INTERINDUSTRY BASED ANALYSIS OF MACROECONOMIC FORECASTING

Picture of a Leopard

19TH INFORUM World Conference
Hazyview
South Africa

INTERINDUSTRY BASED ANALYSIS OF MACROECONOMIC FORECASTING

19TH INFORUM World Conference

Edited by
David Mullins
Jeaunés Viljoen
Herman Leeuwner

Printed by
STN Printers, 2011
126 Soutpansberg Road, Riviera 0033, Pretoria
South Africa
www.stnprinters.co.za

Published by
Conningarth Consulting Economists, 2011
CSIR Premises, Meiring Naude Road
North Gate, Bld 4e, Brummeria 0184, Pretoria
South Africa
www.conningarth.co.za

ISBN 978-0-620-53149-8

CONTENTS

PREFACE

Conningarth Economists was privileged to host the 19th INFORUM World Conference in South Africa, at the Hippo Hollow Wild Life resort, in August 2011. This publication includes a collection of papers presented at the conference. The 14 contributions included originate from China, Germany, Italy, Russia, South Africa, Turkey and the USA. The conference again showed the variety of use and applications possible with the INFORUM modelling concept. The topics covered range from relatively basic application, through more complex approaches, to the more technical aspects of the application of INFORUM modelling. All contributions used dedicated INFORUM related/integrated modelling systems.

The conference addressed a considerable number of issues/challenges related to the development of macroeconomic modelling for projections, forecasting, outlooks and reviews, including productivity measurement from Input-Output economics; prices and price equations; error correction; incorporation of carbon emissions and raw material into final consumption; employment and occupational projections; scenario development and simulations for a future low carbon economy; renewing INFORUM models from experience of Input-Output modelling; the influence of intersectoral competition limitations; household consumption simulation; GIS functionality in multiregional modelling; and running Interdyme models in G. The papers in this publication are presented in two broad categories namely Development and Compilation of Multi-Sectoral Macroeconomic Models and Economic Forecasting and Analysis of Multi-Sectoral Macroeconomic Models.

DEVELOPMENT AND COMPILATION OF MULTI-SECTORAL MACROECONOMIC MODELS

RUNNING INTERDYME MODELS IN G

Clopper Almon[1]

Abstract
A new, clarified and simplified method of running dynamic input-output models built with the G7-Interdyme software is presented and explained.
JEL Classification: C63 and C67
Keywords: Interdyme, G7, Dynamic input-output models

INTRODUCTION

As I developed the G regression program and the Interdyme software for building dynamic multi-sectoral models, I had a fairly clear idea of how they should be used together to run those models. Unfortunately, the program that I wrote and the description of how to use it did not convey that idea clearly. Various procedures sprang up, and even the G code was modified in ways that added to the confusion. In the spring of 2010, I was teaching at the University of Lodz with a big class running an Interdyme model. The need for clarity in the process became pressing. I had to think through the process carefully. As a stopgap measure, I came up with a G "add" file with arguments which took care of the worst of the problems. With more time, I added an Interdyme Run Form to put everything on one form, including a few words of explanation. The Craft of Economic Modelling has been rewritten to use this form with the TINY model developed in its pages.

Here the use of this form is to be explained in the context of the TINY model, but to make the explanation concise because the Interdyme models are already familiar. The starting point is that at which the MODEL.CPP has been written. In reading dates, remember that in the world of TINY, 1993 is the last year of data.

---

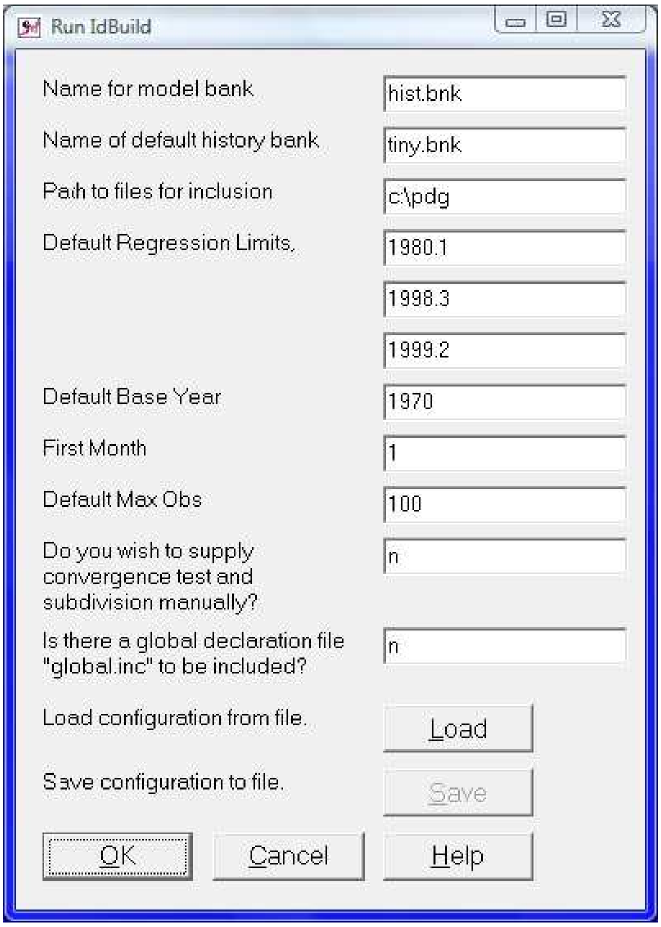
1 Inforum/University of Maryland

RUNNING THE INTERDYME MODEL

With the code of MODEL.CPP ready to go, the G bank can be created with all the macro-variables of the model, write the C++ code for handling the regression equations and identities, compile this code and MODEL.CPP, link the compiled modules (whose file names end in .obj) into an executable program, and, in the process, get started on forecasting the exogenous variables, all by clicking "Model" in the G main menu and then clicking "Run IdBuild and compile model".

These two clicks bring up the window shown on the next page. If there was a BUILD.CFG file in the directory where G was started, then it will have been used to fill in the boxes in this form. Otherwise, the user can fill them in, click OK, and the content will be written as the BUILD.CFG file. The first box, labelled "Name for model bank", contains the name of the G bank to be created having all the variables in the model but no others. The second box, labelled "Name of default history bank", contains the name of a G bank from which to draw historical values of the variables -- until and unless a "bank" command switches to a different input bank. The first bank is created by this program; the second must exist before this program is run. Generally, the G bank created by IdBuild should have the same root name as does the VAM file with historical values of the vectors and matrices.

The next three boxes, labelled "Default regression limits," are not actually used. They are there to keep the format of BUILD.CFG the same as that of G.CFG files; any dates will work fine. Then come the base year of the bank to be created, the first month of that year which is covered (which is always 1 for annual models), and the maximum number of observations (years) to be accommodated in the bank. The next two fields allow for advanced features that will not be used and should for the purposes in mind just contain the letter n for no. When the form has been filled in as desired - and it will usually have been automatically been filled in correctly – click OK.



This one click runs IdBuild, which writes HEART.CPP, and also compiles MODEL.CPP, HEART.CPP and any other modules that need to be compiled, links them together and produces the DYME.EXE, the executable file for running the model. It also writes EXOGALL.REG and RUN.XOG, and creates the HIST bank of variables in the model, including both HIST.BNK and HIST.VAM with time series of vectors and matrices.

You use EXOGALL.REG to make projections of the exogenous variables, exactly as with macro models. It will put the predicted values of each exogenous variable into its own .XOG file, such as this one, GOVTOT.XOG,

update govtot
2003 348.1439 353.9075 360.3546 367.3013 374.6133
2008 382.1923 389.9666 397.8835

As with macro-models, you can edit these .XOG files to change the forecasts. In doing so, you can make use of any function in G[2] . When the file is edited, change the extension of the filename from .XOG to .XG so that your carefully edited file is not overwritten the next time IdBuild is run.

For the present, RUN.XOG will suffice as automatically written (and shown above) and also with all the .XOG files. But a copy is needed of RUN.XOG named RUN.XG. RUN.XOG can just be opened in the editor and saved as RUN.XG.

You can now run the Interdyme model by clicking:

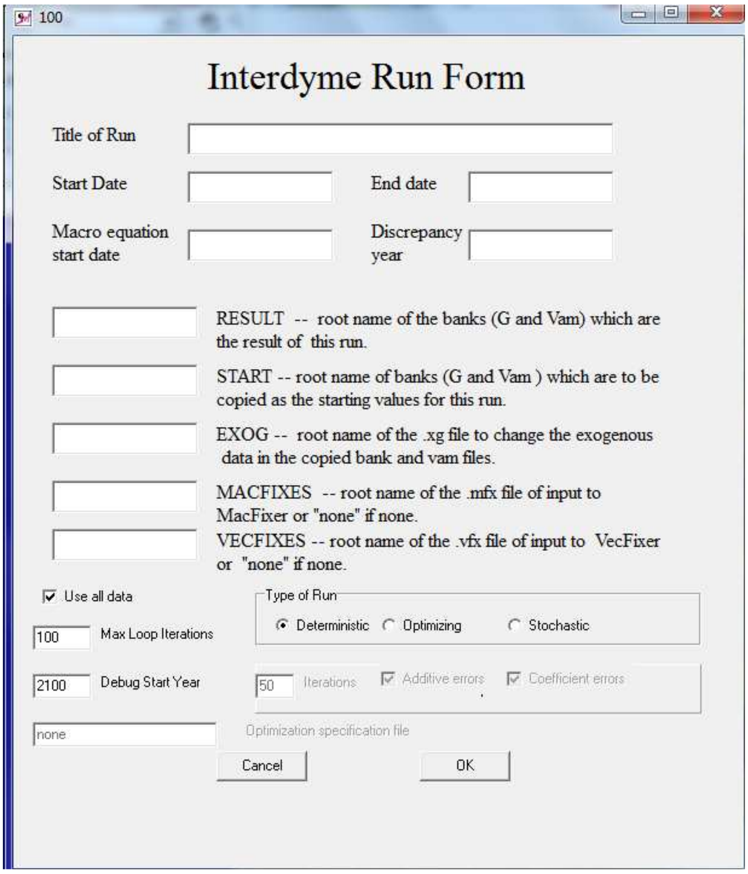
Model | Run Dyme Model

The form shown on the next page appears. This is the new form I want to call to your attention.

---

2 But the convenient device of putting a 0 for values to be linearly interpolated does not work because in G it is sometimes important to give a true 0 to a variable. Instead, in the update command, one leaves out the value to be linearly interpolated and uses G's @lint() function. For example, if the above values are to be kept, of govtot for 2003 – 2007 but set the 2010 value to 420 and interpolate 2008 and 2009 linearly between 2007 and 2010, the following would be put into GOVTOT.XG:

update govtot
2003 348.1439 353.9075 360.3546 367.3013
2007 374.6133
2010 420
f govtot = @lint(govtot)



The "Title of Run" can be anything that fits in the space provided. It will show up on tables made with the Compare program.

The Start Date field should be a four-digit year, for example, 2008. It is the year in which the calculations begin. The End Date field is similar; it is the last year for which calculations will be made.

The Macro equation start date is the first year in which the macro equations will be calculated. In forecasts, it will generally be the last year for which there is data on the values of the macro variables. This data is then used to set the initial value of the rho adjustment. For historical or counter-historical simulations, the macro equation start date is some time before the last available data.

Discrepancy year is used in some models as the year for calculating a discrepancy vector subsequently used in the input-output calculations. If your model does not use this device, just fill in any year.

The next five fields all use the concept of the root name of a file. It is the part of the filename following the directory name but before the dot in the name. Thus, the root name of the file whose full name is C:\MALAYSIA\MODEL\BASE.BNK is just BASE. The part of the file name after the dot is called the extension. In the example just given, the extension is BNK. The expression run bank is also useful. A run bank is the combination of three files, the .VAM, the .BNK, and .IND files associated with a run of the model. All three of these files should have the same root name, and that root name is the root name of the run bank.

The words RESULT, START, EXOG, MACFIXES, and VECFIXES will now be used as names of variables whose values will be the root names of files or run banks. For example, the variable START might be given the value HIST, the root name of a run bank. The values of these variables are specified by the content of the edit boxes just to the left of these names on the form. The START variable should be given as a value the root name of the run bank from which the model begins its calculations. The first time the model is run, the START run bank will have been created by a G-only version of the model. Once a base simulation has been established with a run bank named, say, BASE, this run bank can be used as the START run bank for subsequent runs of the model.

The RESULT field should be filled in with the root name of the run bank which will be created by the run of the model. Examples could be Base or Boom or Crash. Normally, the START run bank is copied to the RESULT run bank before any calculations are done. But if START and RESULT are the same, no copy can be made – a file cannot be copied onto itself -- and the model begins its calculations from the run bank specified by these two names.

