation E_real_wage_c_o
  # Introduces forecast CPI-deflated pre-tax wage into policy
simulation #
  real_wage_c_o = real_wage_c + f_rwage_o;

Equation E_employ_i_o # Introduces forecast employment into
policy simulation #
  employ_i_o  = employ_i + f_employ_i + f_employ_o;

Equation E_real_wage_pt_o
  # Forecast post-tax CPI-deflated wage used in policy simula-
tions #
  real_wage_pt_o = real_wage_pt + f_rwage_pt_o;

Equation E_tax_l_rds_o # Forecast tax rate on wages used in
policy simulations #
  tax_l_rds_o = tax_l_rds + ftax_l_rds_o;

Equation E_wlabnat
sum{d,DST,LAB_IO(d)}*wlabnat = sum{d,DST,LAB_IO(d)*wlab_io(d)};

Equation E_tax_l_rds # Forecast tax rate on wages used in pol-
icy simulations #
sum{d,DST,sum{s,PSEC,TAXS_LAB(d,s)}}*[wlabnat+tax_l_rds]
=
sum{d,DST,sum{s,PSEC,TAXS_LAB(d,s)*[wlab_io(d)+tax_l_r(d,s)]}};

Equation E_tax_l_r # Forecast tax rate on wages used in policy
simulations #
(all,d,DST)(all,s,PSEC)
    tax_l_r(d,s) = f_tax_l_r(d,s) + f_tax_l_rd(s);

Equation E_tax_k_r
# Rate of tax on capital income related to rate of tax on la-
bour income #
```

```
(all,d,DST)(all,s,PSEC)
  tax_k_r(d,s) = tax_l_r(d,s) + f_tax_k_r(d,s);

Equation E_tax_ub_r
# Rate of tax on capital income related to rate of tax on la-
bour income #
(all,d,DST)(all,s,PSEC)
  tax_ub_r(d,s) = tax_l_r(d,s) + f_tax_ub_r(d,s);

Equation E_tax_ab_r
# Rate of tax on capital income related to rate of tax on la-
bour income #
(all,d,DST)(all,s,PSEC)
  tax_ab_r(d,s) = tax_l_r(d,s) + f_tax_ab_r(d,s);

Equation E_tax_ob_r
# Rate of tax on capital income related to rate of tax on la-
bour income #
(all,d,DST)(all,s,PSEC)
  tax_ob_r(d,s) = tax_l_r(d,s) + f_tax_ob_r(d,s);

Equation E_x1lab_od # Industry level employment #
(all,i,IND) ID01[LAB_OD(i)]*x1lab_od(i) =
sum{d,DST,LAB_O(i,d)*x1lab_o(i,d)};

Equation E_employ_i # Employment at national level #
sum{d,DST,LAB_IO(d)}*employ_i =
sum{d,DST,[LAB_IO(d)]*x1lab_io(d)};

Equation E_f_labsup # Regional labour supply  #
(all,d,DST)
labsup(d) = x1lab_io(d)+(100/EMP_RATE(d))*d_UR(d);

Equation E_f_labsupn # National labour supply #
  LAB_SUPN*labsupn = sum{d,DST,LAB_SUP(d)*labsup(d)}+f_labsupn;

Equation E_d_URN # National labour supply #
labsupn=employ_i+[100/EMP_RATEN]*d_URN;

Equation E_labsupn_o # Forecast labour supply used in policy
simulations #
  labsupn_o = labsupn + f_labsupn_o;

Equation E_flab   # Flexible setting of money wages #
(all,i,IND)(all,o,OCC)(all,d,DST)
p1lab(i,o,d)=
p3tot+flab(i,o,d)+flab_id(o)+flab_io(d)+flab_o(i,d)+flab_iod+fl
```

```
ab_od(i);

!##############################################################
########!

!For regional labour supply, choose either:
A: inter-regional labour migration driven by wage differentials
between regions
    [consistent with a national supply of each OCC CET-ting be-
tween regions ]
B: no inter-regional wage differentials  !
!
Equation E_flabsupB # No inter-regional wage differentials #
 (all,o,OCC)(all,d,DST) !! 1.0 represents an elasticity value
!!
  realwage_i(o,d) = flabsupB(o,d) + labslack(o);
!

! rule for awarding extra wages to certain industries !
!

Variable
(all,i,IND)(all,o,OCC)(all,d,DST) flab(i,o,d) # Wage shifter #;
           (all,o,OCC)(all,d,DST) flab_i(o,d) # Wage shifter #;
                      (all,d,DST) flab_io(d)  # Wage shifter #;
                                  flab_iod    # National wage
shifter #;
                      (all,o,OCC) flab_id(o)  # National wage
shifter #;

Equation E_realwage  # Wage fixing rule #
 (all,i,IND)(all,o,OCC)(all,d,DST)
 realwage(i,o,d) = flab(i,o,d) +flab_i(o,d) +flab_io(d)
+flab_id(o) +flab_iod;
!
! usually realwage_i(o,d) will be determined by previous equa-
tions
  so flab_i(o,d) will be endogenous !

!!



!**************************************************************
**************!
!* Section 8.15.      Public sector accounts
*!
```

```
!***************************************************************
**************!

!Subsection 8.15.1 Government, municipal, and social security
fund
expenditures, revenues and deficits
!

Equation
    E_d_gov_defA
    # Public sector deficit, or public sector financing trans-
actions #
    (all,d,DST)(all,s,GSEC)
        100*d_gov_def(d,s) =
        V5TOTS(d,s)*w5tots(d,s) +
V2TOT_G_IS(d,s)*w2totg_is(d,s) +
        100*d_othcapgovs(d,s) - NET_TAXTOTS(d,s)*nettax-
tots(d,s) -
        OTHGOVREVS(s,d)*oth_govrevs(d,s) + 100*d_transfs(d,s) +
        GOVTOMUN(d)*f_govtomun(d) + GOVTOSSF(d)*f_govtossf(d) -
        MUNTOGOV(d)*f_muntogov(d) - SSFTOGOV(d)*f_ssftogov(d);

    E_d_gov_defB
    # Public sector deficit, or public sector financing trans-
actions #
    (all,d,DST)(all,s,LSEC)
        100*d_gov_def(d,s) =
        V5TOTS(d,s)*w5tots(d,s) +
V2TOT_G_IS(d,s)*w2totg_is(d,s) +
        100*d_othcapgovs(d,s) - NET_TAXTOTS(d,s)*nettax-
tots(d,s) -
        OTHGOVREVS(s,d)*oth_govrevs(d,s) + 100*d_transfs(d,s) +
        MUNTOGOV(d)*f_muntogov(d) - GOVTOMUN(d)*f_govtomun(d);

    E_d_gov_defC
    # Public sector deficit, or public sector financing trans-
actions #
    (all,d,DST)(all,s,FSEC)
        100*d_gov_def(d,s) =
        V5TOTS(d,s)*w5tots(d,s) +
        100*d_othcapgovs(d,s) - NET_TAXTOTS(d,s)*nettax-
tots(d,s) -
        OTHGOVREVS(s,d)*oth_govrevs(d,s) + 100*d_transfs(d,s) +
        SSFTOGOV(d)*f_ssftogov(d) - GOVTOSSF(d)*f_govtossf(d);

    E_d_gov_def_d
```

```
    # Public sector deficits, or public sector financing trans-
actions #
    (all,s,PSEC)
        d_gov_def_d(s) = sum{d,DST, d_gov_def(d,s)};

    E_d_gov_def_nat # Combined public sector deficit #
        d_gov_def_nat = sum{s,PSEC, d_gov_def_d(s)};

variable (Change) d_def_gdp_r;
variable (Change) lev_def_gdp_r;

Equation E_d_def_gdp_r
  # Change in the ratio of the government deficit to GDP #
  100*d_def_gdp_r =[100/V0GDPEXP]*d_gov_def_nat-
[GOV_DEF_D/V0GDPEXP]*w0gdpexp;

Equation E_lev_def_gdp_r
  # Level of the ratio of the government deficit to GDP #
  lev_def_gdp_r = R_DEFGDP_B*d_unity + d_def_gdp_r;

    E_d_othcapgov_nat # Combined public sector deficit #
        d_othcapgov_nat = sum{d,DST, sum{s,PSEC,
d_othcapgovs(d,s)}};

    E_w2totg_is # Value of public sector investments #
    (all,d,DST)(all,s,PSEC)
        V2TOT_G_IS(d,s)*w2totg_is(d,s) = sum{i,IND,
        V2SHRSG_(d,i,s)*INVEST_C(i,d)*[s2gov(i)+pinvi-
tot(i,d)+x2tot(i,d)]};




Variable (all,d,DST)(all,i,IND)(all,s,PSEC) x2totg(d,i,s);
Variable (Change)(all,d,DST)(all,i,IND)(all,s,PSEC)
d_f_x2totg(d,i,s);


Equation E_d_f_x2totg
(all,d,DST)(all,i,IND)(all,s,PSEC)
    [V2TOTSG_(d,i,s)+EP]*x2totg(d,i,s)
    =[V2SHRSG_(d,i,s)*INVEST_C(i,d)]*[s2gov(i)+x2tot(i,d)]
    +d_f_x2totg(d,i,s)
;
```

```
Equation E_w2totg_s
(all,d,DST)(all,i,IND)(all,s,PSEC)
w2totg_s(d,i,s)
 =pinvitot(i,d)+x2totg(d,i,s)
;



    E_w2totg_is_ds # Value of public sector investments #
        ID01[V2TOT_G_I_D]*w2totg_is_ds = sum{d,DST,sum{s,PSEC,
        V2TOT_G_IS(d,s)*w2totg_is(d,s)}};



    E_delV0tax_csi (all,d,DST)
        delV0tax_csi(d) =
        sum{c,COM, sum{s,SRC, sum{i,IND, delTAXint(c,s,i,d)}}}
+
        sum{c,COM, sum{s,SRC, delTAXhou(c,s,d) + delTAX-
inv(c,s,d) +
            delTAXgov(c,s,d) + delTAXexp(c,s,d)}} +
        sum{i,IND, delPTX(i,d)};

    E_w0tax_csis #Indirect tax revenue#
    (all,d,DST)(all,s,PSEC)
        ID01[V0TAX_CSIS(d,s)]*w0tax_csis(d,s) =
        100*delV0tax_csis(d,s);

Coefficient
    (all,s,PSEC) ISGSEC(s) # binary dummy #;
Formula
    (all,s,PSEC) ISGSEC(s) = 0;
    ISGSEC("S1311") = 1;
Equation
    E_delV0tax_csis #Indirect tax collection#
    (all,d,DST)(all,s,PSEC)
        delV0tax_csis(d,s) = ISGSEC(s)*delV0tax_csi(d);

    E_d_othcapgovs (all,d,DST)(all,s,PSEC)
        100*d_othcapgovs(d,s) =
OTHCAPGOVS_(s,d)*f_othcapgovs(d,s) +
        d_f_othcapgovs(d,s);

    E_f_othcapgovs (all,d,DST)(all,s,PSEC)
        f_othcapgovs(d,s) = wgdpexp(d) + f_othcapgov(d,s) +
f_othcapgov_d(s);
```

```
    E_d_col_payrs # Total collection of payroll taxes #
    (all,d,DST)(all,s,PSEC)
        100*d_col_payrs(d,s) = sum{i,IND,
        [POW_PAYROLLS(s,i,d)-1]/POW_PAY-
ROLL(i,d)*LAB_O(i,d)*wlab_o(i,d) +
        [LAB_O(i,d)/POW_PAYROLL(i,d)]*powpayrolls(d,i,s)};

    E_nettaxtots # Net collection of genuine indirect taxes and
income taxes #
    (all,d,DST)(all,s,PSEC)
        NET_TAXTOTS(d,s)*nettaxtots(d,s) =
V0TAX_CSIS(d,s)*w0tax_csis(d,s)  +
        INCTAXS(d,s)*taxrev_incs(d,s) + 100*d_col_payrs(d,s);

    E_d_nettaxtot (all,d,DST)(all,s,PSEC)
        100*d_nettaxtot(d,s) = NET_TAXTOTS(d,s)*nettax-
tots(d,s);

    E_d_nettaxtot_d (all,s,PSEC)
        100*d_nettaxtot_d(s) = sum{d,DST, d_nettaxtot(d,s)};

    E_oth_govrevsA
    # Other government revenue, e.g. income from public enter-
prises #
    (all,d,DST)(all,s,GSEC)
        oth_govrevs(d,s) = wnatgdpexp + f_oth_grevs(d,s);
    E_oth_govrevsB
    # Other government revenue, e.g. income from public enter-
prises #
    (all,d,DST)(all,s,LSEC)
        oth_govrevs(d,s) = wgdpexp(d) + f_oth_grevs(d,s);
    E_oth_govrevsC
    # Other government revenue, e.g. income from public enter-
prises #
    (all,d,DST)(all,s,FSEC)
        oth_govrevs(d,s) = wnatgdpexp + f_oth_grevs(d,s);

    E_d_othgovrev (all,d,DST)(all,s,PSEC)
        100*d_othgovrev(d,s) = OTHGOVREVS(s,d)*oth_gov-
revs(d,s);
    E_d_othgovrev_d (all,s,PSEC)
        d_othgovrev_d(s) = sum{d,DST,d_othgovrev(d,s)};

    E_d_transfs # Transfers from the government #
    (all,d,DST)(all,s,PSEC)
        d_transfs(d,s) =
        0.01*UNEMPBENS(s,d)*unemp_bens(d,s) +
```

```
        0.01*AGEBENS(s,d)*age_bens(d,s) +
        0.01*OTHBENS(s,d)*oth_bens(d,s) +
        0.01*GRANTSS(s,d)*grants_s(d,s) + d_net_int_gs(d,s);

    E_taxrev_incs # Income tax revenue #
    (all,d,DST)(all,s,PSEC)
        ID01[INCTAXS(d,s)]*taxrev_incs(d,s) =
            TAXS_LAB(d,s)*[wlab_io(d) + tax_l_r(d,s)] +
            TAXS_CAP(d,s)*[wcap_i(d) + tax_k_r(d,s)] +
            TAXS_LND(d,s)*[wlnd_i(d) + tax_k_r(d,s)] +
            TAXS_AB(d,s)*[age_bens(d,s) + tax_ab_r(d,s)] +
            TAXS_OB(d,s)*[oth_bens(d,s) + tax_ob_r(d,s)] +
            TAXS_UB(d,s)*[unemp_bens(d,s) + tax_ub_r(d,s)];

    E_unemp_bens # Unemployment benefits  #
    (all,d,DST)(all,s,PSEC)
        unemp_bens(d,s) = unempben_rats(d,s) +
        1/[LAB_SUP(d) - EMPLOYS(d)]*
            [LAB_SUP(d)*labsup(d)- EMPLOYS(d)*x1lab_io(d)] +
        f_unemp_bens(d,s) + f_unemp_bens_d(s);

    E_realwage_iod #National real wage change#
        sum{d,DST, LAB_IO(d)}*realwage_iod =
        sum{d,DST, ID01[LAB_IO(d)]*realwage_io(d)};

    E_p3tot #Alias for national consumer price index#
        p3tot=natp3tot("Allhou");

    E_unempben_rats # Unemployment benefit rate #
    (all,d,DST)(all,s,PSEC)
        unempben_rats(d,s) = p3tot + realwage_iod + f_unemp-
ben_rats(d,s);

    E_age_bens # Old age benefits paid by government #
    (all,d,DST)(all,s,PSEC)
        age_bens(d,s) = popaged(d) - popagednat +
        f_age_bens(d,s) + f_age_bens_d(s) + f_age_ben_nat;

    E_oth_bens # Other personal benefits paid by government #
    (all,d,DST)(all,s,PSEC)
        oth_bens(d,s) = pops(d) - popnat +
        f_oth_bens(d,s) + f_oth_bens_d(s) + f_oth_ben_nat;

    E_grants_s # Grants & transf. oth than unemp age & oth bens
#
    (all,d,DST)(all,s,PSEC)
        grants_s(d,s) = pops(d) - popnat +
```

```
        f_grants(d,s) + f_grants_d(s) + f_grants_nat;

    E_d_f_govtossf # Other personal benefits paid by government
#
    (all,d,DST)
        f_govtossf(d) = age_bens(d,"S1311")+ d_f_govtossf(d);

    E_d_f_muntogov # Other personal benefits paid by government
#
    (all,d,DST)
        f_muntogov(d) = nettaxtots(d,"S1313") + d_f_munto-
gov(d);

    E_d_f_ssftogov # Other personal benefits paid by government
#
    (all,d,DST)
        f_ssftogov(d) = age_bens(d,"S1314") + d_f_ssftogov(d);

    E_d_int_psd # Nominal rate of interest on public sector
debt #
        d_int_psd = [1 + INF]*d_rint_psd + [1 +
RINT_PSD]*d_inf;

    E_d_rint_psd
    # Link between real rates of interest on PSD and business
borrowing #
        d_rint_psd = d_rint + d_f_rint_psd;

    E_d_net_int_gs # Net interest payments from government #
    (all,d,DST)(all,s,PSEC)
        d_net_int_gs(d,s) = [[PSDATT(s,d)+PSDATT-
PLUS1(d,s)]/2]*d_int_psd +
        0.5*INT_PSD*[d_psd_ts(d,s) + d_psd_t1s(d,s)];

    E_d_net_int_gd # Net interest payments from government #
    (all,s,PSEC)
        d_net_int_gd(s) = sum{d,DST,
        [[PSDATT(s,d)+PSDATTPLUS1(d,s)]/2]*d_int_psd +
        0.5*INT_PSD*[d_psd_ts(d,s) + d_psd_t1s(d,s)]};

    E_d_transfs_h # Transfers from the government #
    (all,d,DST)(all,s,PSEC)
        d_transfs_h(d,s) =
        0.01*UNEMPBENS(s,d)*unemp_bens(d,s) +
        0.01*AGEBENS(s,d)*age_bens(d,s) +
        0.01*OTHBENS(s,d)*oth_bens(d,s) +
        0.01*GRANTSS(s,d)*grants_s(d,s) +
```

```
        SHRASS_H(d)*d_net_int_gd(s);

    E_d_psd_t1s # Public sector debt, end of year #
    (all,d,DST)(all,s,PSEC)
        d_psd_t1s(d,s) = d_psd_ts(d,s) + d_gov_def(d,s) +
d_f_psd_t1s(d,s);

    E_d_f_psd_ts
    # Gives shock to start-of-year public sector debt, yr-to-yr
sims #
    (all,d,DST)(all,s,PSEC)
        d_psd_ts(d,s) =
        [PSDATT_1_B(d,s) - PSDATT_B(d,s)]*d_unity +
d_f_psd_ts(d,s);

    E_d_psd_ts_d
    # Change in aggregate start-of-year public sector debt #
    (all,s,PSEC)
        d_psd_ts_d(s) = sum{d,DST, d_psd_ts(d,s)};

    E_d_psd_t1s_d
    # Change in aggregate start-of-year public sector debt #
    (all,s,PSEC)
        d_psd_t1s_d(s) = sum{d,DST, d_psd_t1s(d,s)};

    E_d_psd_ts_nat
    # Change in aggregate start-of-year public sector debt #
        d_psd_ts_nat = sum{s,PSEC,d_psd_ts_d(s)};

variable (Change) d_psd_gdp_r;
variable (Change) lev_psd_gdp_r;


Equation E_d_psd_gdp_r
  # Change in the ratio of the government deficit to GDP #
  100*d_psd_gdp_r = [100/V0GDPEXP]*d_psd_ts_nat -
[PSDATT_D/V0GDPEXP]*w0gdpexp;

Equation E_lev_psd_gdp_r
  # Level of the ratio of the government deficit to GDP #
  lev_psd_gdp_r = R_PSDGDP_B*d_unity + d_psd_gdp_r;


!*****************************************************************
*************!
! section 8.16 Household disposable income, household saving
```

```
and    !
! national saving
!
!*************************************************************
*************!

!*************************************************************
*************!
!Section 8.16.1. Household Income and Saving!
!*************************************************************
*************!

!
NAT_SAV       = HOUS_SAV - GOV_DEF + V2TOT_G_I + OTHCAPGOV;
NAT_SAV       = HOUS_SAV - GOV_DEF + V2TOT_G_I + OTHCAPGOV;
GOV_SAV       = NAT_SAV - HOUS_SAV;
VCAB = [V4TOT + C_INTAD +C_INTAE] - [V0IMP_C +  C_INTLD + C_IN-
TLE ] + NETTRN;
!

! Consumption function !