The next variable to be supplied by the user is EXOG, the root name of a file having the extension .XG. This is a file of G commands which change the exogenous variables in the RESULT run bank. These changes can include both exogenous macro variables such as population or money supply and exogenous variables in the VAM bank, such as input-output matrices.

The next variable to be supplied by the user is MACFIXES. Just as macro models need to be manipulated by fixes on their behavioural equations, so too do multisectoral models. The fixes are specified in ways that are similar to but not quite identical with the ways they were specified in macro models. The details are supplied later in this chapter. For the moment, it is enough to note that the specifications should be put in a file having the extension mfx. The root name might be Base or Boom or Crash or any other descriptive word – but not MacFixes. That root name should be typed into the MACFIXES blank, and a special program called Macfixer is called to prepare the fixes for easy use by the model. If the word "none" (without the quotation marks) is typed there, Macfixer is not called and no macro fixes are used.

Besides the fixes on macro-variables, there may be fixes on vectors. As with macro equation fixes the details are specified later in this chapter. The specifications should be in a file with the .vfx extension and the root name of this file should be typed into the VECFIXES blank. It should NOT be VecFixes. They are processed by a special program called Fixer. If the word "none" is in the VECFIXES blank, Fixer is not called and the simulation program does not look for vector fixes.

If the box "Use all data" is checked, all known values of endogenous macro variables will be used. It should not be checked if it is desired to test the model inside the period of known historical values of endogenous macro variables.

The type of run will normally be "deterministic". Optimisation similar to that for macro models is available. Stochastic simulation is not presently (2011) available, but should not be especially difficult to program for macro-equations.

Sometimes, when a model is not behaving correctly, it is useful to put in debugging printout. But often the problem is not visible until the model has run several years. Only then is the printout desired. The "Debug start year" blank provides a way to supply the year in which the printing is given. If it is not used in the model, it may be given a value far out into the future, as has been done in the example.

When this form has been completed, just click the OK button, and the model will be run.

If all goes well, that is all you need to know. But if you would like to know more details about what happens when you click OK, here are the basics.

A DYME.CFG Example

```
Title of run   ;Demonstration
Start year     ;1995
Finish year    ;2010
Start MacEq yr ;2003
Discrepancy yr ;1995
Use all data?  ;yes
VecFix file    ;none
MacroFix file  ;MacFixes.mfx
Vam file       ;base
G bank         ;base
Debug start yr ;3200
Max iterations ;100
Optimization specification file; none
Number of random draws; 0
Additive random errors; no
Random coefficients; no
```

The five fields across the top of the form and the two panes at the bottom are used to create a file called DYME.CFG. The box above shows what it looks like for a base run of Tiny with no vector fixes.

The five edit controls in the middle of the form are used to create an "add" command with arguments to the G command processor. The command is

add run.add <RESULT> <START> <EXOG> <MACFIXES> <VECFIXES>

where the values of the variables <RESULT>, <START>, etc., are taken from form. All but the second of these names can well be the same. For example, a base forecast might be made, starting from the historical run bank by the following command to G:

add run.add base hist base base base

In fact, this way of working is to be recommended, for then the result of the run is a set of files which all have the same root name. In the case of the example, they would be BASE.VAM, BASE.BNK, BASE.IND, BASE.XG, BASE.MFX, and BASE.VFX. As noted, either or both of MACFIXES and VECFIXES can be “none” (without the quotation marks).

Going further behind the scenes, it can be asked (if there is interest in it) "What is the RUN.ADD file and what does it do?" It is a simple text file that needs to be in the directory with the model. It and two helper batch files, CopyToTmp.bat and DymeRunner.bat – which also need to be in the directory with the model – are shown in the boxes below.

The RUN.ADD File

```
#The arguments to this file are:
# %1 RESULT, %2 START, %3 EXOG, %4 MACFIXES, %5 VECFIXES

dos CopyToTmp %2

# Revise macro bank and vam file with EXOG.XG
wsb tmp
vam tmp b
dvam b
add %3.xg
wsb ws
close b

# Tap Enter to run model
pause

dos DymeRunner %1 %2 %3 %4 %5
```

The CopyToTmp.bat File

```
copy %1.ind tmp.ind
copy %1.bnk tmp.bnk
copy %1.vam tmp.vam
```

RUN.ADD first uses the CopyToTmp.bat file to copy the START run bank to a temporary run bank whose components are tmp.ind, tmp.bnk, and tmp.vam. Then it makes the tmp bank the G workspace bank and tmp.vam the default vam file. Then it causes G to use the commands and data in EXOG.xg to update all the exogenous variables, vectors and matrices. (Remember, EXOG here is a variable which will have whatever value you gave it in the Interdyme Run Form.) With all the exogenous variables now stored in the tmp run bank, that bank is now freed by G (the "wsb ws" and "close b" lines) so that they can be opened by the dyme.exe program which runs the model.

RUN.ADD then executes the DymeRunner.bat DOS batch file. If there are vector fixes, they are processed by the Fixer program to form the vecfixes.fin file. If there are macrofixes, they are processed by MacFixer to create the Macfixes G bank used by the Interdyme program. Note: the name of the file that specifies your macro fixes should have the extension .mfx but should NOT be MacFixes.mfx. Likewise the file that specifies the vector fixes should have the extension .vfx but should NOT be VecFixes.vfx.

With all the exogenous data and fixes ready for its use, the Interdyme model is executed by the simple command "dyme". When it finishes, the tmp files are all copied to files with corresponding extensions but the value of the RESULT variable as their root name. Similarly, after execution of MacFixer and VecFixer, their input and check files are copied to RESULT.mfx, RESULT.mck (the check file), RESULT.vfx, and RESULT.vck (the check file from VecFixer). If EXOG is the same as RESULT, then all of the inputs and outputs of the run will have the same root name, a fact which makes it easy to keep track of what goes into and comes out of each run of the model.

The DymeRunner.bat File

```
rem The arguments here have the same meaning as in run.add.
rem If there are no Vector fixes, skip to Macro fixes.
if %5 == none goto macrofixes
rem  Here when there are Vector fixes
copy %5.vfx VecFixes.vfx
fixer
copy VecFixes.chk %1.vck
copy VecFixes.vfx %1.vfx

:macrofixes
if %4 == none goto runmodel
copy %4.mfx MacFixes.mfx
macfixer
copy MacFixes.chk %1.mck
copy MacFixes.mfx %1.mfx

:runmodel
dyme

echo Dyme has finished

copy tmp.* %1.*
```

If all these steps seem a bit complicated, remember that it only takes one click on the OK button to execute them all. Note also that a record of all the input files is made with the value of RESULT as their root name.
The MacFixer.cfg file is assumed to be:

MacFixer.cfg File

```
Input fix file    ;Macfixes.mfx
Output fixes bank ;MacFixes
Model G bank      ;tmp
Output check file ;MacFixes.chk
```

The Fixer.cfg file (for Vecfixer) is assumed to be

The Fixer.cfg File

```
Text input file              ;VecFixes.vfx
Fix index (.fin) output file ;vecfixes
VAM reference                ;tmp
Text check file              ;fixer.chk
```

While these files can be changed by the user, doing so will probably cause the Interdyme Run Form to stop working. The flexibility gained by changing these files is unlikely to be worth the confusion it will probably entail.

So what do you actually have to do to run a scenario which may be called BOOM? Just:

1. Create the BOOM.xg file to supply values of exogenous variables, both macro-variables and vectors and matrices.
2. Create BOOM.vfx and BOOM.mfx to supply values of fixes.
3. Click Model | Run dyme model in G, fill in the blanks with HIST as the value of START and with BOOM as the value of RESULT, EXOG, MACFIXES, and VECFIXES, and then click OK.

That's it. Simple as 1, 2, 3. Happy Interdyme model running!

SOME OF THE VALUE ADDED COMPONENTS IN THE PRICE EQUATIONS

MAURIZIO GRASSINI[3]

Abstract
The price side of an INFORUM multisectoral model has a detailed treatment of value added components at sectoral level. For Italy, as well as any other European Union Member State, the European system of accounts (ESA95) provides sectoral value added disaggregated into wages, social security, subsidies, provisions, and surplus. This paper focuses on the last four values added components. Social security, subsidies and provisions turn out to be by and large policy instruments to be listed among scenario variables while surplus, which contains self-employed income, appears to be correlated to the business cycle. Hence, in the Italian multisectoral model, surplus is going to be explained by means of econometrically estimated equations.
JEL Classification: C51, E37
Keywords: Input-output models, econometric modelling, business cycle

1. SOCIAL SECURITY

The ratio of social security to wages is very stable over time; in the 1990s it was over 40% before declining gradually to 37% where it steadied, showing a flat trend for the last decade. This ratio varies among industries; within each industry it shows a trend similar to that of the aggregate. Social security is a typical policy instrument. In the scenarios analyses, as well as in the counterfactual simulations, the true ratio of this value added component to its basis (wages) strictly belongs to scenario variables.

---

3 University of Florence Italy.

2. SUBSIDIES

The impact of the Wall Street crash reached Europe several years later. In Italy, like any other European country, many industries showed significant deficits as a result of the market turmoil caused by the financial crisis. In 1933 the Italian Government tackled the emergency by reforming the banking system and creating the IRI (Istituto per la Ricostruzione Industriale [Institute for Industrial Reconstruction]). Its first purpose was to rescue three important Italian banks (Commerciale, Credito Italiano, Banco di Roma) and their related companies. Although IRI was set up as a temporary measure, it continued to operate throughout the '30s when its power was extended to directly buy company shares. No formal nationalisation took place though its control of many industrial companies became highly significant. Eventually, IRI took over various important industries which showed deficits that, given the global economic depression, were forecast to last for many years to come. By the late 1930s, IRI owned a considerable share of the Italian economy, bigger than in any other country except the USSR, it is said. It's a matter of fact that IRI survived long after World War II when it became one of the largest conglomerates in Italy. IRI was a prototype for other similar institutions which were created subsequent to the so-called 'reconstruction' period. All of them endorsed the rescue of a great variety of companies. Two main arguments were developed to support public sector expansion in the business world. The first was on social grounds; when an industry experiences a severe economic crisis the government endorses measures to bring the industry back to economic prosperity so as to avoid the social upheaval related to a large number of workers who would otherwise risk losing their jobs. The second argument addressed the strategic role of some key industries; in such cases, state owned industries were given the task, without any economic budget constraint, to pursue the development of a specific industry plan.

Evidence of this peculiar economic governance was shown in the national accounts by the exceptional figures for subsidies in the primary income distribution account. The importance of this economic policy instrument (rescue as well as financial support) changed with European economic integration. Later in the 1980s, the perspective of creating a true common market, declared in the Single Act signed by the European

Council in 1987, which established the basis of the subsequent Maastricht Treaty, put state-owned companies out of Europe's economic future. A process of privatisation then took place in the 1990s; IRI was closed in 2002.
Subsidies have been progressively reduced over the last two decades. Fig. 1 shows that the ratio of subsidies to value added fell from about 2.67% in the early1990s to 1.5%, a clear decline.

Fig. 2 shows sectoral cases similar to the Total shown in Fig.1which represent the Average. Two sectors are reported; Machinery and Equipment, which have resembled the Average since 1994; Post and Telecommunication Services, which cyclically approach the Average. Both sectors start with remarkable deviation from the Average; in particular Post and Telecommunication Services. This sector contains State-owned companies which were quickly submitted to privatisation after approval of the Maastricht Treaty (1992) and prompt reduction in subsidies.

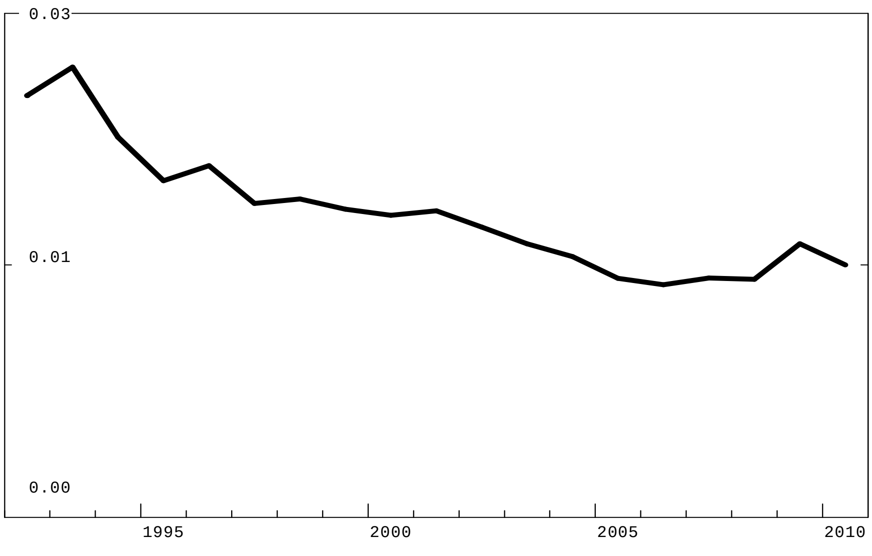


Figure 1: Subsidies to Value Added – Average ratio

Agriculture (Fig. 3) is a special case. The huge amount of subsidies increasing over time in clear contrast to the Average, shows the impact of the Common Agricultural Policy (CAP) on the primary sector of EU Member States. CAP is the most important Common Policy in term of its share of the EU budget since the Common Market was founded in the 1960s. Since then, CAP has changed its allocation criteria from the original protectionism of the internal market to a distribution of subsidies to support farmers' income. Hence, the remarkable amount of subsidies may be modelled through the structure of the EU Financial Perspective, the 7 year budget of the European Union.

Fig. 4 shows a very instructive case. Not only did state-owned companies receive financial support from the government; private industries employing hundreds or thousands of workers received financial help when their economic performance risked ending in bankruptcy. A sudden emergency due to large numbers of unemployed inevitably causes social turmoil; in such case governments willingly help those industries on the brink of going out of business. At the same time other large industries (typically those with production technologies based on assembly lines) threatened to fire their workforce as blackmail to get financial support from the government. All that came to an end; the EU economic policy was rooted on sound competitiveness as the corner stone of the EU market economy. The Automobile industry registered subsidies of up to 17% of value added for the sector in the 1990s; at the end of the first decade of the current century, Automobile subsidies are in line with the Average.

Education (Fig. 5), Printed matter & Recorded media and Transport services (Fig. 6), show exceptions. Recently, besides public Education fully financed by the government, private Education has been recognised as equivalent to a public service and therefore deserving of public financial support. Printed matter includes newspapers which are considered necessary tools for the working of a democracy; hence, all Italian newspapers referring to political institutions may deserve public financial support. Transport represents a case of redistribution of income; costs not covered by low fares are compensated with subsidies.
Fishing, Other Transport Equipment and Mining (Fig. 7) show prevailing trends converging with the Average.

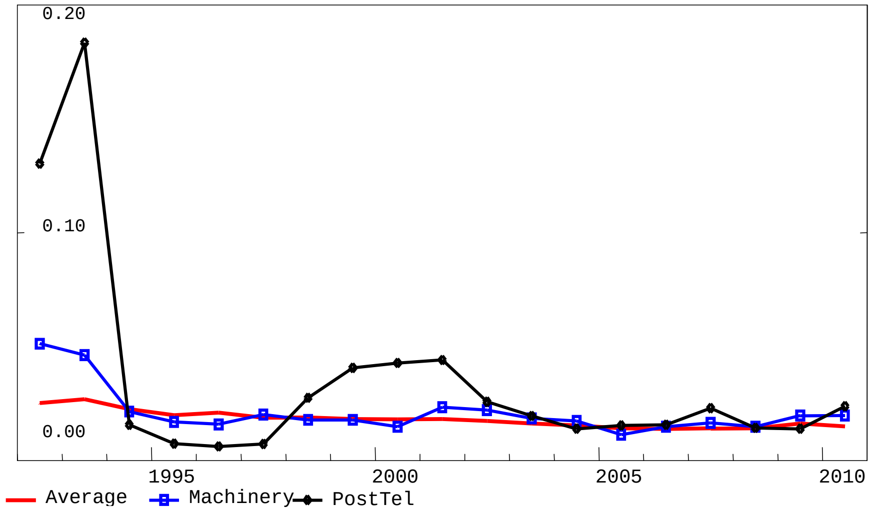


Figure 2: Convergence to Country average

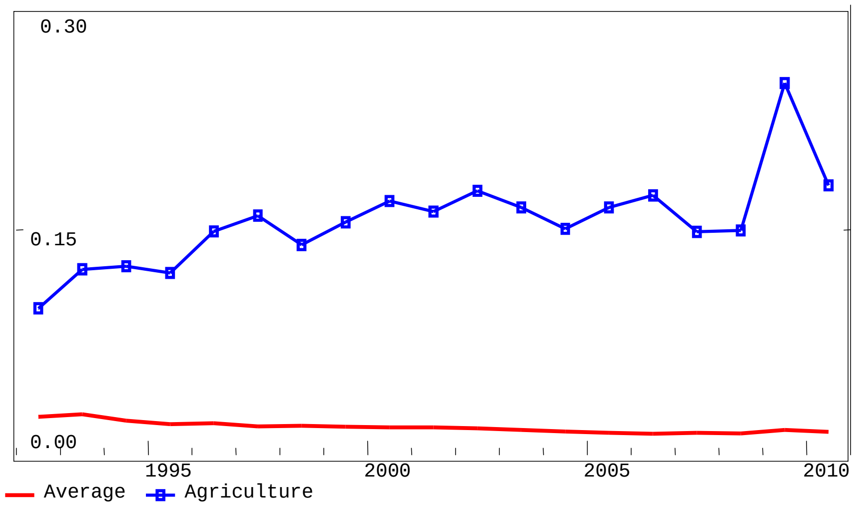


Figure 3: Agriculture – A special case PAC impact in EU Member State

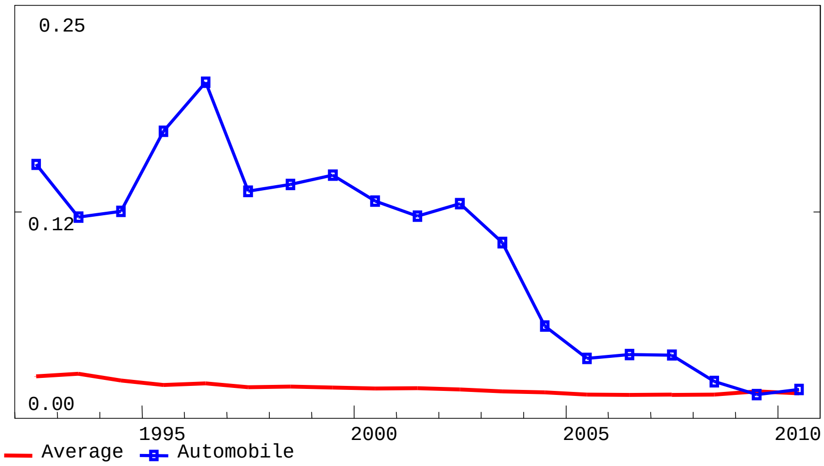


Figure 4: Change for Automobile Industry – Behind the globalisation of FIAT

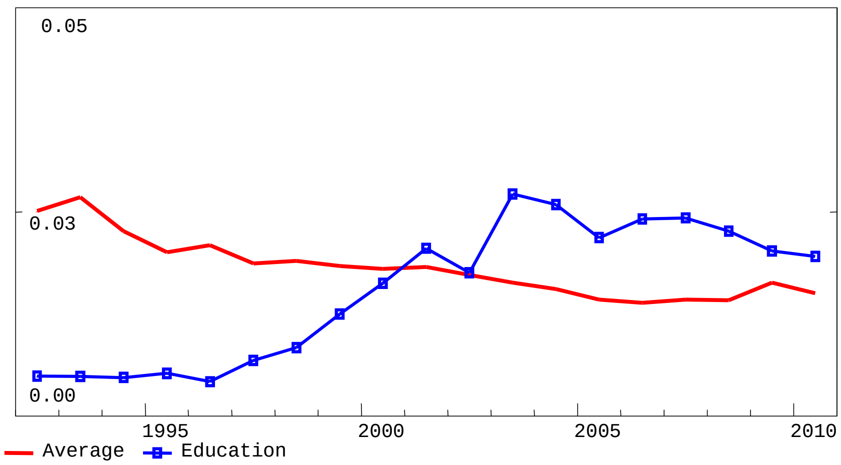


Figure 5: Education – New attention to "private" education

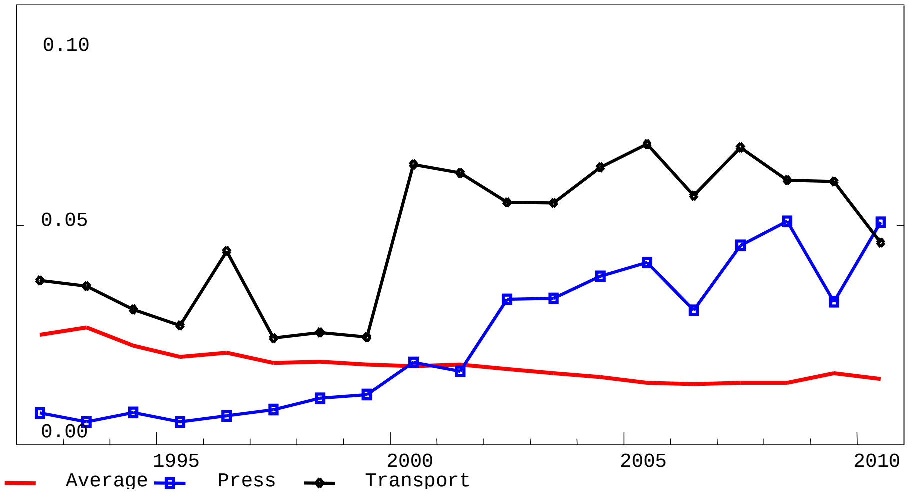


Figure 6: Going against the grain

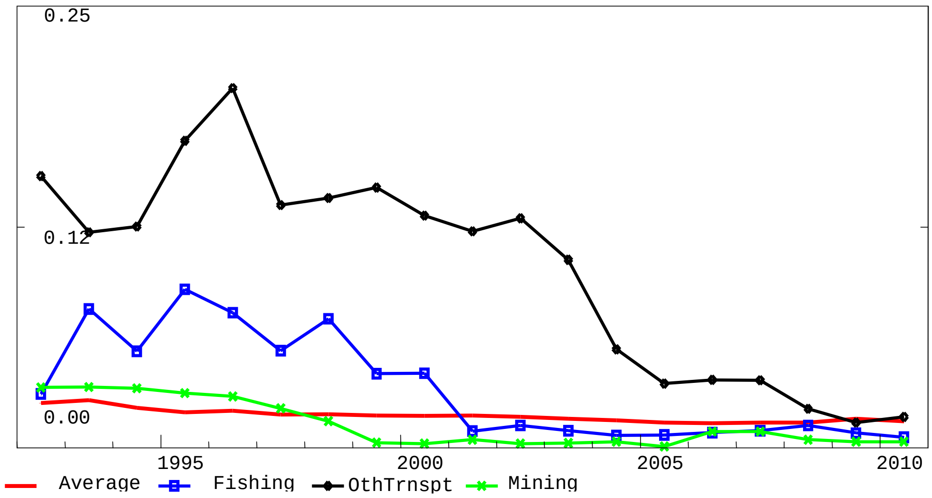


Figure 7: Subsidy fading away

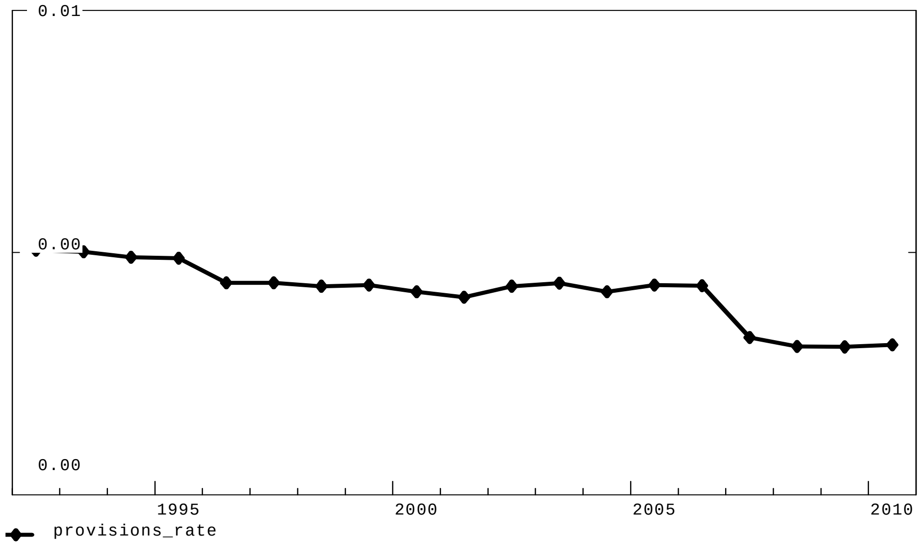


Figure 8: Provisions – Value Added share

3. PROVISIONS

This item in the Value added account bears witness to the practice of computing so-called 'postponed salary'. Usually, workers receive this (cumulated) wage at retirement time. Recently, the laws regulating postponed salary have been reformed. A worker may now ask to deposit this salary in a pension fund. The effect of this reform is most noticeable in Fig. 8 where such amount of liquidity recorded in the firm budget has undergone a clear reduction.

Provisions account for about 0.3% of value added. This item is not particularly important when modelling the formation of industry prices.