Variable
    natfhou # National ratio, nominal household consumption to
GDP #;
Equation
    E_natfhou
        NatMacro("NomHou") = natfhou + NatMacro("NomGDP");
    E_hdispinc # Household disposable income #
    (all,d,DST)
        HOUS_DIS_INC(d)*hdispinc(d) = GDPEXP(d)*wgdpexp(d) +
        sum{s,PSEC, 100*d_transfs_h(d,s) - NET_TAX-
TOTS(d,s)*nettaxtots(d,s) -
        OTHGOVREVS(s,d)*oth_govrevs(d,s)} +
        SHRASS_H(d)*
        [C_INTAD*intad + C_INTAE*intae - C_INTLD*intld - C_IN-
TLE*intle];

    E_hdispinc_d # Household disposable income #
        sum{d,DST,HOUS_DIS_INC(d)}*hdispinc_d =
        sum{d,DST,HOUS_DIS_INC(d)*hdispinc(d)};

    E_housav # Household saving #
    (all,d,DST)
        HOUS_SAV(d)*housav(d) =
        HOUS_DIS_INC(d)*hdispinc(d) - V3TOT(d)*wfin("Hou",d);
```

```
    E_housav_d # National saving #
        sum{d,DST, HOUS_SAV(d)}*housav_d =
        sum{d,DST, HOUS_SAV(d)*housav(d)};

    E_w3tot_d
        w3tot_d = natx3tot("Allhou") + natp3tot("Allhou");

Coefficient
    (parameter) ADJPROP;
Read
    ADJPROP from file EXTRA header "ADJP";

Equation
    E_f_f3tot (all,d,DST)
        [AV_PROP_CON(d)/NAT_PROP_CON]*[f3tot(d) - f_f3tot_d] =
        100*ADJPROP*[1 - AV_PROP_C_B(d)/NAT_PROP_C_B]*d_unity +
        f_f3tot(d) + f3tot_d;

    E_f3tot # Consumption related to disposable income #
    (all,d,DST)(all,h,HOU)
        HOUPUR_C(d,h)*w3tot(d,h) =
        AV_PROP_CON(d)*HOUS_DIS_INC(d)*[f3tot(d) + hdis-
pinc(d)];

!***************************************************************
*************!
!Traces implications of f3tot !
Variable
 (all,d,DST)(all,h,HOU) f3(d,h)
 # Regional propensity to consume from labour income #;

Equation
    E_f3 (all,d,DST)(all,h,HOU)

        w3tot(d,h) = wlab_io(d) + f3(d,h);

!***************************************************************
*************!
!Section 8.16.2. Trade balance and balance of payments!
!***************************************************************
*************!

!***************************************************************
***********!
!Section 8.16. TRADE FLOWS
!
!***************************************************************
```

```
***********!

! Exports to ROW by region of production !
! Strictly speaking, the concept of "Exports by region of pro-
duction" is not
  part of the TERM model. However, we can estimate them by mak-
ing additional
  common-sense assumptions [source share for exports is same as
for overall
  demand !

! Exports to ROW by region of production !
Equation
    E_xrowdem (all,c,COM)(all,r,ORG)(all,d,DST)
        xrowdem(c,r,d) =
        xexp(c,"dom",d) - xtrad_r(c,"dom",d) +
xtrad(c,"dom",r,d);

    E_xrowdem_d (all,c,COM)(all,r,ORG)
        ID01[ROWDEM_D(c,r)]*xrowdem_d(c,r) =
        sum{d,DST, ROWDEM(c,r,d)*xrowdem(c,r,d)};

!   Domestic trade flows    !
    E_xdomexp (all,c,COM)(all,r,REG)
        ID01[VDOMEXP(c,r)]*xdomexp(c,r) =
        TRADE_D(c,"dom",r)*xtrad_d(c,"dom",r) -
        TRADE(c,"dom",r,r)*xtrad(c,"dom",r,r);

    E_xdomimp (all,c,COM)(all,d,REG)
        ID01[VDOMIMP(c,d)]*xdomimp(c,d) =
        TRADE_R(c,"dom",d)*xtrad_r(c,"dom",d) -
        TRADE(c,"dom",d,d)*xtrad(c,"dom",d,d);

    E_xdomexp_c (all,r,REG)
        ID01[VDOMEXP_C(r)]*xdomexp_c(r) = sum{c,COM,VDO-
MEXP(c,r)*xdomexp(c,r)};

    E_xdomimp_c (all,d,REG)
        ID01[VDOMIMP_C(d)]*xdomimp_c(d) = sum{c,COM,VDO-
MIMP(c,d)*xdomimp(c,d)};

    E_xdomloc (all,c,COM)(all,r,REG)
        xdomloc(c,r) = xtrad(c,"dom",r,r);


!Trade balance!
```

```
Equation
    E_x4tot
        V4TOT_D*x4tot =
sum{d,DST,PUR_CS("exp",d)*xfin("exp",d)};
    E_p4tot
        V4TOT_D*p4tot =
sum{d,DST,PUR_CS("exp",d)*pfin("exp",d)};
    E_w4tot
        w4tot = x4tot + p4tot;

    E_x0imp_c
        V0IMP_C_D*x0imp_c = sum{d,DST,IM-
PUSED_C(d)*ximpused(d)};
    E_p0imp_c
        V0IMP_C_D*p0imp_c = sum{d,DST,IMPUSED_C(d)*pim-
pused(d)};
    E_w0imp_c
        w0imp_c = x0imp_c + p0imp_c;
    E_p0toft
        p0toft = p4tot - p0imp_c;
    E_p0realdev
        p0realdev = p0imp_c - p0gdpexp;

    E_delB
        100*V0GDPEXP*delB =
        V4TOT_D*w4tot - V0IMP_C_D*w0imp_c - [V4TOT_D -
V0IMP_C_D]*w0gdpexp;

    E_x0gdpexp
        x0gdpexp = xnatgdpexp;
    E_p0gdpexp
        p0gdpexp = pnatgdpexp;
    E_w0gdpexp
        w0gdpexp = x0gdpexp + p0gdpexp;

    E_gnpnom
        GNP*gnpnom = V0GDPEXP*w0gdpexp +
        C_INTAD*intad + C_INTAE*intae - C_INTLD*intld - C_IN-
TLE*intle +
        100*d_nettrn;

    E_natsav
    # National saving: household saving plus public sector sur-
plus #
        NAT_SAV*natsav = HOUS_SAV_D*housav_d +
100*d_govsav_nat;
```

```
    E_d_natsav
    # National saving: household saving plus public sector sur-
plus #
        d_natsav = 0.01*HOUS_SAV_D*housav_d + d_govsav_nat;

    E_d_govsav_nat # Government saving #
        d_govsav_nat =
        0.01*V2TOT_G_I_D*w2totg_is_ds + d_othcapgov_nat -
d_gov_def_nat;

!Accumulation of foreign assets!

    E_d_dum_year1 # One in year one, zero in later years #
        d_dum_year1 = ADJDUMYEAR1*d_unity;

    E_d_nettrn # Evolution of net transfers #
        d_nettrn = V0GDPEXP*d_f_trn + 0.01*NETTRN*w0gdpexp;

    E_a1e
        C_A1E*a1e = C_A0E*a0e + [C_FE*NAT_SAV]*[fe + natsav] +
        C_A0E*C_REVAE*a0e + 100*C_A0E*d_revae;

    E_a1d
        C_A1D*a1d = C_A0D*a0d + [C_FD*NAT_SAV]*[fd + natsav] +
        C_A0D*C_REVAD*a0d + 100*C_A0D*d_revad;

    E_l1e
        C_L1E*l1e = C_L0E*l0e + 100*d_newle + C_L0E*C_REVLE*l0e
+
        100*C_L0E*d_revle;

    E_l1d
        C_L1D*l1d = C_L0D*l0d + 100*d_newld + C_L0D*C_REVLD*l0d
+
        100*C_L0D*d_revld;

    E_d_newld
        ratio_led = l1e - l1d;

    E_a0e
        C_A0E*a0e = 100*[C_A1E_B - C_A0E_B]*d_unity;

    E_a0d
        C_A0D*a0d = 100*[C_A1D_B - C_A0D_B]*d_unity;

    E_l0e
        C_L0E*l0e = 100*[C_L1E_B - C_L0E_B]*d_unity;
```

```
    E_l0d
        C_L0D*l0d = 100*[C_L1D_B - C_L0D_B]*d_unity;

    E_d_newle
        100*d_cab = C_FE*NAT_SAV*[fe + natsav] +
C_FD*NAT_SAV*[fd + natsav] -
        100*d_newle - 100*d_newld;
    E_d_cab
        100*d_cab = [V4TOT_D*w4tot + C_INTAD*intad + C_IN-
TAE*intae] -
        [V0IMP_C_D*w0imp_c + C_INTLD*intld + C_INTLE*intle ] +
100*d_nettrn;

    E_intad
        intad = roiad + a0d;
    E_intae
        intae = roiae + a0e;
    E_intld
        intld = roild + l0d;
    E_intle
        intle = roile + l0e;

    E_d_Bot
        100*V0GDPEXP*d_bot =
        V4TOT_D*w4tot - V0IMP_C_D*w0imp_c - [V4TOT_D -
V0IMP_C_D]*w0gdpexp;


!#############################################################
##############!
!Section 8.17 Reporting variables
!
!
!
!#############################################################
##############!
!*************************************************************
*************!
! Section 8.17.1.
!
! Variables for reporting purposes: attack problem of % change
in nothing   !
! Below variables MUST be endogenous and should be backsolved
!
!*************************************************************
```

```
*************!
Coefficient (parameter) SIGNIF # Threshold reporting value #;
Formula     (initial)   SIGNIF = 1;

Variable (all,c,COM)(all,d,DST) xexpSHO(c,d)
   # Export demands for domestic all-region composite leaving
port at d #;
Equation E_xexpSHO (all,c,COM)(all,d,DST)
  xexpSHO(c,d) = if(USE(c,"dom","exp",d)>SIGNIF,
xexp(c,"dom",d));

Variable (all,i,IND)(all,d,DST) x1capSHO(i,d) # Capital usage
#;
Equation E_x1capSHO (all,i,IND)(all,d,DST)
  x1capSHO(i,d) = if(CAP(i,d)>SIGNIF, x1cap(i,d));

Variable (all,i,IND)(all,d,DST) pcapSHO(i,d) # Rental price of
capital #;
Equation E_pcapSHO (all,i,IND)(all,d,DST)
  pcapSHO(i,d) = if(CAP(i,d)>SIGNIF, p1cap(i,d));

Variable (all,i,IND)(all,d,DST) x1lab_oSHO(i,d) # Effective la-
bour input #;
Equation E_x1lab_oSHO (all,i,IND)(all,d,DST)
  x1lab_oSHO(i,d) = if(LAB_O(i,d)>SIGNIF, x1lab_o(i,d));

Variable (all,i,IND)(all,d,DST) x2totSHO(i,d) # Investment by
industry #;
Equation E_x2totSHO (all,i,IND)(all,d,DST)
  x2totSHO(i,d) = if(INVEST_C(i,d)>SIGNIF, x2tot(i,d));

!***************************************************************
*************!
! Section 8.17.2.
!
! Sectoral contributions to regional GDP at factor cost
!
!***************************************************************
*************!

Equation
 E_contxprim_i (all,i,IND)(all,d,DST)
   contxprim_i(i,d) = RATIOPRIM_I(d)*PRIMSHR(i,d)*x1prim(i,d);


 E_xprim_i (all,d,DST) xprim_i(d) = sum{i,IND, PRIM-
SHR(i,d)*x1tot(i,d)};
```

```
!above could also be: RATI-
OPRIM_I(d)*xPRIM_I(d)=sum{i,IND,contxPRIM_I(i,d)}!

! Excerpt 32 of TABLO input file: !
! Contributions of endowments, tech change and tax to national
real GDP !

! Keller decomposition
These are matrices (best viewed by ViewHAR from the SOL file)
which add
up to the percent change in real GDP
!
Set CONTINC # Contributors to real income gdp change #
(Land, Labour, Capital,                                      !
factors !
 a1lnd, a1cap, a1lab_o, aprim, atot, a1int_s, atradmar,      !
tech change !
 PRODTAX, ComTax);                                           !
indirect taxes !

Coefficient NATGDPINC # National income-side GDP #;
            RATIOXGDP # (Current/initial) ratio, national real
gdp #;
Formula     NATGDPINC = sum{d,DST, GDPINC(d)};
  (initial) RATIOXGDP = 1;
Update      RATIOXGDP = NatMacro("RealGDP");

Variable
 (change)(all,i,IND)(all,d,DST)(all,c,CONTINC)
  contincind(i,d,c) # Industry contribution terms to national
real income gdp #;
 (change)(all,i,IND)(all,c,CONTINC)
  contincind_d(i,c) # Industry contribution terms to national
real income gdp #;
Equation E_contincind
 (all,i,IND)(all,d,DST)(all,c,CONTINC) contincind(i,d,c) =
[RATIOXGDP/NATGDPINC]*{
  if[c="Land",    LND(i,d)*x1lnd(i,d)]
+ if[c="Labour",  sum{o,OCC, LAB(i,o,d)*x1lab(i,o,d)}]
+ if[c="Capital", CAP(i,d)*x1cap(i,d)]
- if[c="a1lnd",    LND(i,d)*a1lnd(i,d)]
- if[c="Capital", CAP(i,d)*a1cap(i,d)]
- if[c="a1lab_o",  LAB_O(i,d)*[a1lab_o(i,d)+a1lab_od(i)]]
- if[c="aprim",   PRIM(i,d)*a1prim(i,d)]
- if[c="atot",    VCST(i,d)*a1tot(i,d)]
- if[c="a1int_s",  sum{k,COM, PUR_S(k,i,d)*a1int_s(k,i,d)}]
+ if[c="prodtax", PRODTAX(i,d)*x1tot(i,d)]};
```

```
Equation E_contincind_d
 (all,i,IND)(all,c, CONTINC) contincind_d(i,c) =sum{d,DST, con-
tincind(i,d,c)};

Variable
(change) (all,c,COM)(all,s,SRC)(all,d,DST)
   continccom(c,s,d) # COMTAX contribution terms to national
real income gdp #;
Equation E_continccom
(all,c,COM)(all,s,SRC)(all,d,DST)  continccom(c,s,d) =
[RATIOXGDP/NATGDPINC]*{
  sum{i,IND, TAX(c,s,i,d)*x1(c,s,i,d)}
           + TAX(c,s,"hou",d)*x3(c,s,d)
           + TAX(c,s,"inv",d)*x2(c,s,d)
           + TAX(c,s,"gov",d)*xgov(c,s,d)
           + TAX(c,s,"exp",d)*xexp(c,s,d)};

Variable
(change) (all,d,DST)(all,c,CONTINC) contincagg(d,c)
    # Combined contribution terms to national real income gdp
#;
Equation E_contincagg
 (all,d,DST)(all,c,CONTINC) contincagg(d,c) = sum{i,IND, con-
tincind(i,d,c)}
+ if[c="comtax", sum{cc,COM,sum{s,SRC, continccom(cc,s,d)}}]
- if[c="atradmar",  sum{k,COM,sum{s,SRC,sum{m,MAR,sum{r,ORG,
        TRADMAR(k,s,m,r,d)*atradmar(k,s,m,r,d)}}}}];

Variable
(change) (all,c,CONTINC) contincagg_d(c)
    # Contribution terms to national real income gdp #;
Equation E_contincagg_d
 (all,c,CONTINC) contincagg_d(c) = sum{d,DST, contincagg(d,c)};

! COM and REG contributions to national export and import price
indices !
Set TRADDIR (EXP, imp);
Coefficient (all,t,TRADDIR) RatioTOT(t) # Terms of Trade #;
Formula (initial)(all,t,TRADDIR) RatioTOT(t) = 1;
Update
 RatioTOT("exp") = NatMacro("ExportPI");
 RatioTOT("imp") = NatMacro("ImpsLandedPI");
Variable (change)(all,c,COM)(all,q,REG)(all,t,TRADDIR) contTrm-
sTrad(c,q,t)
   # Contributions to national export and import price indices
#;
```

```
Equation E_contTrmsTradA
(all,c,COM)(all,q,REG) WNATMACRO("ExpVol")*contTrm-
sTrad(c,q,"exp") =
 RatioTOT("Exp")*PUR_S(c,"exp",q)*pfin("Exp",q);

Equation E_contTrmsTradB
(all,c,COM)(all,q,REG) WNATMACRO("ImpVolUsed")*contTrm-
sTrad(c,q,"imp") =
 RatioTOT("Imp")*TRADE_D(c,"imp",q)*pimp(c,q);

!**************************************************************
*************!
! Section 8.17.3.
!
! Regional macro reporting variables
!
!**************************************************************
*************!

Equation
 E_MainMacroA (all,q,REG) MainMacro("RealHou",q) =
xfin("Hou",q);
 E_MainMacroB (all,q,REG) MainMacro("RealInv",q) =
xfin("Inv",q);
 E_MainMacroC (all,q,REG) MainMacro("RealGov",q) =
xfin("Gov",q);
 E_MainMacroD (all,q,REG) MainMacro("ExpVol",q) =
xfin("Exp",q);
 E_MainMacroE (all,q,REG) MainMacro("ImpVolUsed",q) =
ximpused(q);
 E_MainMacroF (all,q,REG) MainMacro("ImpsLanded",q) = ximp-
landed(q);
 E_MainMacroG (all,q,REG) MainMacro("RealGDP",q) = xgdpexp(q);
 E_MainMacroH (all,q,REG) MainMacro("AggEmploy",q) =
x1lab_io(q);
 E_MainMacroI (all,q,REG) MainMacro("realwage_io",q) = real-
wage_io(q);
 E_MainMacroJ (all,q,REG) MainMacro("p1lab_io",q) =
p1lab_io(q);
 E_MainMacroK (all,q,REG) MainMacro("AggCapStock",q) =
x1cap_i(q);
 E_MainMacroL (all,q,REG) MainMacro("CPI",q) = pfin("Hou",q);
 E_MainMacroM (all,q,REG) MainMacro("GDPPI",q) = pgdpexp(q);
 E_MainMacroN (all,q,REG) MainMacro("ExportPI",q) =
pfin("Exp",q);
 E_MainMacroO (all,q,REG) MainMacro("ImpsLandedPI",q) = pim-
planded(q);
```

```
 E_MainMacroP (all,q,REG) MainMacro("Population",q) = nhou(q);
 E_MainMacroQ (all,q,REG) MainMacro("NomHou",q) =
wfin("Hou",q);
 E_MainMacroR (all,q,REG) MainMacro("NomGDP",q) = wgdpexp(q);

! Excerpt 29 of TABLO input file: !
! Aggregation of regional macro variables to national macro
variables !

Equation E_NatMacro (all,m,MAINMACROS)
   WNATMACRO(m)*NatMacro(m) =  sum{q,REG,WMAINMACRO(m,q)*Main-
Macro(m,q)};
Equation E_contMainMacro (all,m,MAINMACROS)(all,q,REG)
   WNATMACRO(m)*contMainMacro(m,q)
      =  RATIOMMACRO(m)*WMAINMACRO(m,q)*MainMacro(m,q);

Variable (change) shrBoT # National real balance of trade as %
of real GDP #;
! S=100B/G -> SG=100B -> SdG+GdS=100dB -> SGg/100+GdS=100dB ->
Bg+GdS=100dB !
Equation E_shrBoT
[WNATMACRO("ExpVol")-WNATMACRO("ImpsLanded")]*NatMacro("Real-
GDP")
+ WNATMACRO("RealGDP")*shrBoT =
WNATMACRO("ExpVol")*NatMacro("ExpVol")
                                               -
WNATMACRO("ImpsLanded")*NatMacro("ImpsLanded");

Variable ! shrBoTnom may be chosen as exogenous for trade bal-
ance constra1int !
 (change) shrBoTnom # National nominal balance of trade as % of
nominal GDP #;
! S=100B/G -> SG=100B -> SdG+GdS=100dB -> SGg/100+GdS=100dB ->
Bg+GdS=100dB !
Equation E_shrBoTnom
[WNATMACRO("ExpVol")-
WNATMACRO("ImpsLanded")]*NatMacro("NomGDP")
+ WNATMACRO("RealGDP")*shrBoTnom =
  WNATMACRO("ExpVol")*[NatMacro("ExpVol")+NatMacro("ExportPI")]
-
WNATMACRO("ImpsLanded")*[NatMacro("ImpsLanded")+NatMacro("ImpsL
andedPI")];

! Commodity contributions to selected national results !