4. SURPLUS

Surplus is defined as Value added plus Subsidies minus Wages and Social security. Hence, it is a combination of incomes: self-employed salary, capital compensation, rents and profits. This component is heterogeneous among industries. Its share is inevitably influenced by the relative weight of employed and self-employed workers in the sector. Both workers matter for sectoral productivity; self-employed workers contribute to the size of the sectoral surplus. The percentages of self-employed workers out of total employment fell from 27% in 1992 to 23% in 2010. Although showing different self-employment shares, Food & Beverages, Textiles, Retail Trade & Hotels & Restaurants reflect the economy average (Average). Diversely, in Printed Matters & Recorded Media, Office machinery & Computers, Real estate & Renting services and the Education services sectors, the percentage of self-employed shows a positive trend. These sectoral trends, as well as the Average, reflect factors generating structural changes. Reforms of the labour market, the introduction of new technologies, changes in the industrial sector mix occurring over the last two decades, outsourcing up to the shifting abroad of specific industries are the main factors which have determined the trends shown in Figures 9 and 10.

Changes in self-employ shares necessarily have an impact on sectoral Surplus. In terms of income distribution, a self-employed share increase should induce a Surplus increase. Figures 9 and 10 shows that self-employ shares follow a very smooth trend. This variable, therefore, seems inadequate as an explanatory variable in a Surplus equation. Wages and Surplus aggregates show an apparently smooth trend (Fig. 11); their rates of growth show that Surpluses are more erratic than Wages (Fig. 12).

The difference is much more striking when comparing Wages and Surplus at a sectoral level. Fig. 13 shows that in the Metal Ores & Mining sector the surpluses trend is the shape of a parabola, which reaches maximum values around year 2000 and then shows a steady decline, whereas wages show a slightly positive trend.

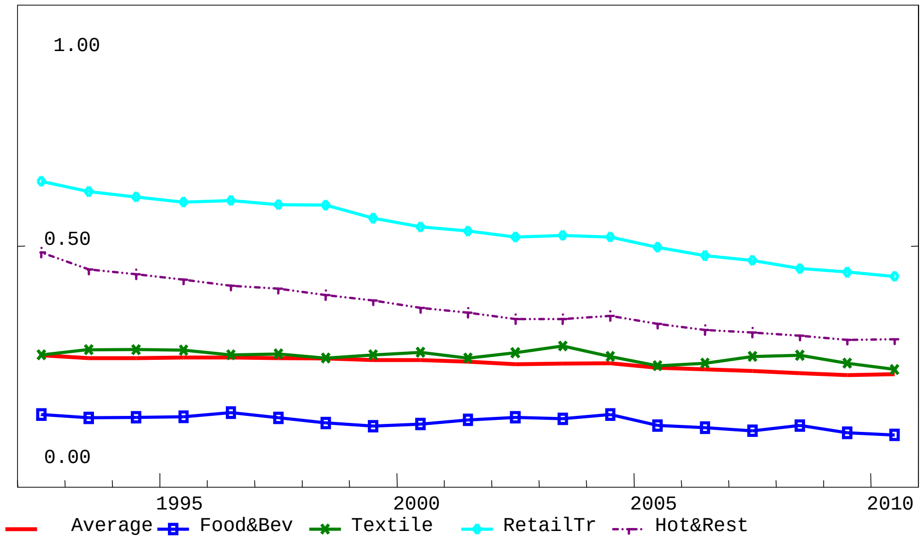


Figure 9: Declining Self-employment

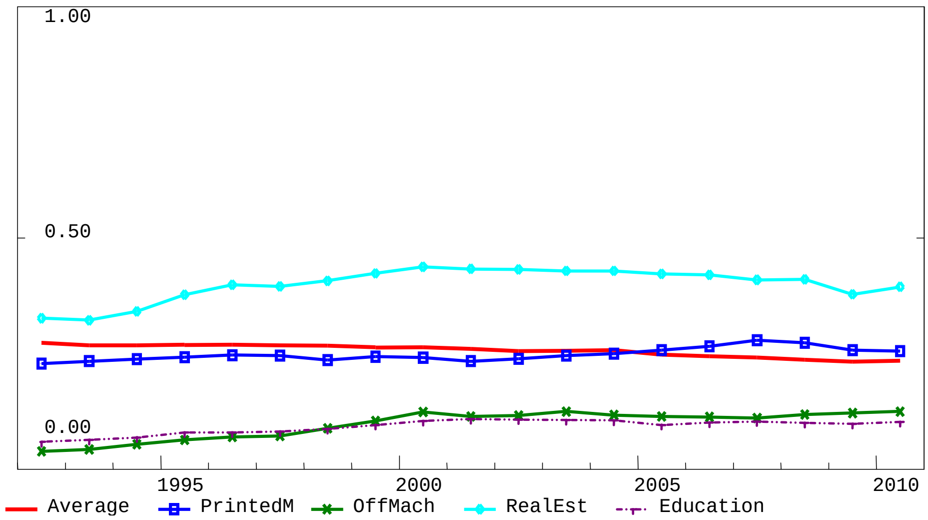


Figure 10: Rising Self-employment

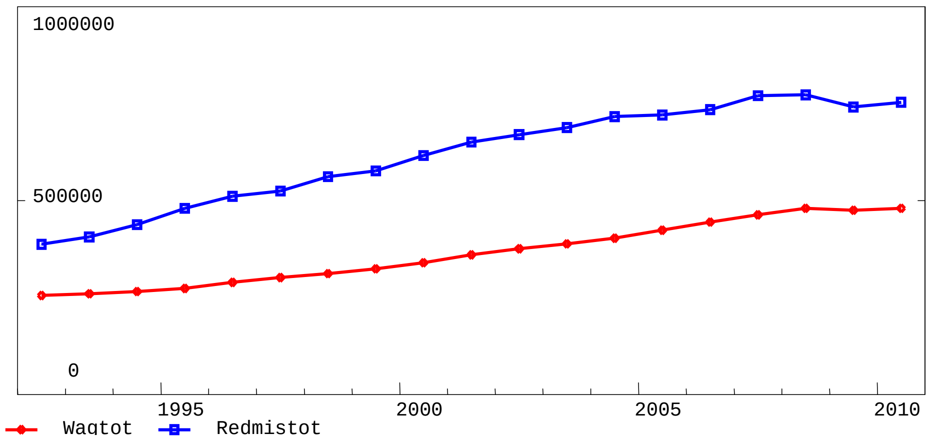


Figure 11: Wages and Surplus - Aggregates

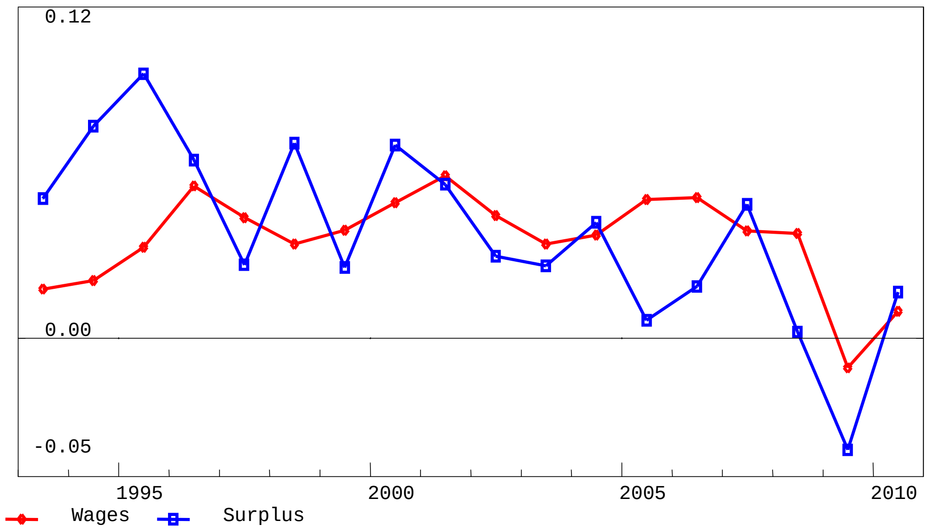


Figure 12: Wages and Surplus – Rates of Growth

Figure 14, Textiles wages declined over the last decade due to a sectoral employment reduction and surpluses shrunk even more. Leather and Leather goods, Figure 15, has wages similar to those of Textiles, while surpluses prevailed over wages in the last decade.

Basic metals, Metal products and Electrical machinery, Figures 16-18, have more volatile sectoral surpluses than sectoral wages, as is the standard case among industries; surpluses show a peculiar and interesting evolution corresponding to the 2008 global financial crisis. These sectors have experienced the consequences of the related fall in demand. It is clear that in these sectors the surplus has been compressed much more than wages. This fact provides a clue to modelling Surplus equations.