Set COMMACROS # MAINMACROS with commodity components #
 (RealHou,  RealInv, RealGov,ExpVol,
```

```
ImpsLanded, CPI,ExportPI, ImpsLandedPI);
Subset COMMACROS is subset of MAINMACROS;
Variable
(change)(all,c,COM)(all,m,COMMACROS)
   contComMacro(c,m) # Commodity contributions to national
macro results #;

Equation
 E_contComMacroA
 (all,c,COM) WNATMACRO("RealHou")*contComMacro(c,"RealHou")
   = RATIOMMACRO("RealHou")*sum{d,DST,
PUR_S(c,"Hou",d)*x3_sh(c,d)};
 E_contComMacroB
 (all,c,COM) WNATMACRO("RealInv")*contComMacro(c,"RealInv")
   = RATIOMMACRO("RealInv")*sum{d,DST,
PUR_S(c,"Inv",d)*x2_s(c,d)};
 E_contComMacroC
 (all,c,COM) WNATMACRO("RealGov")*contComMacro(c,"RealGov")
  = RATIOMMACRO("RealGov")*sum{d,DST,
PUR_S(c,"Gov",d)*xgov_s(c,d)};

 E_contComMacroD
 (all,c,COM) WNATMACRO("ExpVol")*contComMacro(c,"ExpVol")
  = RATIOMMACRO("ExpVol")*sum{d,DST,
PUR_S(c,"Exp",d)*xexp_s(c,d)};

 E_contComMacroE
 (all,c,COM) WNATMACRO("ImpsLanded")*contCom-
Macro(c,"ImpsLanded")
   = RATIOM-
MACRO("ImpsLanded")*sum{r,ORG,TRADE_D(c,"imp",r)*xtrad_d(c,"imp
",r)};
 E_contComMacroF
 (all,c,COM) WNATMACRO("CPI")*contComMacro(c,"CPI")
   = RATIOMMACRO("CPI")*sum{d,DST,
PUR_S(c,"Hou",d)*ppur_s(c,"Hou",d)};
 E_contComMacroG
 (all,c,COM) WNATMACRO("ExportPI")*contComMacro(c,"ExportPI")
   = RATIOMMACRO("ExportPI")*sum{d,DST,
PUR_S(c,"Exp",d)*ppur_s(c,"Exp",d)};
 E_contComMacroH
 (all,c,COM) WNATMACRO("ImpsLandedPI")*contCom-
Macro(c,"ImpsLandedPI")
   = RATIOMMACRO("ImpsLandedPI")*sum{r,ORG,
TRADE_D(c,"imp",r)*pimp(c,r)};

Variable
```

```
 (change) (all,m,COMMACROS) NatComMacrox(m) # Sum of contCom-
Macro(c,m) #;
          (all,m,COMMACROS) NatComMacro(m)  # Check:should =
NatComMacrox(m) #;
Equation
E_NatComMacro  (all,m,COMMACROS) NatComMacro(m) = NatMacro(m);
E_NatComMacrox (all,m,COMMACROS) NatComMacrox(m) =
sum{c,COM,contComMacro(c,m)};

!****************************************************************
*************!
! Section 8.17.4.
!
! Weights for variable aggregation of results
!
!****************************************************************
*************!

Coefficient
 (all,c,COM)(all,q,REG) Import(c,q);
 (all,c,COM)(all,q,REG) Export(c,q);
Formula
 (all,c,COM)(all,q,REG) Import(c,q) = TRADE_D(c,"imp",q);
 (all,c,COM)(all,q,REG) Export(c,q) = PUR_S(c,"exp",q);
Write
Import to file SUMMARY header "IMP" longname "Internat regional
imports";
HOUSHR to file SUMMARY header "HOUP";
INVEST_I to file SUMMARY header "VINV" longname "Investment
costs";
LAB_O to file SUMMARY header "LAB" longname "Labour costs";
PRIM to file SUMMARY header "PRIM" longname "Primary factor
payments";
VARCST to file SUMMARY header "VCST" longname "Variable costs";
CAP to file SUMMARY header "CAP" longname "Capital rentals";
Export to file SUMMARY header "VEXP" longname "Exports";
NATVTOT to file SUMMARY header "NATV" longname "National out-
put";
HOUPUR_H to file SUMMARY header "HOUS";
Set WAGG
(xtot@@VTOT,
ptot@@VTOT,
x1cap@@CAP,
pcap@@CAP,
pimp@@IMP,
xhou@@HOUP,
xinv@@VINV,
```

```
p1lab@@LAB,
x1lab@@LAB,
aprm@@PRIM,
pvar@@VCST,
xexp@@VEXP,
ximp@@IMP,
nvto@@@@NATV,
munx@@@@MVTO,
xhos@@@@HOUS);
Write (Set) WAGG to file SUMMARY header "WAGG";


!**************************************************************
*************!
! Section 8.17.5.
!
! Regional transfers
!
!**************************************************************
*************!


Set AGEPSEC #Age grouping used for age-specific public sector
demand#
read elements from file POPUDATA header "AGEP";

Set AGEWAPSEC (a16_64,a65_74);
Subset AGEWAPSEC is subset of AGEPSEC;

Set AGENWPSEC = AGEPSEC - AGEWAPSEC;

Set AGEOLD (a65_74,a75_84,a85P);
Write (Set) AGEOLD  to file SUMMARY header "AGEO";


Coefficient

(all, ap,AGEPSEC) POPSEC(ap) # Population by PSEC age group #;

Coefficient
            (all,m,REG) MUNPOP(m) #Total population by munici-
pality#;
(parameter) (all,m,REG) MUNPOP_B(m) #Total population by munic-
ipality base#;
            (all,m,REG) MUNPOP_L(m)
                #Total population by municipality one year
```

```
ago#;
(parameter) (all,m,REG) MUNPOP_LB(m)
                    #Total population by municipality one year ago
#;
               (all,m,REG) MUNPOP_2L(m)
                    #Total population by municipality two years
ago#;
(parameter) (all,m,REG) MUNPOP_2LB(m)
                    #Total population by municipality two years
ago#;

               (all,r,MREG)(all,A,AGEPSEC) MRAGPOP(r,A)
                    #Municipalities population by PSEC age group#;
               (all,A,AGEPSEC)(all,r,REG) REGAGPOP(A,r)
                    #All regions' population by PSEC age group#;
               (all,m,REG) MINCTOT_L(m) #Total income of munici-
palities lagged#;
               (all,m,REG) MINCTOT_2L(m) #Total income of munici-
palities two lags#;
               (all,m,REG) MINCPC_L(m) #Total per-capita income of
municipalities#;
               (all,m,REG) MINCPC_2L(m)
                    #Total per-capita income of municipalities#;
(parameter) (all,m,REG) MINCTOT_LB(m) #Total income of munici-
palities 1 lag#;
(parameter) (all,m,REG) MINCTOT_2LB(m) #Total income of munici-
palities 2 lags#;
               (all,m,REG) MINCTOT(m) #Total income of municipali-
ties#;
(parameter) (all,m,REG) MINCTOT_B(m) #Total income of munici-
palities BASE#;
               (all,m,MREG) MAVINCDIF(m)
                    #Difference from average per-cap munic income#;
               (all,m,MREG) MUNEQUAL(m) #Equalisation of municipal
income#;


               MINCAVE #Average per-capita income of municipali-
ties#;
(all,m,REG) MINCUTOFF(m) #Cut-off rate for equalisation calcu-
lus#;
               MUNEQSHARE #Share of income going to redistribu-
tion#;
(parameter)(all,m,REG) MINCUTOFF_B(m) #Cut-off rate for equali-
sation calculus base#;
(parameter) MUNEQSHARE_B #Share of income going to redistribu-
tion base#;
```

```
            (all,r,MREG) MREGEQUAL(r)
                #Income equalisation within mainland region#;
            (all,r,REG) REGEQUAL(r) #Income equalisation mapped
to all region#;
(parameter) (all,r,REG) REGEQUAL_B(r)
                #Income equalisation mapped to all region#;
            MINCAVE_L #Average per-capita income of municipali-
ties#;

            (all,m,MREG) MAVINCDIF_L(m)
                #Difference from average per-cap munic income#;
            (all,m,MREG) MUNEQUAL_L(m)
                #Equalisation of municipal income#;
(all,r,REG) MINCUTOFF_L(r) #Lagged cut-off rate for equalisa-
tion calculus#;
            MUNEQSHARE_L #Lagged share of income going to re-
distribution#;
(parameter)(all,r,REG) MINCUTOFF_LB(r) #Lagged cut-off rate for
equalisation calculus base#;
(parameter) MUNEQSHAR_LB #Lagged share of income going to re-
distribution base#;
            (all,r,MREG) MREGEQUAL_L(r)
                #Income equalisation within mainland region#;
            (all,r,REG) REGEQUAL_L(r)
                #Income equalisation mapped to all region#;
(parameter) (all,r,REG) REGEQUAL_LB(r)
                #Income equalisation mapped to all region#;
(parameter) (all,r,REG) REG2AL(r) #Mapping vector for Aland
figures#;
            ALTAX_L #State income tax revenue in Aaland lagged
by one year#;
(parameter) ALTAX_LB #State inc tax rev in Aaland lagged by one
year, base#;
            ALTAX #State income tax revenue in Aaland#;
(parameter) ALTAX_B #State income tax revenue in Aaland#;
            ALLUMP #State lumpsum paid on budget income to Aa-
land acc to ALSHA#;
(parameter) ALSHA #Aaland's share of state budget income, 0.45
per cent#;
            STINCTAX #State income tax needed for Aaland calcu-
lations#;
(parameter) STINCTAX_B #State income tax needed for Aaland cal-
culations,base#;
            STINCTAX_L #Lagged state income tax needed for Aa-
land calculations#;
(parameter) STINCTAX_LB #Lagged state income tax needed for Aa-
land calc, base#;
```

```
            ALRECOMP
        #Recompensation paid to Aaland Gov acc to income tax
revenue formula#;
            ALRECOMPRE
        #Prel Recompens to Aaland Gov acc to income tax revenue
formula#;
(parameter) RECOMPSH #Recompensation cutoff share, 0.5 per cent
#;
            ALTRTOT #Total transfer to Aland#;
            INDXCUT #Share of p3tot transferred to VOS#;
            (all,r,MREG)(all,A,AGEPSEC) SOHEAGE(r,A)
                #Age-based social and health care VOS to mu-
nicip#;
            (all,r,MREG) SOHEFINSH(r)
                #State financing share of calculated soc &
health costs#;
(parameter) (all,r,MREG) SOHEFINSH_B(r)
                #State financing share of calculated soc &
health costs base#;
            (all,r,MREG) SOHEPAID(r) #Paid sohe-payments#;
            (all,r,MREG) SOHETOT(r) #Calc. sohe-costs#;
            (all,r,MREG) VOSGEN(r) #General-purpose VOS#;
            (all,r,MREG) VOSEDU(r) #Education and culture VOS#;
            (all,r,REG) VOSTOT(r)
                #Total VOS net of income equalisation + Aa-
land#;
            VOSNAT #The state total of VOS to municipalities#;

            (all,r,REG) NETTOMUN(r);

Variable
(change)(all,r,REG) d_mincutch(r) # Change in the cutoff rate#;
(change)
            d_muneqch # Change in the income equalisation
rate#;
(change)(all,r,REG)
            d_mincutch_l(r) # Lagged change in the cutoff
rate#;
(change)
    d_muneqch_l # Lagged change in the income equalisation
rate#;
(change)
    d_indxcutch # Change in the compensation for inflation#;
(change)(all,r,REG)
    d_regeqch(r) # Change in municipal equalisation#;
(change)(all,r,REG)
    d_f_nettomun(r);
```

```
(change)(all,r,REG)
    d_govtomun(r);
(change)(all,r,REG)
    d_d_govtomun(r);
(change)(all,r,REG)
    d_ff_nettomun(r);
    staxinc_l #Lagged state income tax revenue#;
    alinc_l #Lagged state income tax revenue in Aaland#;
    al045trans #Transfer of 0.45 per cent share of state bud
inc to Aland#;
    altottrans #Total transfer to Aland#;
    taxrev_inc_gov;
    vosnatch #State total for VOS change #;
(all,m,MREG)
    muninc_l(m) #Lagged municipal income growth#;
(all,m,MREG)
    muninc_2l(m) #Twice-lagged municipal income growth#;
(all,m,MREG)
    mpop(m) #Municipal population growth#;
(all,m,MREG)
    mpop_l(m) #Lagged municipal population growth#;
(all,m,MREG)
    mpop_2l(m) #Twice-lagged municipal population growth#;
(all,m,MREG)
    taxrev_incm(m);
!
(all,r,MREG)
    finshach(r) #State financing share of health & soc costs#;
!
!
(all,r,MREG)(all,A,AGEPSEC)
    vosagech(r,A) #Age-based soc & health VOS#;
!
!THESE TWO CAN GO!
(all,r,MREG)
    vsohepaid(r) #Paid sohe-payments#;

(all,r,MREG)
    vsohetot(r) #Calc. sohe-costs#;
!
(all,r,MREG)
    vosunemch(r) #Unemployment-based VOS#;
(all,r,MREG)
    othsocvos(r) #Other social VOS#;
!
(change)(all,r,MREG)
    d_vosgench(r) #General-purpose VOS#;
```

```
(change)(all,r,MREG)
    d_voseduch(r) #Education and culture VOS#;
!
(all,r,MREG)(all,A,AGEPSEC)
    f_vosagech(r,A);
(all,r,MREG)
    f_vosunemch(r);
(all,r,MREG)
    f_othsocvos(r);
!
(change)(all,r,MREG)
    d_f_voseduch(r);
(change)(all,r,MREG)
    d_f_vosgench(r);
(change)
    d_f_vosgenchgen;
(all,r,REG)
    vostotch(r) #State transfer to all regions#;
(all,r,REG)
    ff_vos(r) #Ad-hoc changes in VOS - help in calibration#;
(all,A,AGEPSEC)(all,r,REG)
    psecpop(A,r);
(all,r,REG)
    f_nettomun(r);

Read  MINCTOT       from file VOSDATA header "MINC";
Read  MINCTOT_L     from file VOSDATA header "MIN1";
Read  MINCTOT_2L    from file VOSDATA header "MIN2";
Read  MUNPOP        from file VOSDATA header "MPOP";
Read  MUNPOP_L      from file VOSDATA header "MPO1";
Read  MUNPOP_2L     from file VOSDATA header "MPO2";

Read  MRAGPOP       from file VOSDATA header "MRP0";
Read  REGAGPOP      from file VOSDATA header "RPOP";
Read  MINCUTOFF     from file VOSDATA header "MCUT";
Read  MUNEQSHARE    from file VOSDATA header "EQSH";
Read  MINCUTOFF_L   from file VOSDATA header "MCUL";
Read  MUNEQSHARE_L  from file VOSDATA header "EQSL";
Read  REG2AL        from file VOSDATA header "ALRE";
Read  STINCTAX_L    from file VOSDATA header "SITL";
Read  ALTAX         from file VOSDATA header "ALTX";
Read  ALTAX_L       from file VOSDATA header "ALTL";
Read  ALSHA         from file VOSDATA header "LUSH";
Read  RECOMPSH      from file VOSDATA header "RESH";
Read  INDXCUT       from file VOSDATA header "IDXC";
!Read  SOHEAGE       from file VOSDATA header "SHAG";!
Read  SOHEPAID      from file VOSDATA header "SOPA";
```

```
Read   SOHETOT        from file VOSDATA header "SOTO";
!Read  SOHEUNEM        from file VOSDATA header "SHUN";
Read   SOHEOTH        from file VOSDATA header "SOHO";!
Read   VOSGEN         from file VOSDATA header "VOSG";
Read   VOSEDU         from file VOSDATA header "VOSE";

Formula
(initial)
    MUNEQSHARE_B = MUNEQSHARE;
(initial)
    MUNEQSHAR_LB = MUNEQSHARE_L;
(initial)(all,m,MREG)
    MINCUTOFF_B(m) = MINCUTOFF(m);
(initial)(all,m,MREG)
    MINCUTOFF_LB(m) = MINCUTOFF_L(m);
(initial) (all,m,MREG)
    MINCTOT_B(m) = MINCTOT(m);
(initial)(all,m,MREG)
    MUNPOP_B(m) = MUNPOP(m);
(initial)(all,m,MREG)
    MINCTOT_LB(m) = MINCTOT_L(m);
(initial)(all,m,MREG)
    MINCTOT_2LB(m) = MINCTOT_2L(m);
(initial)(all,m,MREG)
    MUNPOP_LB(m) = MUNPOP_L(m);
(initial)(all,m,MREG)
    MUNPOP_2LB(m) = MUNPOP_2L(m);

(initial)
    STINCTAX = sum{d,DST, INCTAXS(d,"S1311")};
(initial)
    STINCTAX_B = STINCTAX;
(initial)
    STINCTAX_LB = STINCTAX_L;
(initial)
    ALTAX_B = ALTAX;
(initial)
    ALTAX_LB = ALTAX_L;
(initial)
    ALLUMP = ALSHA*sum{d,DST,[OTHGOVREVS("S1311",d) + NET_TAX-
TOTS(d,"S1311")]};

(all,m,MREG)
    MINCPC_L(m) = 0 + if[MUNPOP_LB(m)>0, MINCTOT_LB(m)/MUN-
POP_LB(m)];
    MINCAVE = sum{m,MREG,MINCTOT_LB(m)}/sum{m,MREG,MUN-
POP_LB(m)};
```

```
!THESE NEED MOD FOR CUTOFFSHARE AND MUNEQSHARE!
(all,m,MREG)
    MAVINCDIF(m) = 0 + if[MUNPOP_LB(m)>0, MINCPC_L(m) -
MINCUTOFF(m)*MINCAVE];
(all,m,MREG)
    MUNEQUAL(m) = 0 +
    if[MAVINCDIF(m)>0, -MAVINCDIF(m)*MUNEQSHARE*MUNPOP_LB(m)] +
    if[MAVINCDIF(m)<0, -MAVINCDIF(m)*MUNPOP_LB(m)];



(all,r,MREG)
    MREGEQUAL(r) = MUNEQUAL(r);


(all,r,MREG)
    REGEQUAL(r) = MREGEQUAL(r);
(initial)(all,r,MREG)
    REGEQUAL_B(r) = REGEQUAL(r);

(all,m,MREG)
    MINCPC_2L(m) = 0 + if[MUNPOP_2LB(m)>0, MINCTOT_2LB(m)/MUN-
POP_2LB(m)];

    MINCAVE_L = sum{m,MREG,MINCTOT_2LB(m)}/sum{m,MREG,MUN-
POP_2LB(m)};
(all,m,MREG)
    MAVINCDIF_L(m) = 0 + if[MUNPOP_2LB(m)>0,
        MINCPC_2L(m) - MINCUTOFF_L(m)*MINCAVE_L];
(all,m,MREG)
    MUNEQUAL_L(m) = 0 +
    if[MAVINCDIF_L(m)>0, -MAVINCDIF_L(m)*MUNEQSHARE_L*MUN-
POP_2LB(m)] +
    if[MAVINCDIF_L(m)<0, -MAVINCDIF_L(m)*MUNPOP_2LB(m)];

(all,r,MREG)
    MREGEQUAL_L(r) = MUNEQUAL_L(r);

    ALRECOMPRE = ALTAX_LB - RECOMPSH*STINCTAX_LB;
    ALRECOMP = 0 + if[ALRECOMPRE > 0, ALRECOMPRE];
(initial)(all,r,MREG)
    REGEQUAL_L(r) = MREGEQUAL_L(r);

(initial)(all,r,MREG)
    REGEQUAL_LB(r) = REGEQUAL_L(r);
(initial)
```

```
    ALTRTOT = ALLUMP + ALRECOMP;
(all,r,MREG)
    SOHEFINSH(r) = SOHEPAID(r)/SOHETOT(r);
(initial)(all,r,MREG)
    SOHEFINSH_B(r) = SOHEFINSH(r);

(initial)(all,r,MREG)
    VOSTOT(r) = REGEQUAL_LB(r) +
VOSGEN(r) + VOSEDU(r);
(initial)
VOSTOT("Ahvenanmaa")=    ALTRTOT*REG2AL("Ahvenanmaa");

(initial)
    VOSNAT = sum{r,REG, VOSTOT(r)};
(initial)(all,r,REG)
    NETTOMUN(r) = GOVTOMUN(r) - VOSTOT(r);

Equation
E_taxrev_incm (all,m,MREG)
    taxrev_incm(m) = nettaxtots(m,"S1313");


E_taxrev_inc_gov
    STINCTAX*taxrev_inc_gov =
        sum{r,MREG,NET_TAXTOTS(r,"S1311")*nettax-
tots(r,"S1311")};


E_d_regeqch #Change in municipal income equalisation this year#
(all,r,REG)
    d_regeqch(r) = [REGEQUAL_B(r) - REGEQUAL_LB(r)]*d_unity;
E_d_mincutch_l #Lagged change in cut-off rate# (all,r,REG)
    d_mincutch_l(r) = [MINCUTOFF_B(r) -
MINCUTOFF_LB(r)]*d_unity;
E_d_muneqch_l #Lagged change in equalisation share#
   d_muneqch_l = [MUNEQSHARE_B - MUNEQSHAR_LB]*d_unity;