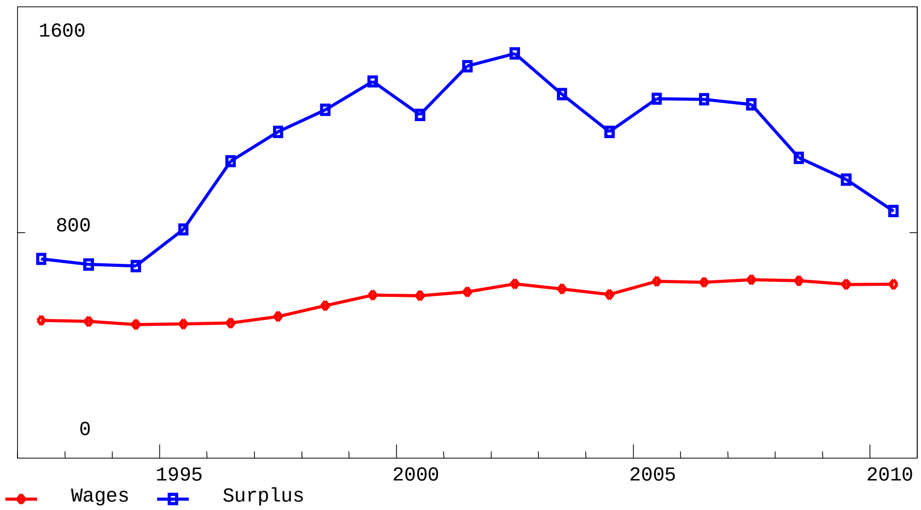


Figure 13: Metal ores, Mining – Rates of Growth

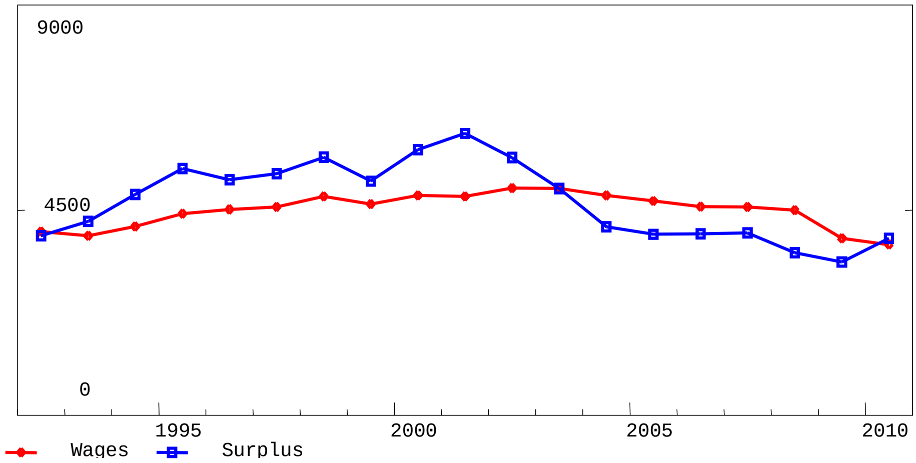


Figure 14: Textiles – Rates of Growth

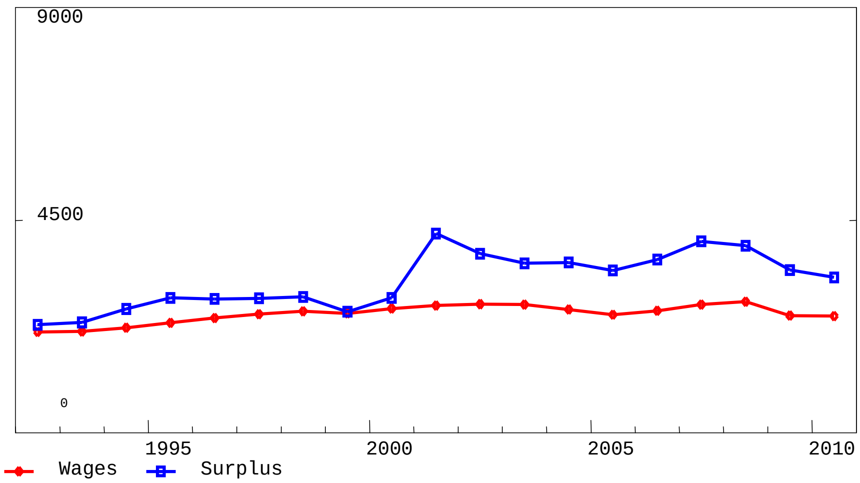


Figure 15: Leather and leather products – Rates of Growth

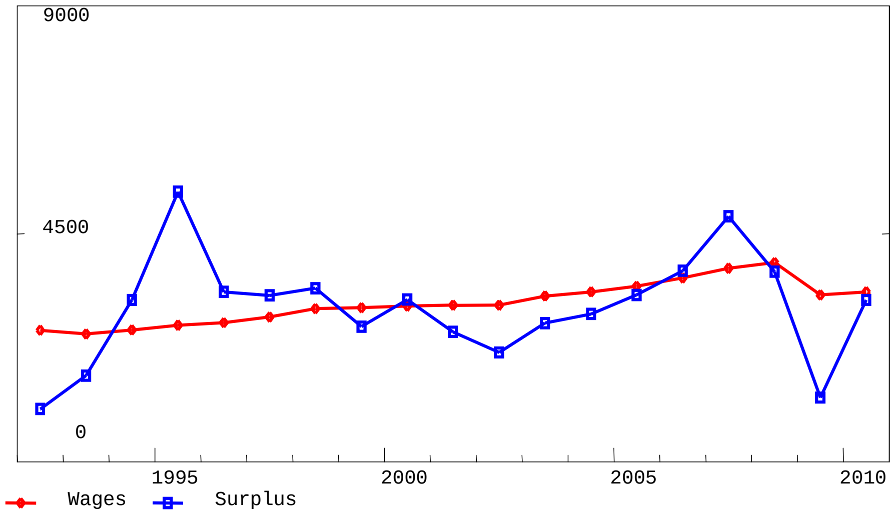


Figure 16: Basic metals – Rates of Growth

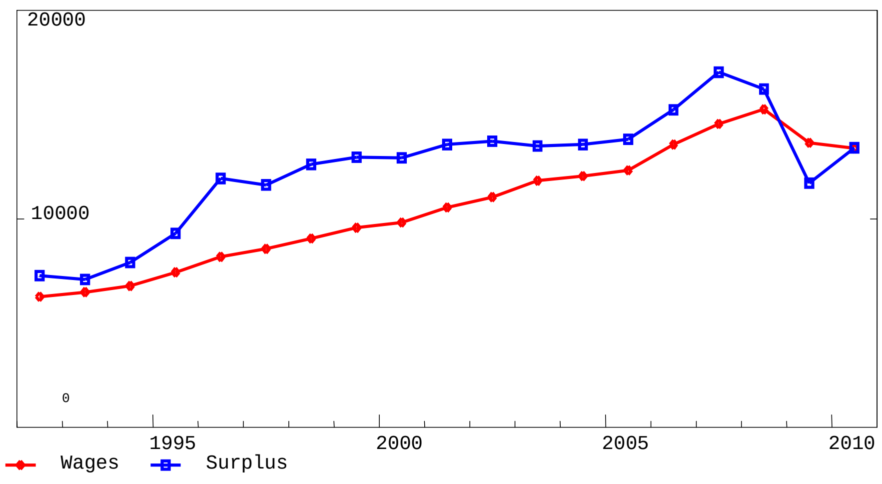


Figure 17: Metal products – Rates of Growth

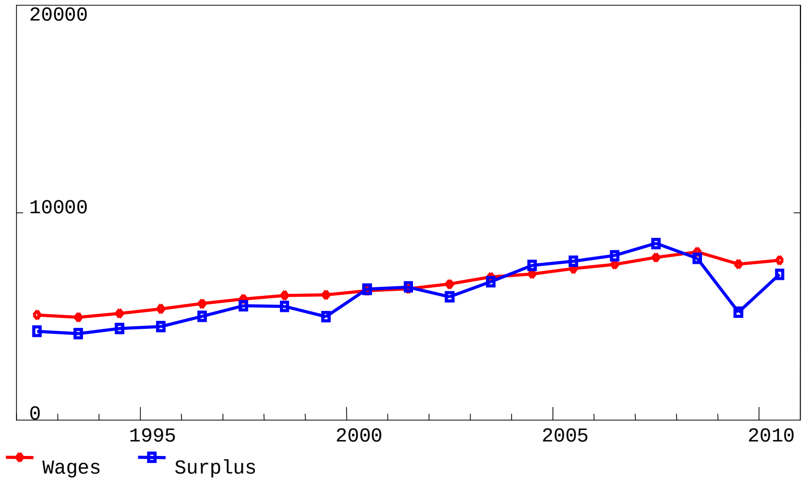


Figure 18: Electrical machinery & apparatus – Rates of Growth

5. SURPLUS EQUATIONS

Surplus may be seen as a cost component in the price equation. Sectoral and aggregate wages are explained by means of econometrically estimated equations. Social securities are obtained applying rates on sectoral wages. Provisions (a modest cost component) are assumed exogenous and measured on the basis of the actual 'postponed salary' policy. In many sectors Subsidies are close to zero; where before they were an important maintenance component of sectoral surplus, now they are converging towards and even below its average value added rate (a modest 1%). For some sectors (Agriculture, Education and Printed matters) Subsidies may be regulated by specific policies. Hence, Subsidies are treated as exogenous variables.

As a cost component, Surplus may be seen as competition with the cost of labour; the historical profits vs. wages struggle has been considered the foundation of income (value added) distribution. Conversely, the full cost theory of price formation relies on the mark-up approach which considers Surplus as a rate applied to all the other cost components. Within the framework of a macroeconomic multisectoral model, price equations and value added distribution are strictly related. Price equations may be modelled on the basis of the mark-up principle or the Surplus itself may be modelled so that the full cost price equation considers all the cost components including Surplus too. In general, Surplus may be calculated as total output in current value minus all the cost components or modelled together with the other cost components. However, Surplus and the cost of labour do not crowd each other out in the long run. Although in the long run the Cost of labour and Surplus may grow at similar rates, in the short run both appear correlated to the business cycle though to differing proportions.

Here, Surplus is modelled like any other (not exogenous from the point of view of price formation) value added component. Surplus contains self-employed wages which are necessarily more volatile than employee wages. The other Surplus components are also inevitably more volatile than the Cost of labour (see Figures 11-18).

The Cost of labour is modelled using macroeconomic and sectoral equations. Sectoral Surplus is thus measured in terms of the sectoral cost of labour and is explained by means of the (sectoral) output growth rate. However, in many sectors Surpluses show clear trends (positive as well as negative). As far as the trend is concerned, no general assumption can be made by observing the time series. The recent history of some industries may throw light on the causes of Surplus trend but those still remain unclear behind the mix of industries grouped in a sector. However, whereas the trend clearly drives surpluses relative to the cost of labour, it is included as an explanatory variable together with the output rate of growth.

Consider four cases, two with trend and two without trend. Figures 19-22 show the observed Surplus to Cost of labour ratio, the predicted value with no trend and that which includes the trend together with the sectoral output rate of growth. Trend is totally ineffective in Agriculture & Forestry; predicted values with and without trend largely overlap each other. Trend and no-trend predicted values are different in Wood products, but the differences are modest; the trend has an irrelevant explanatory effect. Surplus shows a clear trend (negative) in Retail trade and (positive) in Electricity, Gas and Sewage. In these two cases, trend must be listed among the explanatory variables;

contributing to a better fit, at the same time the estimated output rate of growth parameter turns out to be reliable from the economic point of view.

Table 1 shows the estimates of the Surplus equations. The analytical form of the equations is:

$$y = \beta_0 + \beta_1 * X_1 + \beta_2 * trend$$

where y is the sectoral Surplus to Cost of labour ratio, x1 is the sectoral output rate of growth and "trend" follows the values of the years. Two columns show the R-square; one is the R-square of the above equation and the other (no-trend) is the R-square when the trend is omitted; deltaRSQ is the difference of the two R-squares. Of course, the difference is always positive, but its size shows the relevance of the trend as a dependent variable.

In Table 1the Agriculture & Forestry deltaRSQ reflects Figure 19 where trend and no-trend predictions overlap each other. Other Non-metallic mineral products, Basic metals, Metal products, Machinery and Equipment and Office machinery & Computers show a modest difference in deltaRSQ which is related to a substantial absence of trend in the related sectoral Surplus to Cost of labour ratios.

As shown in Figures 21 and 22, Retail trade and Electricity, Gas & Sewage Surpluses have a clear trend shown respectively by the .92 and .97 deltaRSQ.

The value of β1 estimate is related to the Surplus to Cost of labour ratio; of course, the higher the ratio, the higher the β1 estimate as is clearly shown in the Real estate & Renting services sector.

The structure of the Surplus equation is focused on the output rate of growth as the main source of the higher volatility of Surplus with respect to the Cost of labour (Figure 12 for the economy and Figures 17 and 18 respectively for Metal products and Electrical machinery & apparatus). Column β1 corroborates this assumption; those sectors with negative output rate of growth estimated parameters are very atypical. Coal, Crude petroleum, Natural Gas is a 'residual' sector and Health and Social services is mostly represented by the National Health service which is ruled by public authorities (government and regions). Trade, Maintenance & Trade services is a composite sector covering many other industrial activities not elsewhere classified.