E_mpop (all,m,MREG)
 mpop(m) = pops(m);
E_muninc_l #Updating equation for lagged municipal income#
(all,m,MREG)
    ID01[MINCTOT_L(m)]*muninc_l(m) = 100*[MINCTOT_B(m)-MINC-
TOT_LB(m)]*d_unity;
E_muninc_2l #Updating equation for lagged municipal income#
(all,m,MREG)
    ID01[MINCTOT_2L(m)]*muninc_2l(m) =
    100*[MINCTOT_LB(m)-MINCTOT_2LB(m)]*d_unity;
```

```
E_mpop_l #Updating equation for lagged municipal population#
(all,m,MREG)
    ID01[MUNPOP_L(m)]*mpop_l(m) = 100*[MUNPOP_B(m) - MUN-
POP_LB(m)]*d_unity;
E_mpop_2l #Updating equation for twice-lagged municipal popula-
tion# (all,m,MREG)
    ID01[MUNPOP_2L(m)]*mpop_2l(m) = 100*[MUNPOP_LB(m)-MUN-
POP_2LB(m)]*d_unity;

E_staxinc_l #Updating equation for lagged state income tax rev-
enue#
    STINCTAX_L*staxinc_l = 100*[STINCTAX_B -
STINCTAX_LB]*d_unity;
E_alinc_l #Updating equation for state income tax rev in Aa-
land#
    ALTAX_L*alinc_l = 100*[ALTAX_B - ALTAX_LB]*d_unity;
E_al045trans #State budget 045-lumpsum transfer to Aland#
    ALLUMP*al045trans = ALSHA*
    [STINCTAX*taxrev_inc_gov + 100*sum{r,REG, oth_gov-
revs(r,"S1311")}];
E_altottrans #Total transfer to Aland # ALTRTOT*altottrans =
ALLUMP*al045trans;


E_d_vosgench #General-purpose VOS# (all,r,MREG)
    100*d_vosgench(r) = INDXCUT*p3tot_2l + 100*d_f_vosgench(r)
+
    100*d_f_vosgenchgen;
E_d_voseduch #Education and culture VOS# (all,r,MREG)
    100*d_voseduch(r) =  INDXCUT*p3tot_2l +
    100*d_f_voseduch(r);
E_vostotch #Total change in state transfers to local govs#
    (all,r,MREG) VOSTOT(r)*vostotch(r) =
            100*d_vosgench(r) +
            100*d_voseduch(r) +
+ 100*d_regeqch(r)+ff_vos(r);



E_vostot_AL #Total change in state transfers to local govs#
 VOSTOT("Ahvenanmaa")*vostotch("Ahvenanmaa") =
   ALTRTOT*REG2AL("Ahvenanmaa")*altottrans + 100*d_regeqch("Ah-
venanmaa")+ff_vos("Ahvenanmaa");

E_vosnatch #National sum of change in state transfers to local
govs#
    VOSNAT*vosnatch = sum{r,REG, VOSTOT(r)*vostotch(r)};
```

```
E_d_govtomun (all,r,REG)
    100*d_govtomun(r) = VOSTOT(r)*vostotch(r) + NETTO-
MUN(r)*f_nettomun(r) +
    d_d_govtomun(r);
E_d_f_nettomun # Other personal benefits paid by government #
(all,r,REG)
    f_nettomun(r) = w5tots(r,"S1313") + d_f_nettomun(r);
E_d_ff_nettomun # Other personal benefits paid by government #
(all,r,REG)
    f_nettomun(r) = vostotch(r) + d_ff_nettomun(r);
E_d_f_govtomun # Other personal benefits paid by government #
(all,r,REG)
    GOVTOMUN(r)*f_govtomun(r) = VOSTOT(r)*vostotch(r) +
    NETTOMUN(r)*f_nettomun(r) + d_f_govtomun(r);
```

Update

```
STINCTAX         = taxrev_inc_gov;
STINCTAX_L       = staxinc_l;
ALTAX_L          = alinc_l;
ALTAX            = nettaxtots("Ahvenanmaa","S1313");
ALLUMP           = al045trans;
ALTRTOT          = altottrans;
VOSNAT           = vosnatch;

(all,r,MREG)(all,A,AGEPSEC)     MRAGPOP(r,A)     = psecpop(A,r);
!
(all,r,MREG)(all,A,AGEPSEC)     SOHEAGE(r,A)     =
vosagech(r,A);
!
(all,r,MREG)                    SOHEPAID(r)      = vsohepaid(r);
(all,r,MREG)                    SOHETOT(r)       = vsohetot(r);
!
(all,r,MREG)                    SOHEUNEM(r)      = vosunemch(r);
(all,r,MREG)                    SOHEOTH(r)       = othsocvos(r);
!
(change)(all,r,MREG)            VOSGEN(r)        =
d_vosgench(r);
(change)(all,r,MREG)            VOSEDU(r)        =
d_voseduch(r);
(all,r,REG)                     VOSTOT(r)        = vostotch(r);
(all,m,MREG)                     MINCTOT(m)       =
taxrev_incm(m);
(all,m,MREG)                     MINCTOT_L(m)     = muninc_l(m);
(all,m,MREG)                     MINCTOT_2L(m)    = mu-
ninc_2l(m);
```

```
(all,m,MREG)                    MUNPOP(m)       = mpop(m);
(all,m,MREG)                    MUNPOP_L(m)     = mpop_l(m);
(all,m,MREG)                    MUNPOP_2L(m)    = mpop_2l(m);

(all,r,REG)                    NETTOMUN(r)     = f_netto-
mun(r);

(change)(all,r,REG)            MINCUTOFF(r)       =
d_mincutch(r);
(change)                       MUNEQSHARE      = d_muneqch;
(change)(all,r,REG)            MINCUTOFF_L(r)     =
d_mincutch_l(r);
(change)                       MUNEQSHARE_L    = d_muneqch_l;
(change)                       INDXCUT         = d_indxcutch;
(change) (all,r,REG)           REGEQUAL_L(r)   = d_regeqch(r);

!*************************************************************
*************!
! Section 8.17.6.
!
! Regional population
!
!*************************************************************
*************!


Coefficient
(parameter) (all,A,AGEPSEC) NATMIGSH(A)
        #Average age shares of national within-country movers#;
            OLDPOP #Old-age population aggregated from PSEC
popu info#;
            POPTNAT #Total population in the whole country#;
Read NATMIGSH  from file VOSDATA header  "NMSH";

Formula

(initial) (all,A,AGEPSEC) POPSEC(A) = sum{r,REG,
REGAGPOP(A,r)};
(initial) OLDPOP = POPSEC("a65_74") + POPSEC("a75_84") +
POPSEC("a85P");
(initial) POPTNAT = sum{A,AGEPSEC, POPSEC(A)};

Variable
         (all,A,AGEPSEC)(all,r,REG) psecpop_o(A,r);
         (all,A,AGEPSEC)(all,r,REG) f_psecpop(A,r);
         (all,A,AGEPSEC) psecpopn(A) #National age population
```

```
by age struc#;
         (all,A,AGEPSEC) f_psecpopn(A) #Shifter for natl popu-
lation constraint#;
        (all,r,REG) labsup_o(r) #Labsup in baseline#;
         popold #Twin variable for popaged#;
         f_popagednat #Shifter of twin variable for popaged#;
         f_popnat #Shifter for total national population#;
         (all,r,REG) regpop(r) #Regional total population#;
         (all,r,REG) f_pops(r) #Shifter for twin var regional
total pop#;
(change) (all,r,REG) d_f_popaged(r);
(change) (all,r,REG) d_f_nhou(r) #Number of households#;

!For exogenous population forecast psecpop f_labsup and
f_psecpopn exogenous    !
!For endogenous population in policy exogenise psecpop_o lab-
sup_o and d_UR     !
!Labour supply can be exogenous or stem from participation rate
forecasts below!

Equation
E_psecpop_o (all,A,AGEPSEC)(all,r,REG)
    psecpop(A,r) = psecpop_o(A,r) + f_psecpop(A,r)
+f_psecpopn(A);
E_f_psecpopA (all,A,AGENWPSEC)(all,r,REG)
    NATMIGSH(A)*sum{aa,AGEPSEC,REGAGPOP(aa,r)}*f_labsup(r) =
    REGAGPOP(A,r)*f_psecpop(A,r);

E_f_psecpopB (all,A,AGEWAPSEC)(all,r,REG) f_psecpop(A,r) =
f_labsup(r);

E_labsup_o (all,r,REG) labsup(r) = labsup_o(r) + f_labsup(r);

E_popold OLDPOP*popold = POPSEC("a65_74")*psecpopn("a65_74") +
    POPSEC("a75_84")*psecpopn("a75_84") +
POPSEC("a85P")*psecpopn("a85P");
E_psecpopn (all,A,AGEPSEC) POPSEC(A)*psecpopn(A) =
    sum{r,REG, REGAGPOP(A,r)*psecpop(A,r)};
E_popaged (all,r,REG)

[REGAGPOP("a65_74",r)+REGAGPOP("a75_84",r)+REGAGPOP("a85P",r)]*
popaged(r) =
    REGAGPOP("a65_74",r)*psecpop("a65_74",r) +
    REGAGPOP("a75_84",r)*psecpop("a75_84",r) +
    REGAGPOP("a85P",r)*psecpop("a85P",r) + d_f_popaged(r);
E_popagednat popagednat = popold + f_popagednat;
E_popnat POPTNAT*[popnat + f_popnat] = sum{A,AGEPSEC,
```

```
POPSEC(A)*psecpopn(A)};
E_regpop (all,r,REG)
    POP(r)*regpop(r) = sum{A,AGEPSEC,
REGAGPOP(A,r)*psecpop(A,r)};
E_pops (all,r,REG) pops(r) = regpop(r) + f_pops(r);
E_d_f_nhou (all,r,REG) nhou(r) = pops(r) + d_f_nhou(r);

!***********************************************************!
!Section for supply-side Labour-market projection!
!***********************************************************!

Coefficient
(all,A,AGEWAPSEC)(all,r,REG) PARTRATE(A,r);
(all,A,AGEWAPSEC)(all,r,REG) EMPRATE(A,r);
(all,A,AGEWAPSEC)(all,r,REG) EMPWAPS(A,r);
(all,A,AGEWAPSEC)(all,r,REG) LABWAPS(A,r);

Read EMPWAPS from file VOSDATA header "REMP";
Read LABWAPS from file VOSDATA header "RLAB";
Read PARTRATE from file VOSDATA header "PRAT";
Read EMPRATE from file VOSDATA header "ERAT";


Formula
(initial)(all,A,AGEWAPSEC)(all,r,REG) PARTRATE(A,r)=
[1 - DUM_YEAR1]*LABWAPS(A,r)/REGAGPOP(A,r)+DUM_YEAR1*PAR-
TRATE(A,r);
(initial)(all,A,AGEWAPSEC)(all,r,REG) EMPRATE(A,r)=
[1 - DUM_YEAR1]*EMPWAPS(A,r)/LABWAPS(A,r)+DUM_YEAR1*EM-
PRATE(A,r);

Variable
(all,A,AGEWAPSEC)(all,r,REG)(Change) d_part_rate(A,r);
(all,A,AGEWAPSEC)(all,r,REG)(Change) d_emp_rate(A,r);
(all,A,AGEWAPSEC)(all,r,REG) labsup_A(A,r);
(all,A,AGEWAPSEC)(all,r,REG) employ_A(A,r);

Equation E_d_part_rate (all,A,AGEWAPSEC)(all,r,REG)
labsup_A(A,r) = [100/(PARTRATE(A,r))]*d_part_rate(A,r) +
psecpop(A,r);

Equation E_d_emp_rate (all,A,AGEWAPSEC)(all,r,REG)
employ_A(A,r) = [100/(EMPRATE(A,r))]*d_emp_rate(A,r) + lab-
sup_A(A,r);


Variable (all,A,AGEWAPSEC)(all,r,REG) f_labsup_A(A,r);
```

```
Variable (all,A,AGEWAPSEC)(all,r,REG) f_employ_A(A,r);

Equation E_ff_lab_yrs (all,A,AGEWAPSEC)(all,r,REG)
labsup_A(A,r)=labsup(r)+f_labsup_A(A,r);

Equation E_ff_emp_yrs (all,A,AGEWAPSEC)(all,r,REG)
employ_A(A,r)=x1lab_io(r)+f_employ_A(A,r);


Update
(Change)(all,A,AGEWAPSEC)(all,r,REG) PAR-
TRATE(A,r)=d_part_rate(A,r);
(Change)(all,A,AGEWAPSEC)(all,r,REG) EM-
PRATE(A,r)=d_emp_rate(A,r);
(all,A,AGEWAPSEC)(all,r,REG) LABWAPS(A,r)=labsup_A(A,r);
(all,A,AGEWAPSEC)(all,r,REG) EMPWAPS(A,r)=employ_A(A,r);


Variable (Change) d_f_employ_i;
Variable (Change)(all,d,REG) d_fff_labsup(d);
Variable (Change)(all,d,REG) d_f_x1lab_io(d);


Equation E_labsup
(all,d,REG)
(sum{A,AGEWAPSEC,LABWAPS(A,d)})*labsup(d)=
(sum{A,AGEWAPSEC,LABWAPS(A,d)*labsup_A(A,d)})+d_fff_labsup(d);

Equation E_d_f_x1lab_io
(all,d,REG)
(sum{A,AGEWAPSEC,EMPWAPS(A,d)})*x1lab_io(d)=
(sum{A,AGEWAPSEC,EMPWAPS(A,d)*employ_A(A,d)})+d_f_x1lab_io(d);

Equation E_d_f_employ_i
sum{d,REG,(sum{A,AGEWAPSEC,EMPWAPS(A,d)})}*employ_i=
sum{d,REG,(sum{A,AGEWAPSEC,EMPWAPS(A,d)*em-
ploy_A(A,d)})}+d_f_employ_i;

Variable (all,d,DST) d_v_EMP_RATE(d);

Equation E_d_v_EMP_RATE (all,d,DST)
d_v_EMP_RATE(d)=EMP_RATE(d)*d_unity;
```

5. The theory of REFINAGE

5.1 Introduction

In this chapter, we present a formal description of the linear form of REFINAGE. The presentation is based on excerpts taken from the TABLO code.

The chapter is organised as follows. In section 5.2, we describe the AGE theory behind the demand for intermediate goods and primary factors, household and government demand, export demand and margin demand. Section 5.3 is devoted to the dynamic mechanisms of REFINAGE. Section 5.3.1 explains the theory of investment over time, section 5.3.2 asset dynamics, and section 5.2.3 deals with the sluggish wage mechanism. The final section of the chapter deals with income and saving aggregates, the balance of payments, as well as government accounts, and shows how budgetary rules can be introduced in the model.

5.2 The AGE core of REFINAGE

REFINAGE recognises three broad categories of inputs: intermediate inputs, primary factors and energy . Industries are assumed to choose the mix of inputs which minimises the costs of production for their level of output. They are constrained in their choice of inputs by a three-level nested production technology, displayed in figure 2.2. At the first level, the intermediate-input bundles and the primary-factor bundles are used in fixed proportions to output. These bundles are formed at the second level. Intermediate input bundles are constant-elasticity-of-substitution (CES) combinations of international imported goods and domestic goods. The primary-factor-energy bundle is a CES combination of the primary factors labour, capital and land, which combines with a CES bundle of energy inputs electricity, fossil fuels, and in some industries, bioenergy. Finally, the input of labour is formed as a CES combination of inputs of labour from different occupational categories. We describe the derivation of the input demand functions working upwards from the bottom of the tree in Figure 2.2.

5.2.1 Import-domestic composition of intermediate demands

(Section 8.1.1 in REFINAGE code)

At the bottom level of the intermediate good nest are the demands for commodities from various sources. The firms decide on their demands for the domestic commodities and the foreign imported commodities following a similar to the CES nest for occupational groups. Here, the firm chooses a cost-minimising mix of the domestic commodity and foreign imported commodities

$$\sum_{s \in SRC} P1X1(c,s,i)X1(c,s,i) \qquad \text{i} \in \text{IND} \qquad (5.1)$$

where the subscript SRC denotes the sources of the commodities, *dom*, *eu*, and *non-eu*, subject to the production function

$$X1\_S(c,i) = CES\{\frac{X1(c,s,i)}{A1(c,s,i)}\} \qquad \text{c} \in \text{COM}, \ \text{s} \in \text{SRC}, \ \text{i} \in \text{IND}$$

(5.2)

where we denote a constant elasticity to scale aggregator by CES( ), with its arguments inside the brackets. The CES assumption amounts to the standard Armington assumption that domestic commodities are imperfect substitutes for foreign varieties.

The solution to the problem specified by (5.1) and (5.2) yields the input demand functions for the domestic and import commodities. In REFINAGE code, these functions are presented by equation *E_x1*:

```
E_x1 #Dom/imp substitution in intermediate demands#
(all,c,COM)(all,s,SRC)(all,i,IND)(all,d,DST)
x1(c,s,i,d) = x1_s(c,i,d) - SIGMADO-
MIMP(c)*[ppur(c,s,i,d)-ppur_s(c,i,d)];
```

(5.3)

This equation shows that the demands for the domestic commodities and imports are proportional to the demand for the domestic-import aggregate (X1_S(c,i,d)) and to a price term. The X1_S(c,i,d) are exogenous to the producer's problem at this level of the nest. The percentage-change form of the price term is an elasticity of substitution, SIGMADOMIMP(c) multiplied by a price ratio representing the percentage change in the price of the domestic commodity or of the import commodities relative to the purchaser's price of the domestic-import aggregate (ppur_s(c,j,d).

The price index ppur_s(c,i,d) in equation (5.3) is defined in equation E_ppur_s in section 8.8. of the code:

```
Equation E_ppur_s
(all,c,COM)(all,u,USR)(all,d,DST)
          ppur_s(c,u,d) =
sum{s,SRC,SRCSHR(c,s,u,d)*ppur(c,s,u,d)};
```

(5.4)

which is a Divisia index of the individual prices.

5.2.2 Demand for primary factors

(Section 8.1.2. in REFINAGE code)

The demand for primary factors consists of several nests. At the lowest-level nest in the primary-factor nest, producers choose a composition of o occupation-specific labour inputs to minimise the costs of a given composite labour aggregate input. The demand equations for labour of the various occupation types are derived from the following optimisation problem, where industry i's problem is to choose inputs of occupation-specific labour type m, X1LABO(i,o), to minimise total labour cost

$$\sum_{o \in occ} P1LAB(i,o) X1LAB(i,o) \qquad (5.5)$$

subject to

$$X1LAB\_O(i) = \underset{o \in occ}{CES}\{X1LAB(i,o)\} \qquad (5.6).$$

Exogenous to this problem are the price paid by the *i*th industry for each occupation-specific labour type (P1LAB(i,o)) and the industries' demands for the effective labour input (X1LAB_O(i)). The solution to this problem, in percentage-change form, is given by equations *E_x1lab* and *E_p1lab* in REFINAGE code:

```
Equation E_x1lab   # Demand for labour by industry and
skill group #
  (all,i,IND)(all,o,OCC)(all,d,DST)
   x1lab(i,o,d) = x1lab_o(i,d) -
SIGMa1lab(i)*[p1lab(i,o,d) - p1lab_o(i,d)]
    +f_x1lab(i,o,d);
```

(5.7)

```
Equation E_p1lab_o # Price to each industry of labour
composite #
  (all,i,IND)(all,d,DST)
 ID01(LAB_O(i,d))*p1lab_o(i,d) = sum{o,OCC,
LAB(i,o,d)*p1lab(i,o,d)};
```

(5.8)

Equation (5.7.), or *E_x1lab* in the REFINAGE code, indicates that the demand for labour type *o* in each industry and each region is proportional to the demand for the effective composite labour demand and to a price term. The price term consists of an elasticity of substitution, SIGMA1LAB(i,o), multiplied by the percentage change in a price ratio representing the wage of occupation o (p1lab(i,o)) relative to the average wage for labour in industry i (p1lab_o(i))). Changes in the relative wages of the occupations induce substitution in favour of relatively cheapening occupations. In equation *E_p1lab*, the coefficient V1LAB(i,o) is the wage bill for occupation o employed by industry i, whereas the coefficient V1LAB_O(i) is the total wage bill of industry i. Thus, p1lab(j,q) is a Divisia index of the p1lab(i,o).

Summing the percentage changes in occupation-specific labour demands across occupations, using appropriate occupational shares, for each industry gives the percentage change in industry labour demand.

At the next level of the primary-factor branch of the production nest, we determine the composition of demand for primary factors. Primary factors and energy are assumed to be combined with energy to form a KLE-nest. Their derivation follows the same CES pattern as the previous nests. Here, total primary factor costs for industry i are given by

$$P1LAB\_O(i)X1LAB\_O(i) + P1CAP(i)X1CAP(i) + P1LND(i)X1LND(i) \tag{5.9}$$

where P1CAP(i) and P1LND(i) are the unit costs of capital and land (in agriculture and forestry) and X1CAP(i) are the industry's demands for capital. These costs are minimised subject to the production function

$$X1PRIM(i) = CES\left[\frac{X1LAB(i)}{A1LAB(i)}, \frac{X1CAP(i)}{A1CAP(i)}, \frac{X1LND(i)}{A1LND(i)}\right] \tag{5.10}$$

where X1PRIM(i) is the industry's overall demand for primary factors. The above production function allows us to impose factor-specific technological change via the variables A1LAB(i), A1CAP(i) and A1LND(i).

The solution to the problem in percentage-change form is given by equations *E_x1lab_o*, *E_x1cap*, *E_p1lnd* and *E_x1lnd* in REFINAGE code:

```
Equation E_x1lab_o  # Industry demands for effective la-
bour #
  (all,i,IND)(all,d,DST) x1lab_o(i,d) - a1lab_o(i,d)-
a1lab_od(i) =
x1prim(i,d)-SIGMAPRIM(i)*[p1lab_o(i,d) +
a1lab_o(i,d)+a1lab_od(i) - p1prim(i,d)]
-SIGMAPRIM(i)*(a1lab_o(i,d)+a1lab_od(i)-a1primsum(i,d))
            +SHRLK(i,d,"capital")*twistlk(i);
```

(5.11)

```
Equation E_p1cap  # Industry demands for capital #
  (all,i,IND)(all,d,DST)  x1cap(i,d) - a1cap(i,d) =
   x1prim(i,d) - SIGMAPRIM(i)*[p1cap(i,d) + a1cap(i,d) -
p1prim(i,d)]
-SIGMAPRIM(i)*(a1cap(i,d)-a1primsum(i,d))
            -SHRLK(i,d,"labour")*twistlk(i);
```

(5.12)

```
Equation E_plnd  # Industry demands for Land #
  (all,i,IND)(all,d,DST)  x1lnd(i,d) - a1lnd(i,d) =
   x1prim(i,d)
        - SIGMAPRIM(i)*[plnd(i,d) + a1lnd(i,d) -
        p1prim(i,d)]
        - SIGMAPRIM(i)*(a1lnd(i,d)-a1primsum(i,d));
```

(5.13)

From these equations, we see that for a given level of technical change, industries' factor demands are proportional to overall factor demand (X1PRIM(i)) and a relative price term. In change form, the price term is an elasticity of substitution (SIGMAPRIM(i,d)) multiplied by the percentage change in a price ratio representing the unit cost of the factor relative to the overall effective cost of primary factor inputs. Changes in the relative prices of the primary factors induce substitution in favour of relatively cheapening factors.

5.2.3 Demand for energy carriers

(Section 8.1.3. in REFINAGE code)

The demand for the energy composite is derived from the minimisation of the cost of the primary-factor-energy composite. This, in turn, is a given for the optimisation problem yielding the demands for individual energy carriers. These demands are given by E_x1_s_f in REFINAGE code:

```
Equation E_x1_sA  # Demands for fuels composites #
 (All,c,FUEL)(all,i,IND)(all,d,DST)
x1_s(c,i,d) - [a1int_s(c,i,d)] = x1fuel(i,d)
  -  SIGMAFUELS(i)*{ppur_s(c,i,d)-p1fuel(i,d)}
  -  SIGMAFUELS(i)*{a1int_s(c,i,d)-a1_sfuel(i,d)};
```

(5.14)

In the equation, x1fuel is the demand for the energy composite, which is derived in the next section. While energy carriers are included in the primary factor energy nest, the demand for source-specific energy carriers is derived similarly to other commodities. Thus,the demand for source-specific energy goods is given by equation E_x1 (5.3).

5.2.4 Demand for primary factor and energy composites

(Subsection 8.1.4. in REFINAGE code)

The demand for the energy composite and the primary factor composite is derived from the cost-minimisation problem

$$P1PRIM(i)X1PRIM(i) + P1FUEL(i)X1FUEL(i)$$

subject to the production function

$$X1PRIM\_F(i) = CES\left[\frac{X1PRIM(i)}{A1PRIM(i)}, \frac{X1FUEL(i)}{A1FUEL(i)},\right] \quad (5.15)$$

where P1PRIM(i) and P1FUEL(i) are the unit costs of primary factors and energy, and X1FUEL(i) is the industry's demand for energy. In percentage-change form, the solution yields the demand functions for primary factor and energy composites, given by equations E_x1prim and E_x1fuel:

```
Equation E_x1prim  # Demands for primary factor compo-
site #
 (all,i,IND)(all,d,DST)  x1prim(i,d) - [a1prim(i,d) ] =
x1prim_f(i,d)
-  SIGMAGREEN(i)*(p1prim(i,d)-p1prim_f(i,d))
-  SIGMAGREEN(i)*(a1prim(i,d)-a1prim_fsum(i,d));
```

(5.16)

```
Equation E_x1fuel  # Demands for energy composite #
 (all,i,IND)(all,d,DST)  x1fuel(i,d) - [a1_fuel(i,d) ] =
x1prim_f(i,d)
-SIGMA1PRIMEN(i)*{p1fuel(i,d)-p1prim_f(i,d)}
-SIGMA1PRIMEN(i)*{a1_fuel(i,d)-a1prim_fsum(i,d)};
```

(5.17)

It is noteworthy that the demand for primary factors depends on the substitutability of energy inputs and primary factors. This substitutability is reflected by the elasticity SIGMA1PRIMEN(i), showing that changes in the demand for primary factors depends on the changes in the price of the primary factor composite relative to the primary factor-energy composite.

5.2.5 Demand for intermediate and primary factor-energy and other cost components

(Subsection 8.1.5. in REFINAGE code)

The top level of the input nest combines the commodity and primary factor-energy composites. This nest also contains other costs, which represent other production costs not accounted for elsewhere. The demand equations for commodity composites are derived from the following optimisation problem for the ith industry. Total intermediate inputs, the primary-factor-energy composite and 'other costs' are combined using a Leontief production function, denoted by MIN(), given by

$$Z(i) = \frac{1}{A1TOT(i)} \times MIN\left(\frac{X1\_S(c,i)}{A1\_S(c,i)}, \frac{X1PRIM\_F(i)}{A1PRIM\_F(i)}, \frac{X1OCT(i)}{A1OCT(i)} \right)$$

(5.18)

In the above production function, Z(i) is the output of the ith industry, and the A variables are Hicks-neutral technical change terms.

As a consequence of the Leontief specification of the production function, each of the two categories of inputs identified at the top level of the nest are demanded in direct proportion to Z(i,q), as indicated in equations *E_x1_s* and *E_x1prim.*

```
Equation E_x1prim_f
(All,i,IND)(all,d,DST) x1prim_f(i,d) -a1prim_f(i,d) -
a1tot(i,d) = x1tot(i,d);
```
(5.19)

```
E_x1_s #Demand for composite intermediate goods#
(all,c,COMLFUEL)(all,i,IND)(all,d,DST)
   x1_s(c,i,d) = a1tot(i,d) + a1int_s(c,i,d) +
x1tot(i,d)
       -0.15*{ppur_s(c,i,d) + a1int_s(c,i,d) -
```

```
pint(i,d)};
```

(5.20)

Equation E_x1prim_f indicates that the demand for primary factors is directly proportional to output.

Equation *E_x1_s* indicates that the demand for commodity composite i is proportional to total production in industry I except in the case of energy commodities, where the demand is derived from the value-added-energy nest.

5.2.6 Total cost of output

(Subsection 8.1.6 in REFINAGE code)

REFINAGE allows for commodities to be produced by multiple industries. This is often the case when operating with highly disaggregated data. This has the implication that the cost of an industry's output does not necessarily equal the cost of producing a given commodity. From an industry perspective, the total cost of production is defined as the sum of the costs of primary factors, intermediate inputs, other cost tickets, and production taxes. Variable industry costs arge given by equation E_pvart:

```
Equation E_pvar #Variable cost#
(all,i,IND)(all,d,DST)
ID01(VARCST(i,d))*[pvar(i,d)-a1tot(i,d)] =
 LAB_O(i,d)*[p1lab_o(i,d) + a1lab_o(i,d)+a1lab_od(i)] +
PUR_CS(i,d)*pint(i,d);
```

(5.21)

whereas total costs excluding taxes are given by equation E_pcst:

```
Equation E_pcst #Total cost of production excluding
taxes#
(all,i,IND)(all,d,DST)
ID01(VCST(i,d))*[pcst(i,d)-a1tot(i,d)] =
 PRIM(i,d)*[a1prim(i,d)+p1prim(i,d)] +
PUR_CS(i,d)*pint(i,d);
```

(5.22)

Production taxes, in turn, are are given by:

```
Equation E_delPTX #Change in production taxes#
(all,i,IND)(all,d,DST)
delPTX(i,d) =
  0.01*PRODTAX(i,d)*[x1tot(i,d)+pcst(i,d)]    +
VCST(i,d)*delPTXRATE(i,d);
```

(5.23)

Total costs are then given by equation E_pcst:

```
Equation E_ptot #Total cost# (all,i,IND)(all,d,DST)
 ID01(VTOT(i,d))*[ptot(i,d) + x1tot(i,d)] =
 VCST(i,d)*[pcst(i,d) + x1tot(i,d)] + 100*delPTX(i,d);
```

(5.24)

which states that the change in total costs of output depends on changes in ex-tax costs and on changes in production taxes.

REFINAGE assumes perfect competition. This implies that the producer price of goods reflects only the costs of production. However, since a good can be produced by many industries, a link has to be established between producer prices and total costs. This link is given by equation

```
Equation E_xtotA # Average price received by multi-prod-
uct industries #
  (all,i, MIND)(all,d,REG)
    ptot(i,d) = sum{c,MINDCOM, MAKE-
SHR1(c,i,d)*pmake(c,i,d)};
```

(5.25)

```
Equation E_xtotB # Price received by single-product in-
dustries #
  (all,i,SIND)(all,d,REG) ptot(i,d) =
pdom(SIND2COM(i),d);
```

(5.26)

where MAKE denotes the matrix relating commodities to the industries producing them, and p0com is the basic price (price excluding margins and indirect taxes) of commodity c.

5.2.7 Commodity mix of output

(REFINAGE Subsections 8.2.1 REFINAGE code)

In REFINAGE, most industries produce multiple products, and most products can stem from several industries. Notable examples are for energy products, where several petroleum products stem from refining, and service sectors, which produce many different services. There are also some products, such as wood and wood residue used for heating and energy production that can stem from several industries. When an industry produces several outputs, its output mix may be affected by relative prices of the products. The supply of goods to the domestic market as opposed to export markets may also be modelled as a multi-production decision.

The output split of the production of each industry is described by the MAKE matrix. It is assumed that the product mix is adjusted, when the relative prices of the commodities change. Formally, the choice of output mix becomes one of maximising profits by deciding on the product split, subject to the market prices for the commodities in question (Dixon *et al.* (1992)). Industry i's problem is to choose outputs, Q1(c,i), to maximise revenue

$$\sum_{C \in COM} P0COM(c,i) Q1(c,i) \tag{5.27}$$

subject to

$$X1TOT(i) = \underset{C \in COM}{CET} \left\{ \frac{Q1(c,i)}{A1Q(c,i)} \right\}, \tag{5.28}$$

where CET() denotes Constant elasticity of transformation technology.

In REFINAGE code, the solution to the output mix problem is given by the supply function E_q1:

```
E_xmake  # Supplies of commodities by industries #
 (all,c,COM)(all,i,IND)(all,d,REG)
  xmake(c,i,d)+a1q(c,i,d) = x1tot(i,d) + SIG-
MAOUT(i)*[pmake(c,i,d)- ptot(i,d)]
             + SIGMAOUT(i)*[ -a1q(c,i,d) + a1qsum(i,d)];
```

(5.29)

In equation E_xmake, SIGMAOUT(i) is the transformation elasticity between the commodities the industry produces. The equation specifies that the percentage change in the supply of commodity c by multiproduct industry i is made up of two parts. The first is x1tot(i,d), the percentage change in the overall level of output of industry i in region d. The second is a price-transformation term. This compares the percentage change in the price received by industry i for product c (pmake(c,i,d)) with the weighted average of the percentage changes in the prices of all industry i's products (ptot(i,d)). Finally, a1q is output c-enhancing technological change.

The total output of each commodity is given by

```
Equation
E_xcom # Total output of commodities made by several in-
dustries #
(all,c,COM)(all,d,REG)
xcom(c,d) = sum{i,IND, MAKE-
SHR2(c,i,d)*xmake(c,i,d)}+f_x0com(c,d);
```

(5.30)

where xcom(c) is the total output of commodity c. The price index pmake(c,i,d) is related to the output mix of the industry and the relative price the industry receives in comparison to the average price of the commodity c by the two equations below, the first of which indicates the average price of an industry's output. For multi-product industries this zero-profit condition is given by:

```
   E_p1totA # Average price received by multi-product indus-
tries #
    (all,i, MIND)(all,d,REG)
        p1tot(i,d) = sum{c,MINDCOM, MAKE-
SHR1(c,i,d)*pmake(c,i,d)};
```

(5.31)

and for industries only producing a single commodity by:

```
E_p1totB # Price received by single-product industries #
    (all,i,SIND)(all,d,REG)
        p1tot(i,d) = pdom(SIND2COM(i),d);
```

(5.32)

The second equation changes in the firms's price of commodity c to changes in the firms relative share in the production of the commodity:

```
Equation E_pmake  # Demands for commodities from indus-
tries #
 (all,c,COM)(all,i,IND)(all,d,REG)
    pmake(c,i,d) = pdom(c,d) - 0.5*[xmake(c,i,d) -
xcom(c,d)];
```

(5.33)

5.2.8 Demands for investment goods

(Section 8.3 in REFINAGE code)

REFINAGE follows standard AGE practice in modelling the production of capital goods with an accounting sector, whose task it is to combine inputs to form units of capital. In choosing these inputs they cost minimise subject to a Leontief technology. Capital is produced with inputs of domestically produced and imported commodities. No primary factors are used directly as inputs to capital formation. Where REFINAGE differs from most AGE models is the description of the capital goods themselves. In

REFINAGE, capital is genuinely sector specific, in other words, the commodity inputs for capital to each industry are unique. This means that capital is not malleable but that it will only adjust slowly, over time.

The model's demand for investment goods are derived from the solutions to the investor's two-stage cost-minimisation problem. At the bottom level, the total cost of the domestic/foreign-import composite (X2_s(c,i)) is minimised subject to the CES production function

$$X2\_S(c,i) = CES\{X2(c,s,i)\} \qquad c \in \text{COM} \;, i \in \text{IND}.$$

(5.34)

At the top level of the nest, the total cost of commodity composites is minimised subject to the Leontief function

$$X2TOT(i) = \underset{c \in com}{MIN}\{\frac{X2\_S(c,i)}{A2\_S(c,i)}\} \qquad i \in \text{IND},$$

(5.35)

where the total amount of investment in each industry (X2TOT(i)) is exogenous to the cost-minimisation problem and the A2_S(c,i) are technological-change variables in the use of inputs in capital creation. The variable X2_S(c,i) represents the demand for commodity composite c used for investment by industry i. The resulting demand equations for the composite inputs to capital creation (*E_x2*) correspond to the demand equations for the composite input to current production, and are, in REFINAGE code, given by

```
Equation E_x2 # Dom/imp substitution #
(all,c,COM)(all,s,SRC)(all,d,DST)
    x2(c,s,d) = x2_s(c,d) - SIGMADO-
MIMP(c)*[ppur(c,s,"inv",d)-pinvest(c,d)];
```

(5.36)

In equation E_x2 (5.36), the parameter SIGMADOMIMP(c) is the Armington elasticity between domestic and imported commodities. Furthermore, as in the case of intermediate inputs, there are twist variables that present changes in the domestic-imported composition of the composite goods X2_S(c,i).

While the commodity demands related to investment are determined by the equations above, they do not determine the level of investment. In year-to-year dynamic simulations, investment dynamics is determined by the dynamic theory of REFINAGE, which is described in section 5.3. In the context of the present section, it may be important to realise that the fact that capital stocks are not malleable implies path-dependency.

5.2.9 Household demand

Household demand is modelled with a linear expenditure system in REFINAGE. The representative household determines the optimal composition of its consumption bundle by choosing commodities to maximise a Stone-Geary utility function subject to a household budget constraint. A *Keynesian* consumption function determines aggregate household expenditure as a function of household disposable income. The consumption of domestic and import commodities is given by equation E_x3 and is of similar form than those for intermediate input and investment demands:

```
Equation E_x3 # Dom/imp substitution in consumption#
(all,c,COM)(all,s,SRC)(all,d,DST)
x3(c,s,d) = x3_sh(c,d) - SIGMADO-
MIMP(c)*[ppur(c,s,"hou",d)-p3(c,d)];
```

(5.37)

As can be seen from equation E_x3 (5.37), there are twist variables also for household demand. The parameter SIGMA3(c) gives the Armington elasticity between domestic and import commodities in consumption.

With Stone-Geary preferences per-household utility (UTILITY) is given by

$$\text{UTILITY}= \sum_{c\in COM} \beta_c \ln(\frac{X3_c}{B_c} - \gamma_c) \qquad (5.38)$$

with $\sum_{c \in COM} \beta_c = 1$, and where $\gamma_c$is a parameter capturing the susbsistence level of consumption. The demand functions for individual commodities take the form

$$\frac{X3_c}{B_c} = \gamma_c + \frac{\beta_c}{P_c B_c} \sum_{c \in COM} (C - P_c B_c \, \gamma_c). \tag{5.39}$$

Where P_c and B_c are the price of commodity c and its budget share. In TABLO format, (5.39) becomes

```
Equation  E_x3_s # Household demands for composite commodities #
  (all,c,COM)(all,d,DST)(all,h,HOU)
  x3_s(c,d,h) - nhouh(d,h) =
EPS(c,d)*[w3tot(d,h)-nhouh(d,h)] + sum{k,COM,ETA(c,k,d)*p3_s(k,d)}
                 + a3con(c,d,h) - ave_a3con(d,h);    (5.40)
```

Where ETA(.) is the implied price eleasticity of demand and EPS(.) the income elasticity. Taste change enters consumer demands via the a3con(.) terms, the average effect of which is given by

```
Equation E_ave_a3con # Average value of a3com #
(all,d,DST)(all,h,HOU)
  ave_a3con(d,h) = sum{k,COM, S3CON(k,d)*a3con(k,d,h)}; (5.41)
There are also movements in the marginal budget shares and the
susbsistence shares, given by
Equation E_deltapc # Movements in marginal budget shares in LES #
  (all,c,COM)(all,d,DST)(all,h,HOU)
deltapc(c,d,h) = a3con(c,d,h) - sum{k,COM, DELTA(k,d)*a3con(k,d,h)};
(5.42)
and by
 Equation E_d_gamma # Movements in subsistence variables in LES #
  (all,c,COM)(all,d,DST)(all,h,HOU)
d_gamma(c,d,h) = [1 + EPS(c,d)/FRISCH(d)]*[a3con(c,d,h)-
ave_a3con(d,h)]; (5.43)
```

where FRISCH(.) is the Frisch parameter associated with the Stone-Geary/linear expenditure system.

The equations above determine the composition of household demands, but do not determine total consumption. This is determined by household disposable income, which is taken up in a later section.

5.2.10 Export demands

(Section 8.5. in REFINAGE code)

Exports are divided into two groups in REFINAGE: traditional exports, which comprise most manufacturing industries, and non-traditional exports, which cover the exports of services and transports. Exports account for a relatively large share of the total sales of traditional export commodities. In contrast, the non-traditional, or collective, exports stem from industries which are mostly domestically oriented. The advantage of the distinction is that it prevents world market prices from feeding into the prices of service exports. The division of exports into the two categories is controlled by simple set definitions.

For each category, the model allows for a number of ways to change the composition and volume of export demand, for example, to accommodate export forecasts for specific export industries or forecasts for aggregate exports. Forecasts or scenarios of world price developments can also be easily accommodated.

Traditional export commodities are assumed to face a downward-sloping foreign-export demand functions

$$X4(c,d) = F4Q(c,d) \times F4QALL \times \left(\frac{P4(c,d) \times EXCHR}{F4P(c,d) \times F4PALL} \right)^{EXP\_ELAST(c)}$$

$$c \in \text{TRADEXP} \quad d \in \text{XDEST} \qquad (5.44)$$

X4(c,d) is the export volume of commodity d to destination d. The parameter EXP_ELAST(c) is the (constant) own-price elasticity of foreign-export demand. As EXP_ELAST(c) is negative, traditional exports are a negative function of their foreign-currency prices on the export markets (P4(c,d)). They are also affected by the exchange rate. The variables F4P(c,d) and F4PALL allow for horizontal (quantity) and vertical (price) shifts in the demand schedules. The variables F4Q(c,d) and F4QALL allow for economy-wide horizontal and vertical shifts in the demand schedules. In REFINAGE code, the demand equation for traditional exports is given by E_xexp, which defines individual export demand functions for each of the traditional export goods:

```
Equation E_xexp #Export demands #

(all,c,COM)(all,s,SRC)(all,d,DST)

   xexp(c,s,d) = f_qexp_dc +
```

```
f_qexp_d(c)+f_qexp_c(d)+f_qexp(c,d)+fqexp(c,s)

- ABS[EXP_ELAST(c)]*[ppur(c,s,"Exp",d)-f_pexp_dc -

fpexp(c,s)-f_pexp_d(c)-phi];
```

(5.45)

Equation (5.45) is the percentage change version of (5.44), but makes explicit that REFINAGE allows for exchange rate changes to affect exports. Exchange rate changes are given by the variables phi_eu and phi_non_eu, with the dummies DUM_X(d) controlling which of the export markets is in question.

5.2.11 Government and inventory demands

(Section 8.6. in the REFINAGE code)

Government demand for commodities is modelled with the help of public sector - spcific trends

```
E_xgov #Public sector demands #

(all,c,COM)(all,s,SRC)(all,d,DST)

    xgov(c,s,d) = sum{p,PSEC,

V5SHRS_(d,c,p)*f5totr(d,c,p)}; (5.46)
```

While stocks may be important for the supply of non-perishable goods, REFINAGE does not attempt to offer a theory of the determination of stocks. It does allow for two alternative assumptions, namely, either the assumption that stocks follow current production, or that they are exogenously determined. The determintation of stocks is given by

```
Equation E_xstocks #Inventory demands
#(all,i,IND)(all,d,DST)
  xstocks(i,d) = x1tot(i,d) + f_stocks(i,d)+
f_stocks_d(i);
```

(5.47)

5.2.12 Margin demands

(Section 8.7. in the REFINAGE code)

In REFINAGE, some of the commodities are used as margins. Typical margin commodities are wholesale and retail trade, and transport services provided by several transport sectors. These commodities, in addition to being consumed directly by the users (e.g., consumption of transport services when taking holidays or commuting to work), are also consumed to facilitate trade (e.g., the use of transport services to ship commodities from point of production to point of consumption). The latter type of demand for transport is called demand for margins. Margin demands are assumed to be proportional the demand for each commodity. The demand for margins related to consumption demand is given by

```
Equation E_xtradmar # Leontief demand for margins #
 (all,c,COM)(all,s,SRC)(all,m,MAR)(all,r,ORG)(all,d,DST)
  xtradmar(c,s,m,r,d) =  xtrad(c,s,r,d) + at-
radmar(c,s,m,r,d)
```

(5.48)

5.2.13 Product market equilibrium

(Section 8.8. in the REFINAGE code)

5.2.14 Market-clearing equations

(Section 8.8.1 in the REFINAGE code)

An important part of a regional model is the handling of trade between the regions in the country. REFINAGE assumes that goods stemming from each region are imperfect substitutes, implying again price-sensitivity in their demand. Margins have an important role here, since they account for the difference between delivered-prices of goods stemming from different regions and consumed within a region. The demand equations are given by

```
Equation E_xtrad # CES between goods from different re-
gions #
(all,c,COM)(all,s,SRC)(all,r,ORG)(all,d,DST)
xtrad(c,s,r,d)=xtrad_r(c,s,d)-SIG-
MADOMDOM(c)*[pdelivrd(c,s,r,d)-puse(c,s,d)]
 +  sum{k,ORG,  [if(k eq r,1) -
DELIVRD(c,s,k,d)/{DE-
LIVRD_R(c,s,d)+0.000000000001}]*twistsrc(c,s,k) };
```

(5.49)

Market clearing implies that the demands for all commodities equal supply. This is achieved via the adjustment of prices. In REFINAGE, we first define sales aggregates that summarise the sales to each market.

```
Equation E_pdomA # Demand = supply for non-margins #
 (all,c,NONMAR)(all,r,REG)
   xcom(c,r) = xtrad_d(c,"dom",r);
```

(5.50)

```
Equation E_pdomB # Demand = supply for margins #
 (all,m,MAR)(all,p,REG)
   MAKE_I(m,p)*xcom(m,p) =
TRADE_D(m,"dom",p)*xtrad_d(m,"dom",p)
                              + SUPPMAR_RD(m,p)*xsupp-
mar_rd(m,p);
```

(5.51)

5.2.15 Purchaser's prices and zero-profit conditions

(Section 8.8.2 in the REFINAGE code)

Prices in REFINAGE are divided into base prices, prices as delivered, and purchasers' prices, which include taxes. The base price of a product reflects the costs of production including production taxes but excluding indirect taxes levied on the output. Importantly, they also exclude margins. The base price comes close to the concept of producer's price – and is often called that – but it actually differs slightly from standard usage of the term producer's price because base prices exclude margins. The distinction is made because REFINAGE models margins explicitly.

The delivery price of goods to stemming from different regions is given by

```
Equation E_puse # Delivered price of regional composite
good c,s to d #
 (all,c,COM)(all,s,SRC)(all,d,DST)
  ID01(DELIVRD_R(c,s,d))*puse(c,s,d)
= sum{r,ORG,DELIVRD(c,s,r,d)*pdelivrd(c,s,r,d)};
```

(5.52)

The third price concept, purchaser's prices, includes margins and indirect taxes and is comparable to the standard usage of the term. The basic values of all flows are evaluated at basic prices, net of taxes, but taxes and margins are included in the purchasers' price. This means purchasers' prices may differ from customer to customer. For example, for household demand we have

```
Equation E_ppur # Purchasers prices #
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
 ppur(c,s,u,d) = puse(c,s,d) + tuser(c,s,u,d);
```

(5.53)

REFINAGE assumes perfect competition in the sense that there are no mark-ups in pricing. If there is imperfect competition, it is taken into account by the inclusion of the other cost tickets. Equation E_p3 thus imposes zero profits for consumer prices. In the equation, p3(c,s) gives the change in purchasers' prices, which is linked to changes in the basic price p0(c,s), changes in the prices of margins (p0dom(c,s)), and changes in indirect consumption taxes (t3(c,s). Similar equations apply to investment, export, government and margin demands. Together, these equations define the purchasers' prices for all markets.

Of interest in equation (5.53) are the indirect taxes. They are a typical policy variable in simulations, and we explain their presentation in the model in more detail in the next sections.

5.2.16 Indirect taxes and indirect tax revenues

(Section 8.9. in the REFINAGE code)

The REFINAGE database covers indirect taxes in great detail, allowing the model to be used for the study very specific changes in them. The presentation of indirect taxes in TABLO code introduces a convention that is not familiar for most readers, however.

TABLO follows the convention that taxes are expressed in terms of powers of taxes. The meaning of a power of a tax is best illustrated with an example.

The indirect tax revenue on any commodity flow or production tax revenue on the basic value of an industry's output can be written as

$$T = P*X*(\Pi-1) , \qquad (5.54)$$

where

T is the tax revenue;

P is the basic price of the relevant commodity or industry output;

X is the quantity flow or output; and

Π is the power (one plus the rate) of the tax applicable to the basic value of the flow or output.

From (5.54), we obtain

$$100*del\_T = T*(p + x) + (T + B)*\pi \qquad (5.55)$$

where

del_T is the change in tax revenue;

B is the basic value of the flow, i.e., B= P*X; and

p, x and π are percentage changes in P, X and Π.

The reason for the convention of using powers instead of rates can be seen with the help of equation (5.55). By using powers of taxes instead of their rates, there is no danger of running into zeroes. If a tax has a zero rate, its power equals one, whence, say, the introduction of a non-zero rate can easily be accomplished. The use of powers also facilitates the analysis of tax policies. The power of a tax, Π, can be expressed as the product of shift variables, $\Pi_{g,1}...\Pi_{g,n}$:

$$\Pi = \Pi_{g,1}...\Pi_{g,n} \quad . \qquad (5.56)$$

This leads to the percentage-change equation:

$$\pi = \sum_{q=1}^{n} \pi_{g,q} \quad + \quad \sum_{q=1}^{m} \pi_{ph,q} \qquad (5.57)$$

With obvious translations in notation, equation E_tuser gives the change in indirect taxes on goods:

```
Equation E_tuser # Usr x Dst taxes driven by commodity
specific shifter #
(all,c,COM)(all,s,SRC)(all,u,USR)(all,d,DST)
tuser(c,s,u,d)=tuser_ud(c,s)+tuser_sd(c,u);
```

(5.58)

As can be seen from the equation, indirect taxes can be given commodity and industry specific shocks – or all indirect taxes can be given uniform shocks.. The advantage of this formulation is that it is easy to set up simulations where the tax for a particular good is changed.

Equation (5.54) also provides the underlying theory for keeping track of the evolution of indirect tax revenues in equations E_delV1TAX through E_delV5TAX in REFINAGE code. For example, the revenue of indirect consumption taxes is given by

```
E_delTAXhou (all,c,COM)(all,s,SRC)(all,d,DST)
  delTAXhou(c,s,d)   =
0.01*TAX(c,s,"hou",d)*[x3(c,s,d)+puse(c,s,d)]
                  +
0.01*PUR(c,s,"hou",d)*tuser(c,s,"hou",d);
```

(5.59)

where delTAXhou(c,s,d) in the change in the revenue, TAX(c,s,"Hou") the coefficient presenting the basic flow of taxes, x3(c,s,d) the percentage change in the consumption of commodity c from source s, and tuser(c,s,"hou",d) is the percentage change in the power of tax for commodity c stemming form source s. With the help of the revenue equations, it is easy to link changes in taxes to their revenue, and to impose revenue neutrality or budget balance conditions as required.

5.2.17 GDP aggregates

(Sections 8.10., 8.11. and 8.12. in the REFINAGE code)

This section collects the income and expenditure aggregates of the GDP, as well as their price indices. Their definitions are straightforward, but it is worth noting that observing GDP from both the income and the expenditure sides provides a check for the consistency of the model's results.

The percentage change of the GDP from the income side is given by equation E_delGDPINCa and the following four equations by expenditure category. For example, the change in GDP attributable to Labour is given by

```
E_delGDPINCc (all,d,DST) delGDPINC(d,"Labour")
   = 0.01*LAB_IO(d)*wlab_io(d);
```
(5.60)

Nominal income side GDP is an add-up of these categories, given by

```
Equation E_wgdpinc
 (all,d,DST) GDPINC(d)*wgdpinc(d) = 100*sum{i,GDPINCCAT,
delGDPINC(d,i)};
```
(5.61)

Similarly, the percentage change of the expenditure side GDP in equation is an add-up of the changes attributable to the demand categories, with, for example, E_delGDEXPa, giving the change due to final demand:

```
Equation
 E_delXGDPEXPa (all,d,DST)(all,u,FINDEM) delXGDPEXP(d,u)
   = 0.01*PUR_CS(u,d)*xfin(u,d);
```
(5.62)

The percentage change of the expenditure side GDP equation E_xgdpexp:

```
Equation E_xgdpexp
 (all,d,DST) GDPEXP(d)*xgdpexp(d) = 100*sum{i,GDPEXPCAT,
delXGDPEXP(d,i)};
```
(5.63)

and its value by

```
Equation E_wgdpexp   (all,d,DST) wgdpexp(d) =
xgdpexp(d)+pgdpexp(d);
```
(5.64)

REFINAGE code also contains GDP decompositions which are dealt with in a later section.

5.3 REFINAGE dynamics

REFINAGE contains several dynamic links between periods. These are each described in the current section. Central to the results that the model produces are the theory of investment, the lagged adjustment mechanisms in real wages and – if so specified – national saving and government finances. The section commences with investment theory and the wage mechanism is described in section 5.3.2. Government finances are covered in the context of national income and expenditure aggregates in section 5.4.

5.3.1 Investment over time

(Section 8.13 in the REFINAGE code)

5.3.1.1 Capital growth and the logistic investment function

In REFINAGE, investment over time is determined by functions which specify that investors are willing to supply increased funds to industry j in response to increases in j's expected rate of return. However, investors are cautious. In any year, the capital supply functions limit the growth rate of the capital stocks so that disturbances in rates of return are eliminated only gradually.

The resulting dynamics for capital stocks and investment can be compared with that in models recognizing costs of adjustment (see, for example, Bovenberg and Goulder, 1991). In costs-of-adjustment models, industry i's capital growth (and investment) in any year is limited by the assumption that the costs per unit of installing capital for industry i in year t are positively related to the i's level of investment in year t. In REFINAGE, it is assumed that the level of i's investment in year t has only a negligible effect (via its effects on unit costs in construction and other capital supplying industries) on the costs per unit of i's capital. Instead of assuming increasing installation costs, we assume that i's capital growth in year t is limited by investor perceptions of risk. Investors are willing to allow the rate of capital growth in industry i in year t to move above i's historically normal rate of capital growth only if they expect to be compensated by a rate of return above i's historically normal level.

This MONASH theory of investment is fully covered in Dixon and Rimmer (2002); here, we give an introduction to it while explaining the central equations in REFINAGE model code.

In REFINAGE code, the most important equations concerning the dynamics of investment are given by the accumulation equations for capital and the equations concerning expected and actual rates of return on capital.

In levels, the accumulation of capital in any industry is defined by equation

$$K_{+1} = (1 - D)*K + I \tag{5.65}$$

where
K is the capital stock at the beginning of year t;

K_{+1} is the capital stock at the end of year t;

I is investment during year t; and

D is a parameter giving the rate of depreciation.

In change form, (5.65) can be written as

$$K_{+1}*k_{+1} = (1 - D)*K*k + I*y \ , \tag{5.66}$$

where k_{+1}, k and y are percentage deviations in the values of K_{+1}, K and I from their values in the initial solution for year t. E_x1cap_at_tplus1 can be obtained from (5.66) by adding industry identifiers i, by making obvious notational conversions and by including the coefficient, TINY which prevents indeterminacy problems that arise if QCAPATTPLUS1(j) is zero.

In REFINAGE code, equation (5.66) is given by E_x1cap_at_tplus1:

```
Equation E_x1cap_tplus1
  # Capital accum thru the fcst year (t) related to invest-
ment in
    the year #
  (all,i,IND) [QCAPATTPLUS1(i) + TINY]*x1cap_tplus1(i)
```

```
= [1-DEP(i)]*QCAPATT(i)*x1cap(i) + QIN-
VEST(i)*x2tot(i);
```
(5.67)

The coefficients QCAPATT(j) and QINVEST(j) are both evaluated from values and prices, while QCAPATTPLUS(j) is evaluated from QCAPATT(j) and QINVEST(j) according to (5.67). An intuitive interpretation for the equation is that it defines the quantity of investments needed to satisfy the growth rate of capital stock in period (t+1) specified by the inverse logistic relationship described shortly.

REFINAGE dynamics requires an initial solution. In most simulations, the initial solution for year t is the final solution for year t–1. In these simulations, the initial solution for an industry's opening capital stock is the opening capital stock in the previous year. In the year t computation, the percentage deviation (k) that should then be imposed on the opening capital stock (K) is given by

$$k = 100*(KBASE_{+1} - KBASE)/KBASE \qquad (5.68)$$

or equivalently by

$$k = 100*(IBASE - D*KBASE)/KBASE \quad , \qquad (5.69)$$

where KBASE, $KBASE_{+1}$ and IBASE are the initial solutions for K, K_{+1} and I, i.e., KBASE and $KBASE_{+1}$ are the opening and closing capital stocks in year t-1, and IBASE is investment in year t-1. In the model code, this equation is given by