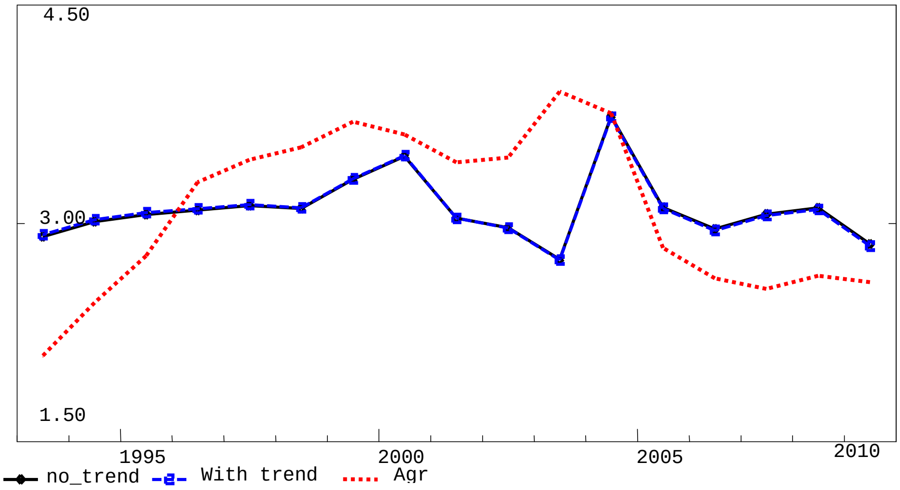


Figure 19: Agriculture & Forestry

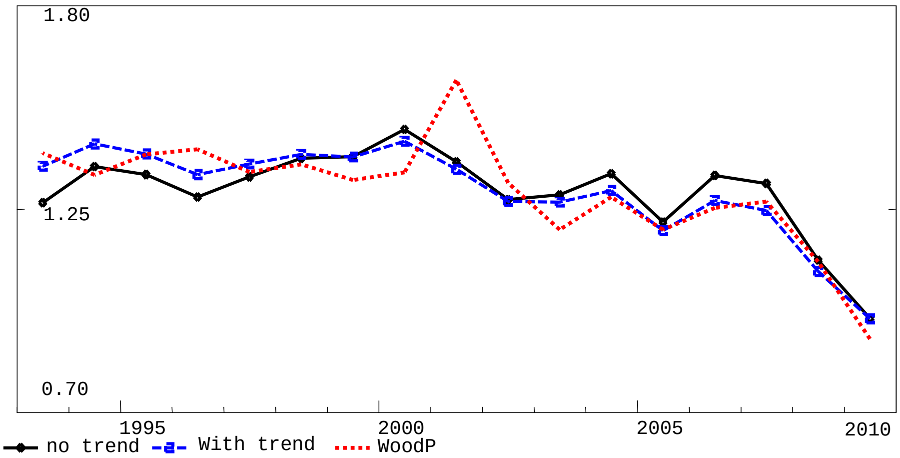


Figure 20: Wood Products

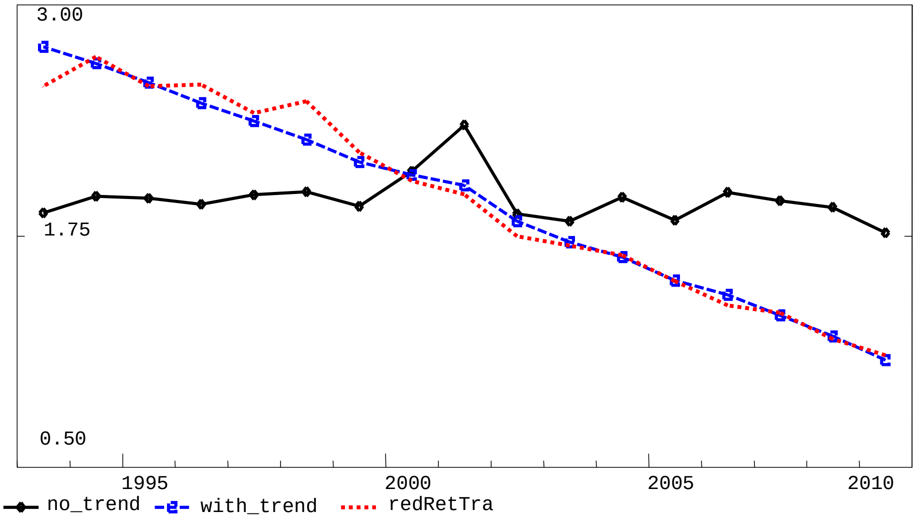


Figure 21: Retail Trade

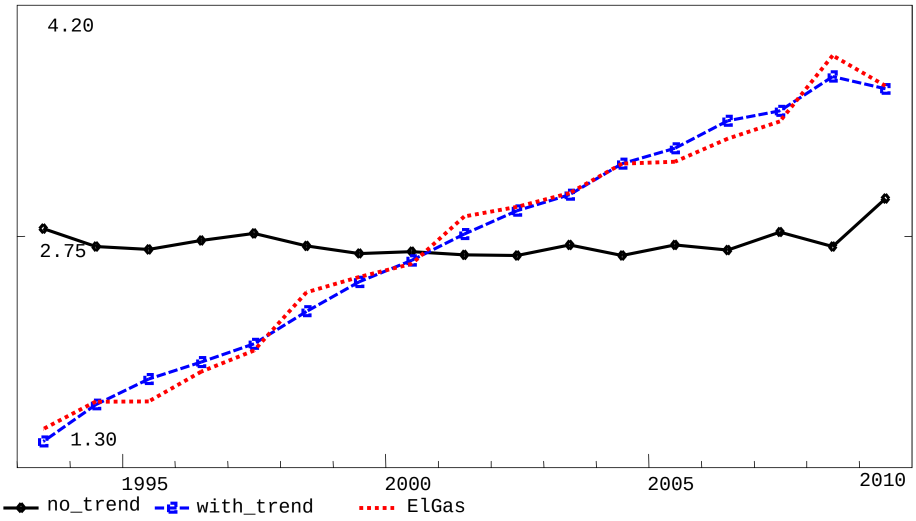


Figure 22: Electricity – Gas - Sewage

6. AFTER THE ESTIMATION OF THE SURPLUS EQUATIONS

The trend has a widespread explanatory power in many equations as shown by the deltaRSQ column in Table 1. Here, as in many other economic time series, trend is a gratifying explanatory variable according to goodness of fit indexes. The impact of trend becomes problematic when these equations are introduced in a model used to produce forecasts. In other words, trend is a tricky variable when impact is evaluated 'out of the sample'.

Model builders are well aware of this problem. It is possible to avoid the consequences of a trend leading to explosive forecasts or to economically inconsistent negative values of a strictly positive economic variable such as, for example, employment. The trend is used to estimate Surplus equations, but is treated as a scenario variable in the multisectoral model. In other words, trend is used within the sample period as it was used in the estimation process; out of the sample it must be fixed unless information concerning the future of the Surplus to Cost of labour suggests leaving the trend following the calendar time. However, a different analytical form may be the more adequate approach to such Surplus equations.

Table 1: The estimates of Surplus equations

	SECTORS	intercept	output	trend	RSQ		deltaRSQ
		β_0	β_1	β_2	trend	no_trend	
1	Agriculture & Forestry	6,4	6,543	-0,002	0,18	0,17	0,00
2	Fishing & Fishing products	263,5	1,521	-0,131	0,75	0,11	0,64
3	Coal, Crude petroleum, Natural Gas	477,3	-0,702	-0,236	0,66	0,01	0,65
4	Metal ores, Mining, Quarrying	-36,2	1,767	0,019	0,53	0,36	0,17
5	Food, Beverages, Tobacco	26,8	0,823	-0,013	0,30	0,08	0,22
6	Textiles	17,3	0,707	-0,008	0,64	0,56	0,08
7	Wearing apparels, Furs	5,3	0,670	-0,002	0,16	0,13	0,03
8	Leather and leather products	-44,7	0,387	0,023	0,63	0,11	0,52
9	Wood products, Cork	23,8	0,921	-0,011	0,73	0,63	0,10
10	Pulp, Paper & Paper products	39,7	1,300	-0,019	0,67	0,46	0,21
11	Printed matter & Recorded media	-37,5	1,042	0,019	0,55	0,03	0,51
12	Coke,Refined petroleum	177,7	5,864	-0,088	0,37	0,17	0,20
13	Chemical products, Fibres	23,4	1,217	-0,011	0,53	0,40	0,13
14	Rubber & Plastic products	38,2	0,662	-0,019	0,83	0,59	0,23
15	Other Non-metallic mineral products	-1,3	1,205	0,001	0,72	0,71	0,00
16	Basic metals	19,2	0,791	-0,009	0,31	0,27	0,04
17	Metal products	10,6	0,581	-0,005	0,52	0,47	0,05
18	Machinery and Equipment n,e,c	12,6	0,500	-0,006	0,66	0,54	0,12
19	Office machinery & Computers	-31,3	1,609	0,016	0,52	0,47	0,05
20	Electrical machinery & apparatus n,e,c,	-24,0	0,791	0,012	0,83	0,31	0,52
21	Medical, Precision instruments	50,1	0,863	-0,025	0,64	0,25	0,39
22	Motor vehicles & Trailers	-30,2	0,363	0,015	0,32	0,03	0,28
23	Other transport equipments	-11,5	0,523	0,006	0,15	0,09	0,06
24	Furniture and Manufactured goods n,e,c,	11,8	0,215	-0,005	0,38	0,23	0,15
25	Electrical energy, Gas, Sewage	-291,2	1,622	0,147	0,99	0,01	0,97
26	Construction work	2,2	1,101	0,000	0,61	0,60	0,00
27	Trade, Maintenance & Trade services	116,6	-0,154	-0,057	0,73	0,12	0,60
28	Wholesale Trade	44,7	2,670	-0,021	0,59	0,49	0,10

29	Retail Trade	211,4	0,351	-0,105	0,97	0,06	0,92
30	Hotel & Restaurant services	47,9	0,901	-0,023	0,73	0,32	0,40
31	Land transport & Pipeline services	-47,8	1,160	0,025	0,58	0,00	0,58
32	Water, Air Transport services	53,1	-0,014	-0,026	0,74	0,07	0,67
33	Post & Telecommunication services	-168,9	2,565	0,085	0,75	0,01	0,74
34	Financial services	-60,5	0,255	0,031	0,79	0,04	0,75
35	Insurance & Pension funds	-343,7	6,624	0,172	0,56	0,06	0,50
36	Financial auxiliary services	-9,0	0,227	0,005	0,02	0,00	0,02
37	Real estate & Renting services	-1061,6	66,106	0,560	0,47	0,11	0,36
38	Computer & Research services	33,2	0,446	-0,016	0,76	0,34	0,42
39	Other Business services	91,3	1,999	-0,045	0,69	0,26	0,43
40	Public administration & Defence	-15,6	0,894	0,008	0,82	0,32	0,49
41	Education services	-10,0	0,735	0,005	0,67	0,23	0,43
42	Health and Social services	-5,0	-0,191	0,003	0,31	0,00	0,31
43	Recreational, Cultural, Sporting services	22,7	0,268	-0,011	0,20	0,05	0,16
44	Other services	82,8	0,603	-0,041	0,97	0,00	0,96
45	Private households & employed persons	0,0	0,000	0,000	0,03	0,00	0,03

MAPVIEW: PROVIDING GIS FUNCTIONALITY FOR MULTI-REGIONAL INFORUM-TYPE MODELS

FRANK HOHMANN[4]

Abstract
Multi-regional macroeconomic INFORUM-type models are usually built upon a huge database. The more regions a model contains, the harder it becomes to analyse the dataset efficiently by using traditional visualisation techniques like tables and graphs. GIS (Geographic Information Systems) are valuable tools to overcome this problem but cannot be used without additional effort (e.g. data conversion). The software MapView described in this article is a user-friendly, model-independent graphical user interface which was designed to provide GIS functionality for multi-regional macroeconomic INFORUM-type models.
JEL classification: C52, C82
Keywords: GIS, Geographic Information System, INFORUM, MapView, macroeconomic model

1. INTRODUCTION

Multi-regional macroeconomic INFORUM-type models are usually built upon a huge database. For every region r (e.g. country, state, county) the

4 Gesellschaft für Wirtschaftliche Strukturforschung mbH, Osnabrück, Germany, Corresponding author. Tel: +4954140933130, Fax: +4954140933110, E-mail: hohmann@gws-os.com

database contains a set of n variables[5] which leads to r*n database variables. The more regions a model contains, the harder it becomes to analyse the dataset efficiently by using traditional visualisation techniques like tables and graphs.

One example is the German model PRREGIO (Distelkamp et al. 2009), which is an extension of the German 3E model PANTA RHEI (an econometric model for calculation of the employment effects of a given policy, including the key social concern in the evaluation of sustainability policies). PRREGIO was built to aid in developing concepts for reducing land consumption and for encouraging sustainable land management. The model is one part of a research project sponsored by the German Federal Ministry of Education and Research (BMBF) in the funding program "Research for the Reduction of Land Consumption and for Sustainable Land Management" (REFINA). PRREGIO contains more than 200 variables for each of the 413 counties, almost 100 variables for each of the 16 federal states, plus a set of macroeconomic variables.

One key requirement of the project was to enable end-users of the model to analyse the model results by providing an easy-to-use graphical user interface. This interface named MapView was built to support efficient analysis of multi-regional INFORUM-type macroeconomic (Almon 1991) models by using GIS (Geographic Information System) functionalities.

Section 2 of this paper gives an overview of the key concepts found in GIS and also describes the problems which arise from combining existing GIS with multi-regional INFORUM-type macroeconomic models. Section 3 gives an overview of the main features of the MapView software. Some of the most important technical implementation details are presented in section 4. The limits and possible future enhancements of the MapView software are discussed in section 5.

5 The set of variables for each region should be the same to be able to compare them.

2. GIS (GEOGRAPHIC INFORMATION SYSTEM) OVERVIEW

A GIS is a system that is designed to manage and analyse all types of data for which a certain relation between a value and a certain location exists. Beginning from the late 1960s, such systems have been widely used in different areas like military planning and demographic studies (Coppock et al. 1991).

In contrast to conventional database management systems (DBMS) where almost every variable can act as a key index to store and retrieve data, a GIS uses a geographical reference as the key index by creating a mapping between a spatial information (e.g. country, county or a single longitude/latitude coordinate) and a certain value in time. One example is the population in 2010 for Germany.

GIS usually make use of maps for data visualisation. Those maps are either created from raster images or vector data.

Raster images are produced by either taking digital photos or by digitising existing material like printed maps. The main disadvantages of raster images are the huge amount of storage space and loss in quality if areas of the image have to be enlarged.

Vector data overcomes these limitations by composing maps from primitive geometrical shapes like points, lines and polygons. Each point is stored as a two-dimensional x/y coordinate. This technique allows for compact storage, lossless scaling of a map and the possibility to create layers of corresponding maps (e.g. combining a map with state boundaries and a map with elevation levels). The main disadvantage in comparison to raster images is the increased computation power that is needed to visualise a map from hundreds of thousands of data points. Today's computing power allows for real-time computation even on low-cost computers, though. Therefore, vector data maps are much more common in GIS than raster images although sometimes combinations of the two formats make sense.

The most common vector data format understood by almost every GIS is the so-called "shape file" format invented by ESRI (ESRI 1998) (Environmental Systems Research Institute, Inc.). In this specification, spatial vector data is separated from actual attributes [time-based] (e.g. population for a certain year and region). The geographical reference is established by giving each spatial area a unique number which in turn is referenced by the attributes.

Spatial vector data is stored in SHP files (shape files). These files contain vertices (x/y coordinates) stored as double numbers for different primitive geometrical shapes (e.g. points, lines, polygons). It is possible to create areas from parts (see Figure 1) where each part is a collection of vertices (one application of this feature is a country which consists of a main land plus islands).