```
Equation E_d_f_ac_p_y
  # Gives shock in yr-to-yr forecasting to capital at
beginning of year t #
(all,d,DST)(all,i,IND) [QCAPATT(d,i) +
TINY]*x1cap(i,d)!x1cap(d,i)!=
     100*{QINV_BASE(d,i) - DEP(d,i)*QCA-
PATT_B(d,i)}*d_unity+100*d_f_ac_p_y(d,i);
```
(5.70)

In equation (5.70), the variable d_unity merits a note. It's function is to give a shock of unity to the equation, implying that the change on the RHS of the equation obtains the value 100 times QINV_BASE(i) – DEP(i)*QCAPATT_B(i). It is also worth emphasizing that, for the parts of a simulation that cover history, this shock stems from the data for the base year, implying the model has to satisfy the national accounting identities for capital and investment for several consecutive years. Finally, in making the year t computation, we could treat k as an exogenous variable and compute its value outside the model in accordance with (5.68) or (5.69). It is more convenient, however, to compute k inside the model.

The most intricate part of the investment theory involves the way expected rates of return and investment are related.

In simplified notation, expected rates of return are given by

$$EROR_i = EEQROR_i + DIS_i \qquad (5.71)$$

where

$EROR_i$ is the expected rate of return[3] in year t to owners of industry i's capital;

$EEQROR_i$ is the equilibrium expected rate of return, i.e., the expected rate of return required to sustain indefinitely the current rate of capital growth in industry i; and

DIS_i is a measure of the disequilibrium in i's current expected rate of return.

The equilibrium expected rate of return is specified as an inverse logistic function:

$$EEQROR_i = \{RORN_i + F\_EEQROR\_I_i + F\_EEQROR\} \qquad (5.72)$$
$$+ (1/C_i)*[\ln(K\_GR_i - K\_GR\_MIN_i) - \ln(K\_GR\_MAX_i - K\_GR_i) - \ln(TREND\_K_i - K\_GR\_MIN_i) + \ln(K\_GR\_MAX_i - TREND\_K_i)] .$$

[3] What we mean by j's expected rate of return is defined precisely in the next subsection.

where

K_GR_i is the rate of growth of capital in industry i through year t, that is,

$$K\_GR_i = \left(\frac{K_{i,t+1}}{K_{it}} - 1 \right);$$

$K\_GR\_MIN_i$ is the minimum possible rate of growth of capital and is set at the negative of the rate of depreciation in industry i;

$TREND_i$ is the industry's historically normal capital growth rate. This is an observed growth rate in capital over an historical period;

$K\_GR\_MAX_i$ is the maximum feasible rate of capital growth in industry i. It is calculated by adding a difference, DIFF, to TRENDi. For example, if DIFF has been set at 0.06, and the historically normal rate of capital growth in an industry is 3 per cent, then we impose an upper limit on its simulated capital growth in any year t of 9 per cent;

$RORN_i$ is the industry's historically normal rate of return. For each industry j, RORNi is an estimate of the average rate of return that applied over the historical period in which the industry's average annual rate of capital growth was TRENDi;

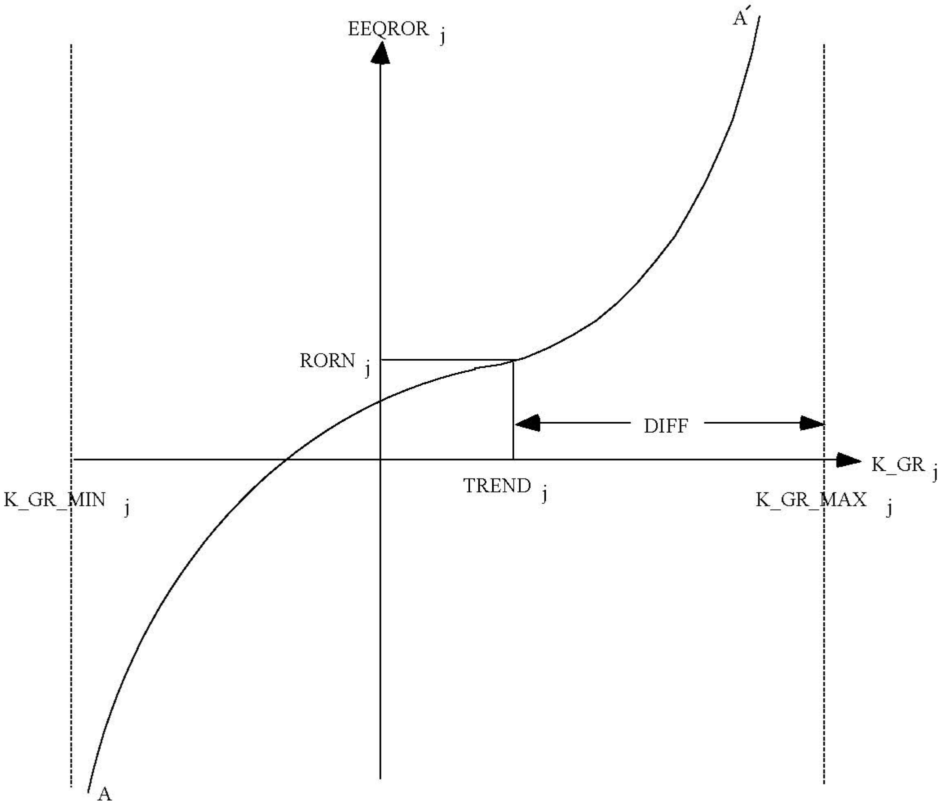
C_i is a positive parameter that controls the sensitivity of the equilibrium expected rate of return to variations in its capital growth (and consequently the sensitivity of i's capital growth to variations in its equilibrium expected rate of return). The value of this parameter is chosen so that the responses of investment to changes in rates of growth are realistic.

The inverse logistic function is illustrated in figure 5.1. For understanding (5.71) and (5.72), it is helpful to start by assuming that $F\_EEQROR\_J_i$, F_EEQROR and DIS_i are all fixed at zero. Then (5.71) and (5.72) mean that for industry i to attract sufficient investment in year t to achieve a capital growth rate of $TREND\_K_i$, it must have an expected rate of return of $RORN_i$. For the industry to attract sufficient investment in year t for its capital growth to exceed $TREND\_K_i$, its expected rate of return must be greater than $RORN_i$. Similarly, if the expected rate of return in the industry is less than that observed in the historical period, then provided that there is no disequilibrium, (5.71) and (5.72) imply that investors will restrict their supply of capital to the industry to below the level required to generate capital growth at the historically observed rate.

An important characteristic of the logistic equation is that the shift variables on the RHS of (5.72) allow for vertical shifts in the capital supply curves, the AA′ curves in Figure 5.1. Being able to move the AA′ curves is useful in forecasting and historical simulations. In these simulations we often have information from outside the model on either investment by industry or aggregate investment.

In other words, the investment equation can be calibrated to historical data or exogenous forecasts, which is a very useful device in practical simulations.

Figure 5.1 The equilibrium expected rate of return schedule for industry j



We assume that this disequilibrium disappears over time according to the schedule:

$$DISEQ_i = (1 - i_j) * DISEQ\_B_i \, , \qquad (5.73)$$

where $DISEQ_j$ and $DISEQ\_B_j$ are the gaps between industry j's expected rate of return and the industry's expected equilibrium rate of return in the current year and in the data year (t–1), and Φ_j is a parameter with a value between 0 and 1.

5.3.1.2 Actual and expected rates of return under static and forward-looking expectations

The investment dynamics in REFINAGE can be run either under static expectations or under forward-looking expectations. The latter are important when evaluating policies that involve, say, delayed tax increases to compensate for present tax cuts. However, for many other applications forward-looking expectations may not be relevant.

We next derive the rate of return on investment. To start with, the present value (PV) of purchasing in year t a unit of physical capital for use in industry i is given by:

$$PV_{i,t} = -\Pi_{i,t} + [Q_{i,t+1}*(1-T_{t+1}) + \Pi_{i,t+1}*(1-D_i) + T_{t+1}*\Pi_{i,t+1}*D_i]/[1 + INT_t*(1-T_{t+1})] \quad (5.74)$$

where

$\Pi_{i,t}$ is the cost of buying or constructing in year t a unit of capital for use in industry j;

D_i is the rate of depreciation;

$Q_{i,t}$ is the rental rate on i's capital in year t, i.e., the cost of using a unit of capital in year t;

T_t is the income-tax rate in year t;

and

INT_t is the nominal rate of interest in year t.

In (5.74), we assume that units of capital bought or constructed in year t yield to their owners three benefits in year t+1. First, they generate rentals with a post-tax value of $Q_{i,t+1}*(1-T_{t+1})$. Second, they can be sold at the depreciated value of $\Pi_{i,t+1}*(1-D_i)$. Third, they give a tax deduction. We assume that this is calculated by applying the tax rate (T_{t+1}) to the value of depreciation ($\Pi_{i,t+1}*D_j$). To obtain the present value (value in year t) of these three benefits, we discount by one plus the tax-adjusted interest rate [$INT_t*(1-T_{t+1})$].

Equation (5.74) is converted to a rate of return formula by dividing both sides by $\Pi_{i,t}$, i.e., we define the actual[6] rate of return, $ROR\_ACT_{i,t}$, in year t on physical capital in industry j as the present value of an investment of one euro. This gives

$$ROR\_ACT_{i,t} = -1 + [(1-T_{t+1})*Q_{i,t+1}/\Pi_{i,t} + (1-D_i)*\Pi_{i,t+1}/\Pi_{i,t} + T_{t+1}*D_i*\Pi_{i,t+1}/\Pi_{i,t}]/[1 + INT_t*(1-T_{t+1})] \quad (5.75)$$

As we saw in the previous subsection, the determination of capital growth and investment depends on expected (rather than actual) rates of return. In most simulations, we assume that capital growth and investment in year t depend on expectations held in year t concerning $ROR\_ACT_{i,t}$.

Under static expectations, we assume that investors expect no change in the tax rate (i.e., they expect T_{t+1} will be the same as T_t) and that rental rates (Q_i) and asset prices (Π_i) will increase by the current rate of inflation (INF). Under these assumptions, their expectation of $ROR\_ACT_{i,t}$ is

$$ROR\_SE_{i,t} = -1 + [(1-T_t)*Q_{i,t}/\Pi_{i,t} + (1-D_i) + T_t*D_i]/(1+R\_INT\_PT\_SE_t), \quad (5.76)$$

where ROR-SEj,t is the expected rate of return on capital in industry j in year t under static expectations, and $R\_INT\_PT\_SE_t$ is the static expectation of the real post-tax interest rate, defined by

$$1 + R\_INT\_PT\_SE_t = [1 + INT_t*(1-T_t)]/[1+INF_t] \ . \quad (5.77)$$

Under forward-looking or rational expectations, we assume that investors correctly anticipate actual rates of returns, i.e., their expectation of $ROR\_ACT_{i,t}$ is $ROR\_ACT_{i,t}$. This implies that we need to set i's expected rate of return equal to i's actual rate of return in a year-t simulation. The difficulty is that i's actual rate of return in year t depends on future rentals ($Q_{i,t+1}$), future tax rates (T_{t+1}) and future asset prices ($\Pi_{i,t+1}$). In the sequential approach to computing REFINAGE solutions, the values of variables in year t+1 cannot normally be known in the computation for year t. This problem is solved by adopting an algorithmic approach.

In the first iteration of the algorithm used for solving REFINAGE, we compute solutions for years 1 to T under the assumption of static expectations. Thus, if are happy to assume static expectations, we require only one iteration. However, if we wish to assume forward-looking expectations, then we will usually need further iterations (i.e., further calculations of solutions for years 1 to T). This is because the expected rates of return assumed for year t [$ROR\_SE_{i,t}$] are unlikely to equal the actual rates of return [$ROR\_ACT_{i,t}^{1}$] implied in the first iteration by the solutions for years t and t+1.

For the final year (T), we do not generate information on future values of variables. We assume that industry j's actual rate of return in year T [$ROR\_ACT_{i,T}^{1}$] is the same as that in year T-1 [$ROR\_ACT_{i,T-1}^{1}$].

In the second iteration, we assume that the expected rates of return in years 0 to T are the actual rates of return calculated from the first iteration, i.e.,

$$EROR_{i,t}^{2} = ROR\_ACT_{i,t}^{1},\ t = 0, \ldots T. \qquad (5.78)$$

From the resulting solutions for years 1 to T and the data for year 0, we compute the implied actual rates of return, $ROR\_ACT_{i,t}^{2}$, t=0, …T-1. As in the first iteration, we assume that the actual rates of return in the final year are equal to the actual rates of return in the second last year, i.e.,

$$ROR\_ACT_{i,T}^{2} = ROR\_ACT_{i,T-1}^{2}\ . \qquad (5.79)$$

For the third and subsequent iterations, we adjust the expected rates of return according to

$$EROR_{i,t}^{n} = EROR_{i,t}^{n-1} + ADI\_RE_{i} *(ROR\_ACT_{i,t}^{n-1} - EROR_{i,t}^{n-1}),$$

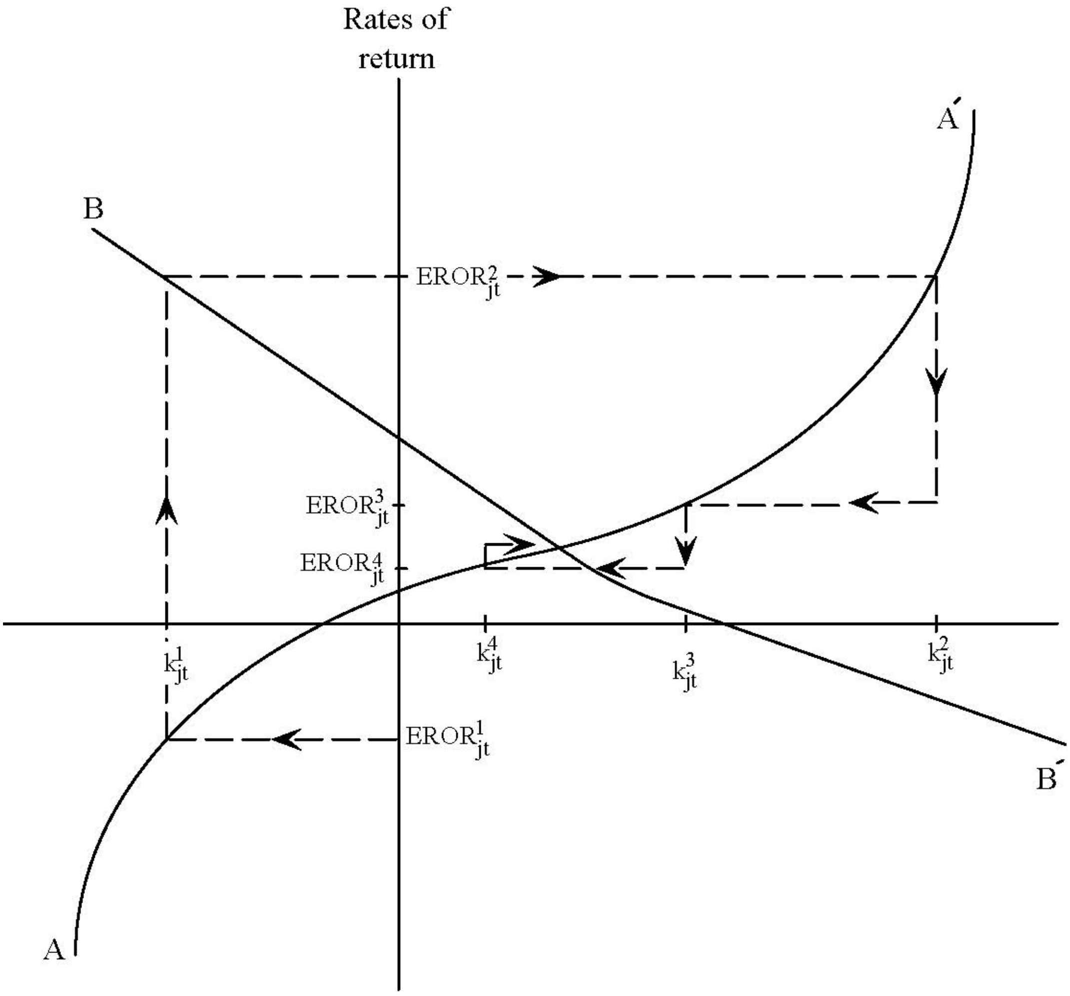
for n>2, t=0,…,T,[7] and i belongs to IND, (5.80)

where ADJ_RE_i is a parameter set between 0 and 1.

Convergence is achieved when

$$EROR_{i,t}^{n} = ROR\_ACT_{i,t}^{n} \text{ for all } i \text{ and } t. \qquad (5.81)$$

Figure 5.2. **Convergence of the algorithm for imposing forward-looking expectations**



As in Figure 5.2, we assume that there is no disequilibrium in expected rates of return. Thus, we assume that the REFINAGE outcomes for expected rates of return and rates of capital growth in year t in industry j are on the AA′ schedule. We also assume that REFINAGE outcomes for actual rates of return and rates of capital growth are on the BB′ schedule. In drawing BB′ we have in mind the capital demand schedule for year t+1 which, other things being equal, implies a negative relationship between the availability of physical capital to industry j in year t+1 and its rental rate in year t+1, and thus a negative relationship between capital growth in year t and the actual rate of return in year t. In REFINAGE computations, BB′ moves between iterations and we do not necessarily operate on AA′. Nevertheless, we find Figure 5.2 a useful device for thinking about the convergence of our algorithm. For example, with the AA′ and BB′ curves in our diagram, convergence is very rapid when ADJ_REj is set at 0.5 (the illustrated case). If ADJ_REj is set at 1.0, then readers will find, after a little experimenting with the diagram, that the algorithm may become stuck in a non-converging cycle, or converge very slowly.

In REFINAGE code, the logistic equation (5.72) is given by

```
Equation E_d_f_eeqror
   # Change in equilibrium expected rate of return in
forecast year #
(all,d,DST)(all,i,IND) d_eeqror(d,i) = [1/CO-
EFF_SL(d,i)]*
    [1/[K_GR(d,i)-K_GR_MIN(d,i)]+1/[K_GR_MAX(d,i)-
K_GR(d,i)]]*d_k_gr(d,i)
                   + d_f_eeqror_i(d,i) +
d_f_eeqror(d)+d_f_eeqror_d(i);
```

(5.82)

where d_eeqror(i) is the expected change in the equilibrium rate of return for industry I, and d_f_eeqror(i) and d_f_eeqror are shifters that affect capital growth.

The expected change of the rates of return, corresponding to (5.100), is given by

```
Equation E_d_eeqror
  # Expected ror equals equil. expec. ror plus disequi-
librium in expec. ror #
(all,d,DST)(all,i,IND) d_eror(d,i) = d_eeqror(d,i) +
d_diseq(d,i);
```

(5.83)

where d_diseq(i) gives the disequilibrium in expectations. The disequilibrium arises, since usually the data for year t-1 (either observed or the final t-1 simulated solution) for expected rates of return and for capital growth in industry j will not usually give a point on i’s AA′ curve (in figure 5.1). Consequently, in our data for year t-1, DISEQj will normally be non-zero.

In year-to-year simulations we usually assume that this disequilibrium is eliminated over time. If the expected rate of return in industry j was initially high relative to j's rate of capital growth ($DISEQ_i > 0$) then for any given change in the expected rate of return [d_eror(i)], the elimination of $DISEQ_i$ will (via E_d_eeqror) increase d_eeqror(i) and hence (via E_d_f_eeqror_i) increase i's rate of capital growth [d_k_gr(i)]. Thus we tend to forecast an increased rate of capital growth for any industry currently experiencing a lower growth rate than would be anticipated in light of its expected rate of return and its AA′ curve.

The elimination of disequilibrium is achieved according to:

either

$$DISEQ_i = (1 - \Phi_i)*DISEQSE\_B_i \ , \qquad (5.84a)$$

or

$$DISEQ_i = (1 - \Phi_j)*DISEQRE\_B_i \ , \qquad (5.84b)$$

where

$DISEQ_i$ is the value for $DISEQ_i$ in the current year (t);

$DISEQSE\_B_i$ and $DISEQRE\_B_i$ are alternative values for $DISEQ_i$ in the data (t–1);

and

Φ_i is a parameter with a value between 0 and 1, usually set at 0.5.

The alternative measures of $DISEQ_i$ reflect alternative definitions of expected rates of return. $DISEQSE\_B_i$ is used for static expectations and $DISEQRE\_B_i$ for forward-looking expectations.

From the view point of the TABLO code, it is useful to express (5.84a) as

$$DISEQ_i - DISEQSE\_B_i = - \Phi_i*DISEQSE\_B_i*UNITY \quad (5.85)$$

In our year t computation, $DISEQSE\_B_i$ is treated as a parameter and $DISEQ_i$ and UNITY are variables. Under static expectations, (5.85) is satisfied by the initial solution for year t because in that solution we assume that $DISEQ_i$ equals $DISEQSE\_B_j$ and that UNITY equals zero. In the required or final solution for year t, UNITY must be one to allow the final value of $DISEQ_i$ to satisfy (5.75a). Thus, if we are assuming static expectations, we evaluate the change in $DISEQ_i$ in year t (d_diseq_i) from its initial value ($DISEQSE\_B_i$) according to the equation:

$$d\_diseq_i = -\Phi_i * DISEQSE\_B_i * d\_unity \quad , \tag{5.86}$$

where d_unity is set exogenously at 1. In slightly different notation and with the inclusion of a shift variable, (5.86) appears in the TABLO code as E_d_diseq.

```
Equation E_d_diseq
  # Gives shock to disequil. in s.e. rors, moves them
towards zero #
(all,d,DST)(all,i,IND) d_diseq(d,i) =
    - ADJ_COEFF(d,i)*DISEQSE_B(d,i)*d_unity +
d_f_diseq(d,i);
```
(5.87)

This completes the description of investment dynamics. We next turn to lagged real wage adjustment.

5.3.2 Labour markets and wage rigidities

(Section 8.14. in the REFINAGE code)

While it is customary to assume perfectly competitive labour markets in comparative static simulations, in dynamic simulations this assumption may be less satisfactory. REFINAGE contains an alternative theory for wage setting over time that allows for gradual adjustment in the labour markets as a response to policy shocks. This theory can be motivated by Layard-Nickell type monopoly unions, and parameters for the kind of centralised wage setting the theory implies have also been estimated for Finland.

The theory assumes that real wages adjust sluggishly over time, which implies that, in the short run, labour market adjustment takes place via employment. In the code, the real wage equation is given by

```
Equation E_del_f_wage_pt
# Relates deviation in CPI-deflated post-tax wage to de-
viat. in employment #
(RWAGE_PT/RWAGE_PT_OLD)*(real_wage_pt - real_wage_pt_o)
    =    100 * ((RWAGE_PT_B/RWAGE_PT_O_B)
    -   (RWAGE_PT_L_B/RW_PT_O_L_B))*d_unity
    +    ALPHA1*(EMPLOY/EMPLOY_OLD)*(employ_i - em-
ploy_i_o)
    -    100*ALPHA1*((RWAGE_PT_B/RWAGE_PT_O_B)^ALPHA2
    -   (RWAGE_PT_L_B/RW_PT_O_L_B)^ALPHA2)*d_unity
    +    del_f_wage_pt;
```

(5.88)

where RWAGE_PT gives the actual, post tax real wage in year t, and RWAGE_PT_OLD gives the baseline forecast for the post-tax real wage in year t, while real_wage_pt and real_wage_pt_o give the percentage changes in them. The theory allows for the possibility that wage setting is affected by changes in employment as well, which is captured by the terms involving the coefficients EMPLOY and EMPLOY_OLD and their respective percentage changes. The coefficients ALPHA1 and ALPHA2 are parameters determined outside the model that control the speed of adjustment. With ALPHA2 set to zero, employment tends to return to its forecast growth path, whereas with a non-zero ALPHA2, employment may change from forecast even in the long run.

It is important to realise that the wage mechanism is not in use in the forecast simulation. Instead, the forecast values of employment and wages take place are obtained from the forecast simulation and used in the policy simulations. This necessitates a re-run of the model using policy closures. During the rerun of the forecast, the predicted baseline values of these variables are stored in the database, to be used in the dynamic equations in the policy simulation. Finally, it may be worth emphasising that when the model is run under rational expectations, these forecasts are model consistent.

5.3.3 Government accounts, balance of payments and national saving

(Sections 8.15 in the REFINAGE code)

REFINAGE covers the three main levels of government in Finland, namely, the central government, the communal sector, and the social security funds. Each of these is subject to genuine budget constraints and can also run deficits independently if necessary. Transfers between the sectors also form an important part of the expenditures and incomes of these sectors.

To commence with the expenditures, REFINAGE contains no explicit theory for the determination of the government and inventory demands for commodities. Most often it is assumed that the commodity composition of government demand is exogenous. However, it is possible to endogenise total government expenditure or parts of it. In year-to-year simulations, there are also many parts of government demand that typically stem from exogenous scenarios outside of the model, such as the demand for health care and educational services provided by the public sector. Inventory demand also contains no explicit theory. In forecast simulations, it is usually assumed that inventories do not change or that they follow output.

In REFINAGE code, equation *E_x5* (5.45) gives government demand for commodities:

```
Equation E_xgov #Public sector demands
#(all,c,COM)(all,s,SRC)(all,d,DST)
       xgov(c,s,d) =  fgovtot(d) + fgov(c,s,d) +
fgov_s(c,d) + fgovgen;
```

(5.89)

Equation E_x5 contains a useful device for allowing the growth of government demand to follow overall consumption growth. In the equation, the percentage change in government demand is affected by the shift variables f5(c,s) and f5tot.

investment