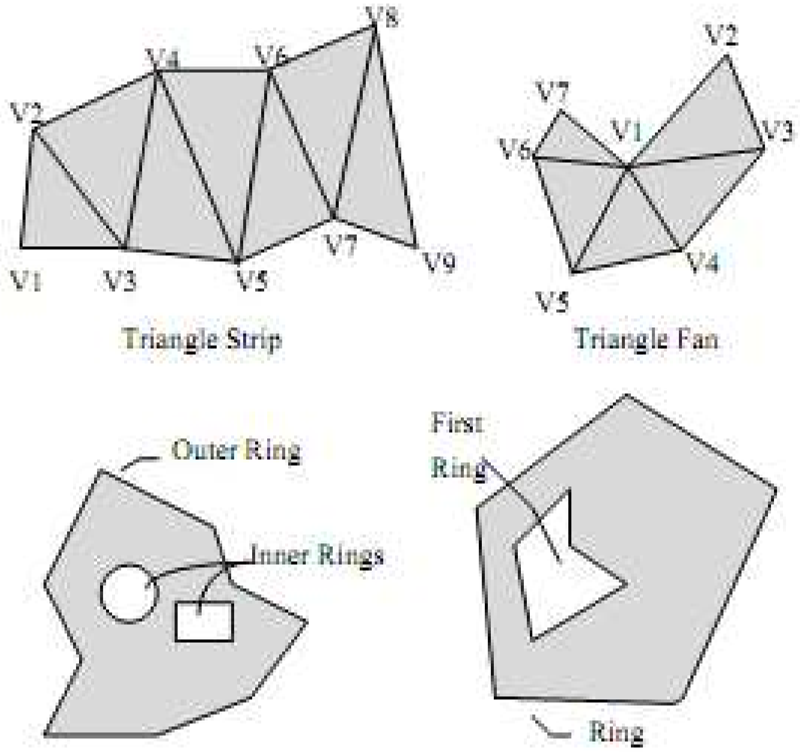


Figure 1: Combined shapes (Source: ESRI)

The attributes are stored in tables where each row (or record) contains attribute values for each of the shapes (or areas). Each attribute record is associated with a certain shape (or area) by using the same index. Example: If a map contains a shape i then the attribute for this shape has to be stored in row i in the table. A table may contain more than one column to store more than one attribute for each shape.

This one-to-one relationship guarantees that a valid geographical reference exists for each of the attributes. The tables are stored as dBase files. Although the original dBase software for which the format was invented does not exist anymore, this format is still very popular not only in GIS but also many other areas of software development, mostly due to the facts that this format not only can be read and written by a wide range of applications but also that this format is very well documented (Bachmann 2010) and programming libraries exist for almost every popular programming language.

3. PROBLEMS WITH COMBINING EXISTING GIS WITH MULTI-REGIONAL INFORUM-TYPE MODELS

Although GIS become more and more sophisticated, are widely available (e.g. the ESRI family of products, see http://www.esri.com, MapWindow, see http://mapwindow.org) and organisations like OGC (Open Geospatial Consortium, see http://www.opengeospatial.org/) put much effort into creating standards (e.g. data formats) for GIS, potential GIS users are still facing the problem that creating maps from existing data is still a challenging and time consuming task. Of course, this is not much of a problem if only a single or a few maps have to be created but becomes much more evident if the task to analyse a huge multi-regional macroeconomic model with thousands of time series.

The problem does not stem from the availability of appropriate maps. These can be easily found on the web[6] or can be purchased from specialised companies or official agencies.

The main problem is that the data that has to be analysed usually does not already contain the geographical reference and/or data format which is required by every GIS. Therefore, the existing data has to be transformed into an appropriate format first, e.g. dBase files.

6 Most maps found on the web are free for research purposes only. Commercial use normally requires a paid license.

The two-dimensional table structure of dBase files puts a serious burden on storing time series data which are core building blocks of every macroeconomic model: Either, one dBase file has to be created for every variable with the years in the columns and the attribute values in the rows or one dBase file has to be created for every year with the different variables (e.g. population, disposable income) in the columns and the attribute values in the rows. This problem gets worse if more than one simulation comes into play.

For INFORUM-type models, storing spatial data for which time series are available can be easily accomplished by taking advantage of the vector data type: A vector represents a certain attribute (e.g. population); each row in the vector holds the attribute value for a certain area (e.g. state, county); the database contains slices of data where one slice represents one year. In principle, this storage format is almost ideal for storing and handling spatial data which comes as time series.

Unfortunately, INFORUM databases cannot be easily linked to GIS. To use these databases in GIS, the contents have to be transformed (and by doing so, are duplicated) into GIS-compatible data formats. For sophisticated models, this approach requires programming skills because performing the necessary steps "by hand" (e.g. copy & paste) is not feasible for big data sets. Extending existing GIS by providing data import routines is also almost impossible, either because these systems do not offer appropriate programming interfaces and/or the amount of effort that has to go into programming such an interface is way too big.

Even if the problem with different data formats could be solved, the task of analysing huge data sets as found in multi-regional macroeconomic models is still quite labour-intensive because maps need to be prepared separately for every attribute (and year).

As shown in the next section, MapView solves these problems by taking the existing model databases and linking them directly to the maps without any data conversion.

4. MAPVIEW: PROVIDING GIS FUNCTIONALITY FOR MULTI-REGIONAL INFORUM-TYPE MODELS

MapView was built to provide GIS functionality for multi-regional INFORUM-type models. The main key requirements were model independence, a user-friendly interface and instant results.

Although MapView was initially programmed for analysing the PRREGIO model databases, the source code software does not contain any reference to this specific model. The software is model independent, meaning that it can be used with any INFORUM-type multi-regional model as long as appropriate databases and maps are available. This is accomplished by putting all the relevant information into one configuration file[7] which contains references to the maps, the databases and the attribute values.

On program start-up, MapView picks up the necessary information from the configuration file and links the attribute values from the databases to the map shape files. The initial screen is shown in Figure 2[8]. As shown in the figure, the software immediately displays a map without any interaction from the user. From there on, the user can start to produce maps by clicking on the various controls to customise the map appearance.

7 Technical details are discussed in the next section.
8 The current version of the software is only available in German.

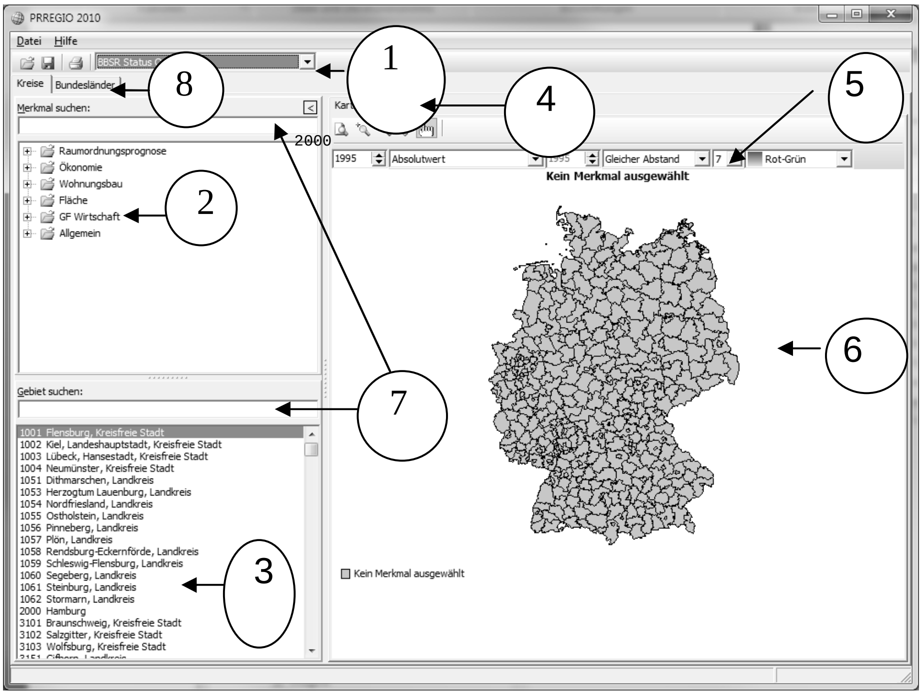


Figure 2: MapView: Start-up screen

The user interface controls which are used to create maps and to adjust the appearance are as follows:

(1) Database selection: This control is used to select one of the databases (e.g. different simulations).

(2) Attribute selection: This control contains a hierarchical list of attributes (database variables). Variables may be grouped (e.g. "economy" variables) for easier navigation.

(3) Area selection: This control contains a list of areas (e.g. countries, regions, counties). Clicking on one of the items highlights the selected area in the map control (6).

(4) Mode selection: Switches between map view and single view which shows a graph and a value table for the item selected with control (3).

(5) Customisation controls: This set of controls can be used to adjust the database year, colour schemes, map zoom in/out and various options for value display (e.g. absolute values, growth rates, differences, etc.). The map is updated instantly after any of these settings have been changed.
(6) Map control: This is the core control which displays the map according to what the user selected by clicking and adjusting the values for controls (1) – (5).
(7) Search controls: These controls are used to search for attributes/areas. The user can enter a term or keyword to search for and MapView will immediately jump to the first matching entry.
(8) Map selection: This control is used to switch between different predefined maps (see explanation for Figure 4 below).

The next Figure 3 shows a map for population data (county level) in Germany for the year 2010. Due to the huge differences in population between the counties, the display was optimised by building seven ranges with an equal number of items[9]:

9 The maps come up in colour but had to be transformed to gray scale for this paper.

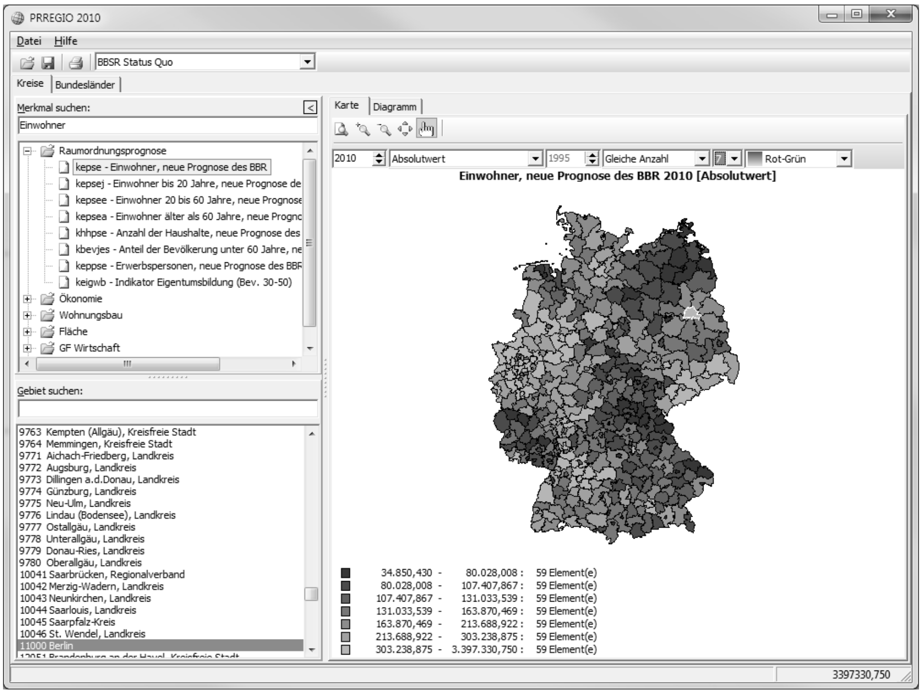


Figure 3: MapView: Map with population data for German counties in 2010

Figure 3 shows which areas of Germany have higher popluation (light gray) and which have less population (dark gray). Traditionally, the counties with the highest population can be found in the Western part of Germany ("Ruhrgebiet"). For Eastern Germany, the counties with higher population are the ones surrounding the capitol Berlin (the highlighted shape).

MapView can be configured to manage more than one shape file at the same time. To use this feature, data for all shape files has to be stored in the same database. In addition to the map on a county level for Germany, MapView has been configured to provide a map for Germany's federal states. Figure 4 shows a map with population data for German federal states in 2010:

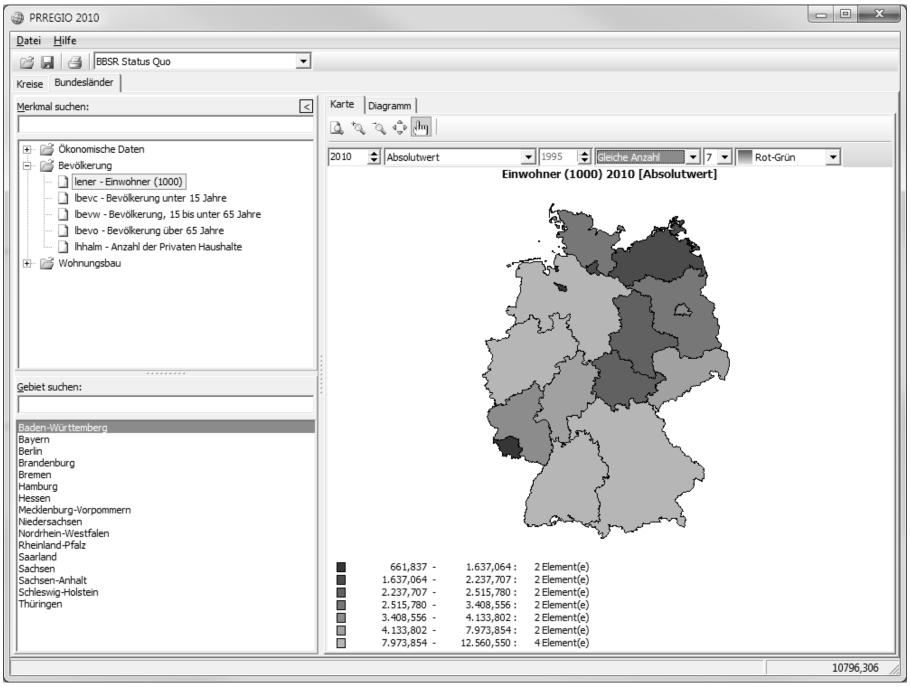


Figure 4: MapView: Map with population data for German federal states in 2010

This figure shows that in general the Eastern federal states have a lower population (dark gray) than the states in Western Germany (light gray).