```
Equation E_w2totg_is # Value of public sector investments
#
(all,d,DST)(all,s,PSEC)
V2TOT_G_IS(d,s)*w2totg_is(d,s) =
sum{i,IND,V2SHRSG_(d,i,s)*INVEST_C(i,d)*(s2gov(i)+pinvi-
tot(i,d)+x2tot(i,d))};
```

(5.90)

The determination of government incomes has been touched upon in the previous discussion on tax and tariff revenues. We have also discussed government demands for commodities and investment goods. As already noted, REFINAGE contains no explicit theory for the determination of specific commodity demands by the government. It does contain various alternatives for linking overall government demands to the rest of the economy, however. Here, we concentrate on the more dynamic elements of the public sector, especially transfer payments from the government to other sectors in the economy, as well as the various specifications for overall government spending that REFINAGE allows for.

In REFINAGE, government revenue consists of income taxes and indirect taxes, and transfers from other sectors. The revenue from taxes and tariffs is defined in earlier parts of the REFINAGE code.

In the model, all incomes are taxed, and thus the revenue is the sum of taxes on labour and capital incomes, as well as taxes on benefits (which include age-dependent, unemployment, and other benefits). The coefficients are calculated form base data by formulas in section 5.10, and include aggregate income taxes and aggregate tax revenues:

```
INCTAX = TAX_LAB + TAX_CAP + TAX_LND + TAX_AB + TAX_OB +
AX_UB;
```
(5.91)

and

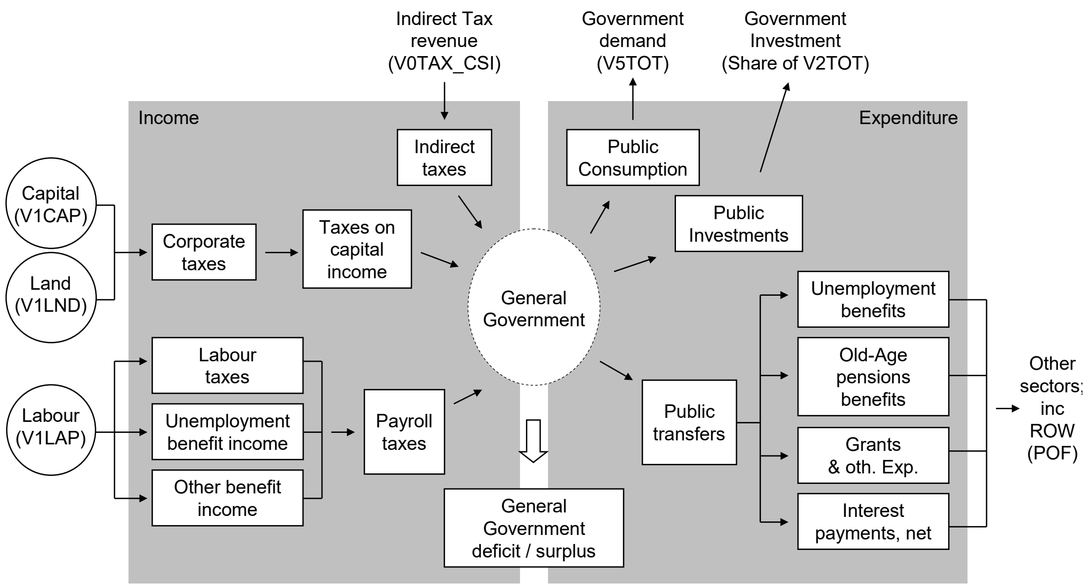
```
NET_TAXTOTG = V0TAX_CSI + INCTAX + COL_PAYRTOT;
```
(5.92)

Government spending, on the other hand, consists of the demand for commodities for immediate consumption and investment, and transfers payments. The transfers are made up of age-dependent, unemployment, and other benefits, grants, and net interest payments on the public sector debt. The corresponding coefficients are:

```
TRANS = UNEMPBEN + AGEBEN + OTHBEN + GRANT + NETINT_G;
    (5.93)
```

Figure 5.3 shows schematically the allocation of overall government spending is allocated and the collection of government revenue.

Figure 5.3. Government spending and revenue in REFINAGE



The public sector deficit is defined as the difference between expenditures and revenues, including net interest on government debt. In REFINAGE code, government deficit evolves according to

```
Equation E_d_gov_defs1
  # Public sector deficit, or public sector financing
transactions #
(all,d,DST)(all,s,GSEC)
  100*d_gov_defs(d,s) =
                V5TOTS(d,s)*w5tots(d,s) +
V2TOT_G_IS(d,s)*w2totg_is(d,s)
                +      100*d_othcapgovs(d,s)
```

```
                        - NET_TAXTOTS(d,S)*nettaxtots(d,s)
                        - OTHGOVREVS(s,d)*oth_govrevs(d,s) +
100*d_transfs(d,s)
                    +GOVTOMUN(d)*f_govtomun(d)
                    +GOVTOSSF(d)*f_govtossf(d)
                    -MUNTOGOV(d)*f_muntogov(d)
                    -SSFTOGOV(d)*f_ssftogov(d)
;
```

(5.94)

where the change in public deficit is caused by changes in the value of public consumption, changes in the value of public investment demand, change in other government capital expenditure, changes in net tax revenue, changes in other government revenue; and changes in transfer payments.

The accumulation of government debt is linked to deficits and is given by

```
Equation E_d_psd_t1s # Public sector debt, end of year #
(all,d,DST)(all,s,PSEC)
d_psd_t1s(d,s) = d_psd_ts(d,s) +
d_gov_defs(d,s)+d_f_psd_t1s(d,s);
```

(5.95)

In other words, current deficits contribute to the debt stock. As with other financial assets, the evolution of debt is governed by the following equation:

```
Equation E_d_f_psd_ts
  # Gives shock to start-of-year public sector debt, yr-
to-yr sims #
(all,d,DST)(all,s,PSEC)
d_psd_ts(d,s) = [PSDATT_1_B(d,s) -
PSDATT_B(d,s)]*d_unity + d_f_psd_ts(d,s);
```

(5.96)

We now turn to the determination of the transfers from the government. REFINAGE assumes that these depend on the size of the population receiving them but also allows them to be indexed to consumer prices and/or real wages, or to be given entirely exogenously. For example, changes in pensions and age-related benefits can be indexed to real wages and consumer prices:

```
Equation E_age_bens # Old age benefits paid by govern-
ment #
(all,d,DST)(all,s,PSEC) age_bens(d,s) =
popaged(d)-popagednat+f_age_bens(d,s)+f_age_ben_nat;
```

(5.97)

where pop_aged gives the change in old-age population, p3tot changes in consumer prices and real_wage_c is the change in the pre-tax real wage rate. However, it is also possible to give the forecast of age benefits exogenously, using information from outside of the model.

Finally, overall government investment can also be determined exogenously, or it can be tied down to the evolution of the overall level of private investments. The choice between exogenous scenarios and the in-built mechanisms in the model depend entirely on the nature of the policy experiment.

REFINAGE allows for different budget, or fiscal rules to be used. One of them is dynamic and involves the balancing of deficits with an eye on overall national saving. This mechanism was introduced in chapter 2.3.4, and allows for a specification where the government budget is not immediately balanced. This is accomplished by specifying a budget rule that links national saving – which is related to government deficits as will be explained late – and employment, to allow for deficits while employment is below normal (or rather, expected).

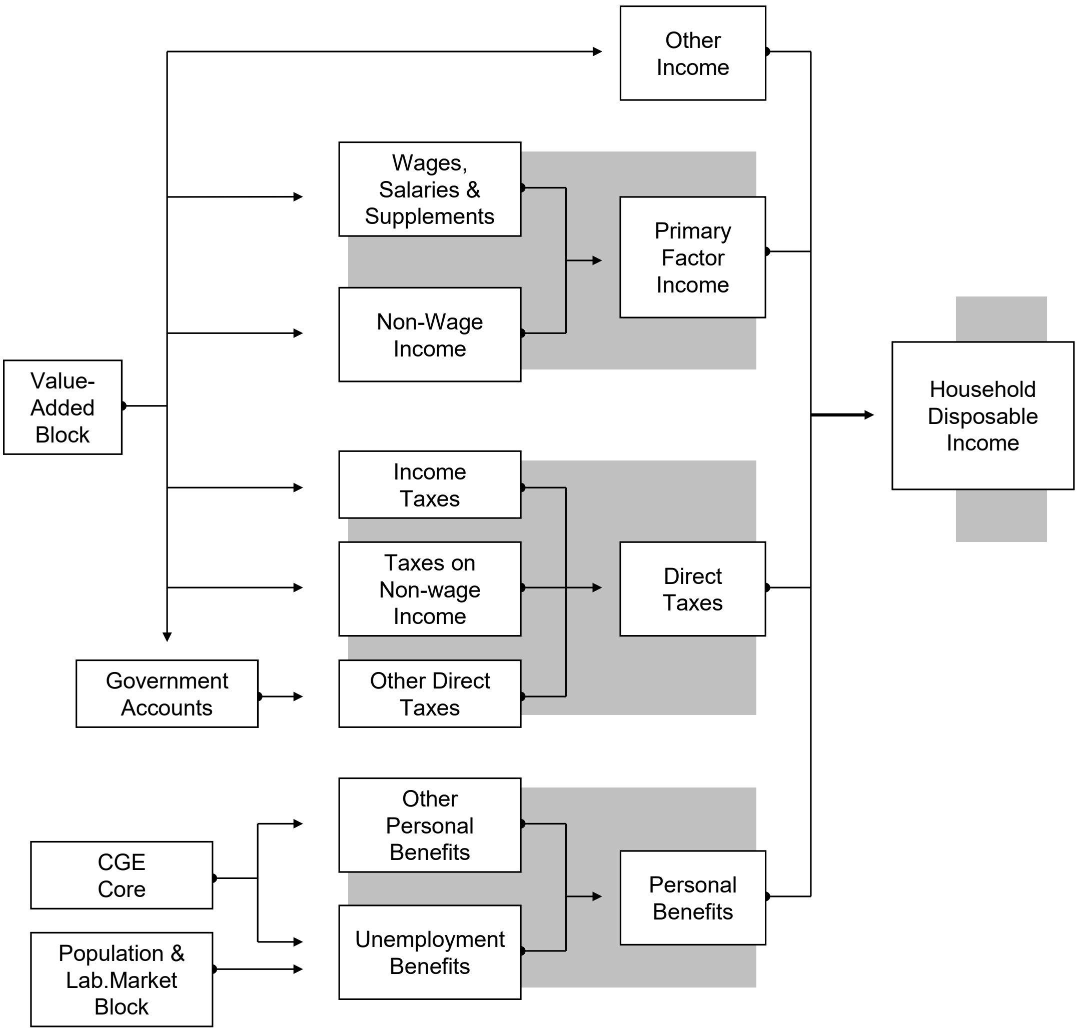
5.3.4 Income and Saving aggregates

(Sections 8.16. in the REFINAGE code)

Section 8.16. 1 in the REFINAGE code contains definitions for household income and saving aggregates. The section commences with household disposable income.

In REFINAGE, household income stems from several sources: factor incomes, transfers from the government, and from foreign assets. These sources are summarised in figure 5.4.

Figure 5.4. **Household disposable income**



In REFINAGE code, household income is given by

```
Equation E_hdispinc # Household disposable income #
(all,d,DST) HOUS_DIS_INC(d)*hdispinc(d) =
    GDPEXP(d)*wgdpexp(d)
+ (sum{s,PSEC,100*d_transfs_h(d,s)
```

```
   - {NET_TAXTOTS(d,s)*nettaxtots(d,s) + OTHGOV-
REVS(s,d)*oth_govrevs(d,s)}})
   +SHRASS_H(d)*[C_INTAD*intad+C_INTAE*intae -
C_INTLD*intld - C_INTLE*intle];
```

(5.98)

On the RHS of the equation, factor incomes are expressed in terms of GDP, from which government expenditures and debt servicing costs are deducts. The second but last line in the equation represents asset and equity income from abroad less interest on foreign debt and equities.

```
Equation E_housav # Household saving #
(all,d,DST) HOUS_SAV(d)*housav(d) =
    HOUS_DIS_INC(d)*hdispinc(d) - V3TOT(d)*wfin("Hou",d);
```

(5.99)

The level of consumption in REFINAGE is determined by a consumption function relating disposable income to consumption. The consumption function is given by

```
Equation E_f3tot # Consumption related to disposable in-
come #

(all,d,DST)(all,h,HOU)  HOUPUR_C(d,h)*w3tot(d,h) =
    AV_PROP_CON(d)*HOUS_DIS_INC(d)*[f3tot(d) + hdis-
pinc(d)];
```

(5.100)

where AV_PROP_CON is the average propensity to consume out of disposable income. A constant propensity to consume is a characteristic of the steady state of many theories of economic growth. REFINAGE displays this characteristics but it also allows for short run deviations from a constant propensity to consume. REFINAGE also allows the propensity to consume to be determined by the model in forecast simulations, for example, to accommodate for short term macroeconomic forecasts of the macro variables stemming from outside the model. Finally, the consumption function also implies a link between disposable income and saving.

5.3.5 Balance of payments

(Subsection 8.16.2 in the REFINAGE code)

TRADE FLOWS – something here as well

Equation E_p0imp_c, defines an index for the landed-duty-paid prices of imports. Comparison of results for p0imp_c defined in this equation with those for the GDP deflator (p0gdpexp) provides a useful indication of changes in the competitive position of imports in the domestic economy. This can be important in explaining simulated shifts in the ratio of imports to GDP.

```
E_w0imp_c          w0imp_c = x0imp_c + p0imp_c;
```

(5.101)

Equation E_toft, defines the percentage change in the terms of trade as the difference between the percentage changes in the f.o.b. price index for exports and the c.i.f. price index for imports.

```
E_p0toft            p0toft = p4tot - p0imp_c;
```

(5.102)

Finally, equation E_p0realdev defines the percentage real devaluation. This is normally measured by

```
E_p0realdev      p0realdev =  p0imp_c - p0gdpexp;
```

(5.103)

In E_realdev, we measure domestic inflation by the percentage change in the GDP deflator (p0gdpexp), and we assume that foreign inflation is reflected in the foreign currency price of imports, implying that it equals the percentage change in the c.i.f. domestic price of imports (p0cif_c).

We still have to establish the link between the domestic economy and foreign sectors. This link is provided by accounting for national saving, foreign assets, the trade balance, and the accumulation of new assets.

National saving is defined as an aggregate private and government saving. In the code, it is given by

```
Equation E_natsav
  # National saving: household saving plus public sector
surplus #
  NAT_SAV*natsav = HOUS_SAV_d*housav_d
+100*d_govsav_nat;
```

(5.104)

where the public sector surplus is defined by

```
Equation E_d_govsav_nat # Government saving #
  d_govsav_nat = - d_gov_def_nat
                  + 0.01*V2TOT_G_I_D*w2totg_is_ds
                  + d_othcapgov_nat;
```

(5.105)

Equation (5.104), a simple national accounting identity, links household disposable income, government deficits, and government investments.

Figure 5.4 shows how the domestic economy is linked to the foreign sectors. The trade balance reflects the exports and imports of the economy, the theory of which was explained in the first part of this chapter. The second link is formed by the (historically given) ownership of foreign assets and liabilities, which determines asset incomes from abroad and interest payments on foreign assets and equities. The current account balance provides the final link, connecting changes in the ownership of assets to changes in domestic saving and domestic deficits, as well as changes in the trade balance.

The current account balance combines the trade balance with financial account balances. In REFINAGE code, changes in the current account are given by

```
Equation E_d_cab
100*d_cab =
```

```
  [V4TOT_D*w4tot + C_INTAD*intad +C_INTAE*intae]
    - [V0IMP_C_D*w0imp_c +  C_INTLD*intld + C_INTLE*in-
tle ] +100*d_nettrn;
```

(5.106)

where C_INTAD and C_INTAE are incomes from foreign assets and equities, and C_INTLD and C_INTLE are outstanding foreign debt and liabilities. The changes in the contribution of these assets to the current account balance (the terms intad, intae, intld and intle), account for changes in the interest rates on these assets, on to changes in their amounts. The term d_nettrn present changes in net transfers abroad, which consist of payments to international organisations and the like that can be taken as exogenous. REFINAGE assumes that changes in the ownership of foreign assets are due to changes in national saving, or to revaluation effects. Part of national saving is thus directed towards foreign assets and equities.

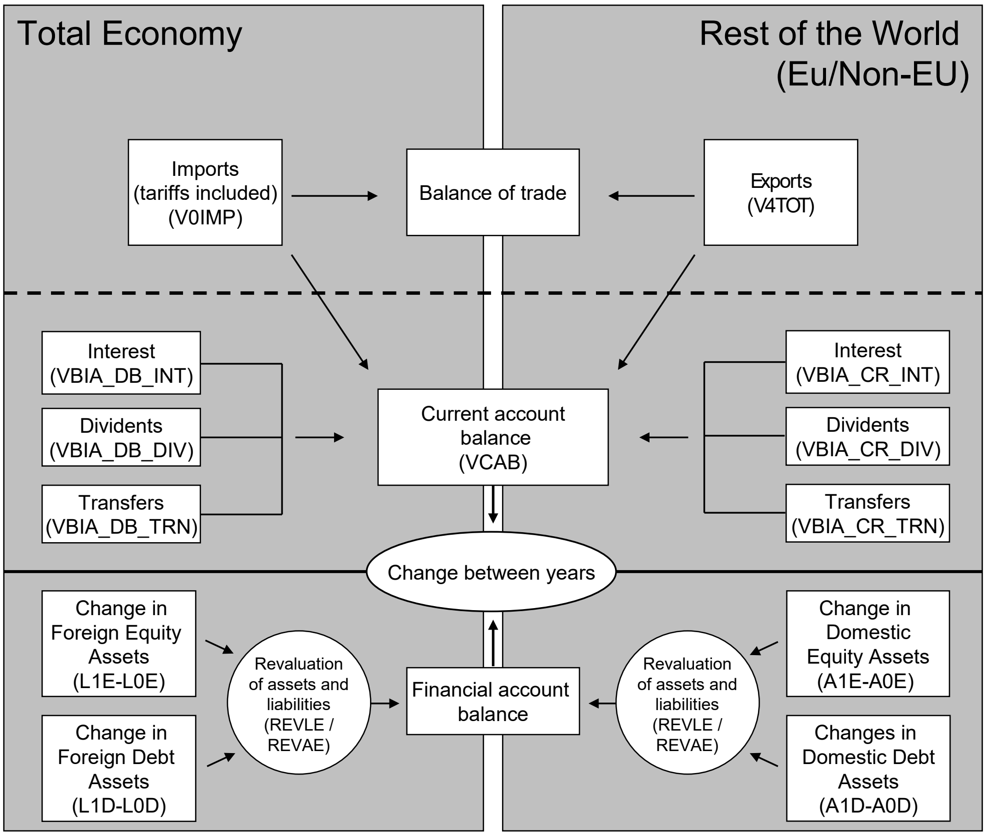
The accumulation of foreign assets is affected by changes in national saving. The accumulation of foreign liabilities, on the other hand, is affected by changes in the net financial position of the economy. For example, when the current account balance is weakening, because of unfavourable changes in relative prices increasing the trade balance deficit, the debt servicing costs do not respond in the short run. Assuming national savings are not affected, the deficit must be met with increased foreign liabilities. This connection is recognised in equation E_d_newle, which links changes in liabilities to the current account deficit:

```
Equation E_d_newle
100*d_cab = C_FE*NAT_SAV*(fe+natsav) +
C_FD*NAT_SAV*(fd+natsav)
                      - 100*d_newle - 100*d_newld;
```

(5.107)

REFINAGE assumes that the split of new lending between equities and debt is only changed from what it historically was if there are changes in the rates of interest, which are exogenously given.

Figure 5.5. The links between the current account and asset accumulation in REFINAGE



5.4 Reporting variables and miscellanea

(Section 8.17 in the REFINAGE code)

The final sections of REFINAGE code contains useful reporting variables, as well as some equations that can be used to link taxes to each other. Greenhouse gas accounting is also included among the miscellaneous equations.

The miscellanea in REFINAGE code contain some indexes not elsewhere defined, but also a useful device for forecasting that allows us to introduce forecasts based on more highly aggregated data than is otherwise used. These equations do not introduce any new theory to the model.

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NACE (Nomenclature Générale des Activités Economiques dans les Communanautés Européennes) is statistical industry classification used in European Union.

ISIC (International Standard Industrial Classification of All Economic Activities) is a statistical industry classification confirmed by United Nations.

CPA (Statistical classification of products by activity in the European Economic Community) is used by the European Union in national and regional accounts for input-output analysis.

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