Sometimes it is necessary to see the (historical) values for one or more of the areas. Since values and shapes cannot be easily combined, esp. not for many areas (shapes), MapView is also able to display time series for a single area both as a graph and a data table: This is accomplished by clicking and selecting one of the areas and then selecting the "diagram" tab at the top.

Figure 5 shows the population data as a time series for the German federal state "Baden-Württemberg":

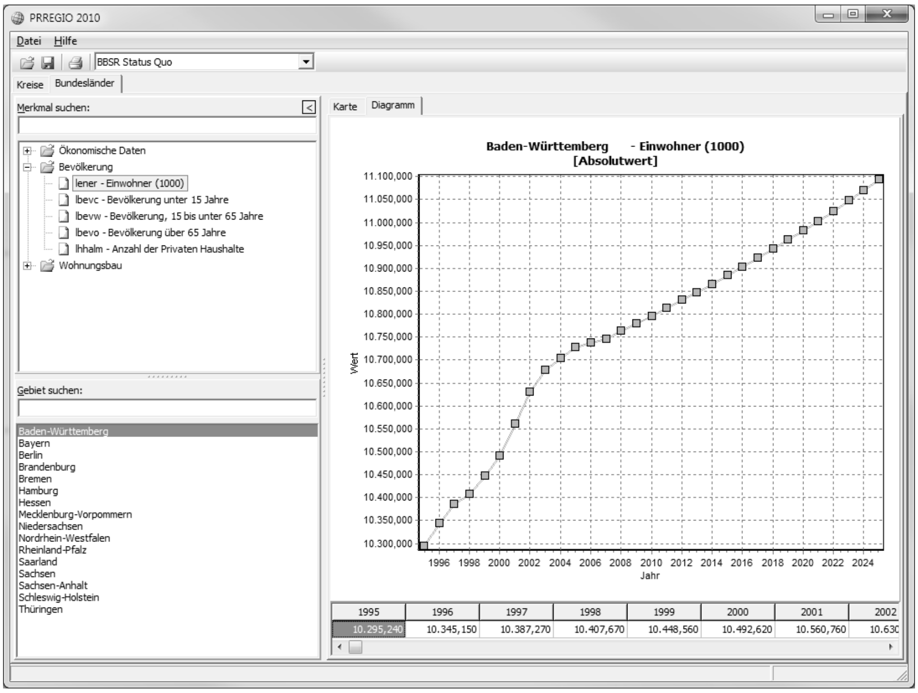


Figure 5: Population data for „Baden-Württemberg"as time series

5. TECHNICAL IMPLEMENTATION DETAILS

As already pointed out in Section 3, MapView uses the contents of the model databases directly and therefore no time-consuming data conversion processes are needed. This is accomplished by mapping vector rows to shape indices as shown in Figure 6:

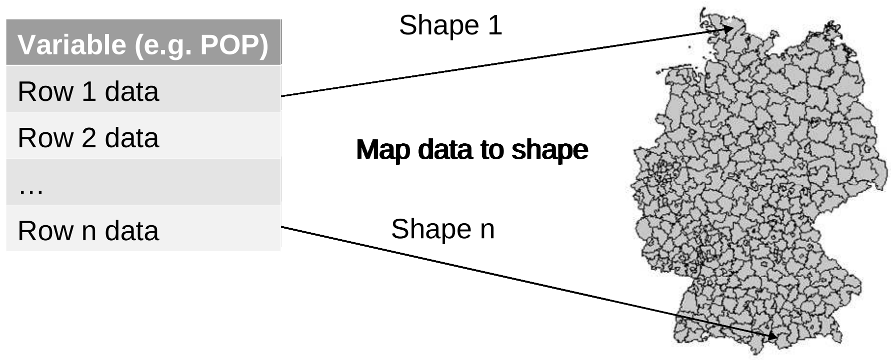


Figure 6: Mapping vector data to shape data

The vectors in the database must have the same number or rows and must be in the same order as the shapes in the shape file. This allows for a 1:1 mapping between the data from the database and the map within the shape file which can be handled automatically be the MapView software.

Creating the MapView GIS software for multi-regional INFORUM-type macroeconomic models involved some technical hurdles, i.e. providing model independence and instant results.

Model independence requires software which can be freely configured for use with different databases and maps. Additionally, it must be able to display the huge set of attributes in a hierarchical structure (e.g. different attributes for population data, economy or land use). Candidates for maintaining sets of in-homogeneous, hierarchical data are file formats like XML or JSON.

XML (Extended Mark-up Language) is a text file format which is an accepted industry standard for representing structured information (W3C 2011). The format is understood by a wide range of applications and programming libraries exist for every popular programming language. One disadvantage to be mentioned is that the format uses so called “tags” to represent data which not only remarkably increases the size of the data files but also makes it more difficult to read and maintain the data.

JSON (JavaScript Object Notation) is a lightweight data-interchange format (JSON 2011). It is based on the same concepts as XML but tries to minimise the problems of the latter (readability, increased size).

For MapView, none of these formats was chosen, mainly due to the fact that existing programming libraries proved to be too slow with huge data sets. Instead, a customised data format was developed which is able to represent hierarchical data structures, is readable by humans, has a minimal impact on file size and also can be parsed by machines at high speed.

The parser was implemented with the YACC/LEX (Levine 1992) toolset[10]. The grammar is close to JSON with the following differences:

- Complex, nested structures are enclosed between < and > characters (JSON uses { and })
- Identifiers are not enclosed between "" characters
- Element lists are not separated by the , character

These differences result in even more compact data files, improve readability for humans and allows for high-speed parsing even with huge files. An excerpt of the configuration file for the PRREGIO model is shown in Figure 7:

10 The discussion of compiler-writing techniques is beyond the scope of this article.

```
mapview <
  appname: "PRREGIO 2010"
  datapath: "scenario"
  mappath: "imagine\maps"
  map <
    title: "Kreise"
    filename: "vg2500_kr413_gk3_sortiert.shp"
    startdate: 1995
    enddate: 2020
    showvariablenames: true
    items <
      shapes <
s1001 : "1001  Flensburg, Kreisfreie Stadt"
s1002 : "1002  Kiel, Landeshauptstadt, Kreisfreie Stadt"
s1003 : "1003  Lübeck, Hansestadt, Kreisfreie Stadt"
…
```

Figure 7: MapView: Configuration file format

Instant results, i.e. displaying maps in real time, requires highly optimised drawing routines. Shape files contain several hundreds of thousands of vertices as well as hundreds or even thousands of parts. To handle this huge amount of data, a technique called double buffering was applied: Instead of writing each of the points and parts into the memory of the graphics device, they are written to an off-screen bitmap first. Drawing into an off-screen bitmap is magnitudes faster than directly drawing into video memory. Once the image is completely drawn to this bitmap, the bitmap is copied to video memory ("blitting") with only one instruction. Another problem related to providing instant results is how to detect which of the shapes has been clicked by the user. Maps usually are composed of irregular shapes which make it much more difficult to perform hit-testing. To minimise delays, a two-step approach was taken: In step one, the software eliminates non-matching shapes by checking whether the screen coordinates of the click event are inside or outside of the boundary box of each shape. In step two, the software counts the number of boundary crossings for each of the remaining shapes (see Figure 8).

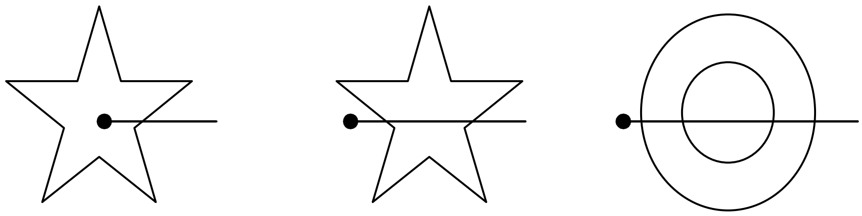


Figure 8: Performing hit-testing

If the number of crossings is odd (left shape in Figure 8), the click occurred inside of the shape. If the number of crossings is even, the click occurred outside of the shape (middle and right shape in Figure 8). This technique is not only fast but also works for any kind of irregular shape, even those that contain "holes".

6. CONCLUSIONS

MapView has proven to be a useful tool for analysing multi-regional INFORUM-type models. Due to its user-friendly interface and processing speed, the user can instantly produce a huge number of maps without being forced to perform any kind of data conversion. Additionally, it takes less than an hour to learn how to use the software efficiently: Users neither need to have sophisticated computer skills nor do they need to be familiar with GIS.

Of course, there is still room for improvement. Firstly, an editor for the configuration file is missing. Therefore, this file needs to be created manually and can only be maintained by users who are familiar with the file format. Secondly, the interface is only available in German. The software is already prepared to be translated into other languages, though. Thirdly, an option to compare different simulations is missing. This option would be very helpful to analyse models with a huge set of different simulations more efficiently but was left out in the initial version of the software due to the limited budget.

REFERENCES

ALMON, C. (1991): The INFORUM Approach to Interindustry Modelling. *In: Economic Systems Research* 3, 1-7.

BACHMANN, E: *Xbase File Format Description,* http://www.clicketyclick.dk/databases/xbase /format/index.html

COPPOCK J.T. & RHIND D.W. (1991): The History of GIS. In Maguire D.J., GOODCHILD M.F., AND RHIND D.W. (editors) *Geographical Information Systems: Principles and Applications,* Volume 1, pages 21-43.

DISTELKAMP, M., ULRICH, P. (2009). *Sustainable settlement development – Assessing the effects of state measures in scenario analysis.* GWS Discussion Paper 2009/9

ESRI (1998): *ESRI Shape file Technical Description,* http://www.esri.com/library/whitepapers /pdfs/shapefile.pdf

JSON (2011): *Introducing JSON,* http://json.org/

LEVINE, J. R., MASON, T., BROWN, D. (1992): lex & yacc, O'Reilly

W3C (2011): *XML Technology,* http://www.w3.org/standards/xml/

A MACROECONOMIC MODEL FOR NORTH CYPRUS MMNC

GAZI ÖZHAN[11], YINCHU WANG[12] AND MERAL ÖZHAN[13]

Abstract
Behavioural equations of the macroeconomic model for the North Cyprus economy basically detect a large influence from the Turkish economy for obvious reasons, particularly in the formation of price equation. The model contains 43 equations for 43 endogenous variables and 11 exogenous variables. Due to a limited amount of statistical data other than some basic macroeconomic variables, only simple linear regression equations for most endogenous variables are estimated. Historical simulation of the model for 37 variables over the period 1998-2008, shows a high degree of accuracy: About 83% of the 370 results showed less than 5% error, and only 0.54% showed more than 10% error.
JEL Classification: C53, E27
Keywords: North Cyprus economy, macroeconomic model, simulation

1. INTRODUCTION

A macroeconomic model makes it simpler to simulate and forecast the consequences of the choices on the economy in the medium and long term. There are other roles of models, which justify any attempt to build

---

11 European University of Lefke.
12 China Economic Information Network of the State Information Centre.
13 European University of Lefke.

one for any economy big or small. For example, building models assists and tests economists' understanding on how the economy works (Werling, 2010). For more on macroeconomic modelling one should read Almon (2008). In the case of North Cyprus, the main aim here is to build a working model of the economy which enables the policy makers to evaluate the past trends of the main economic aggregates, forecast their possible time paths in the future, and finally, design alternative development programs. The State Planning Organisation (SPO) in North Cyprus is assigned to frame medium/long-term development plans and annual programs which are supposedly based on carefully constructed macroeconomic models. However, there has been no modelling work reported and published neither by the SPO nor by academic researchers. The first serious attempt was the work of Salmon-Özhan-Özhan (2008) in which an INFORUM-type multisectoral model namely TinyTRNC was built and tested.

In this present work, a simple macroeconomic model was built for North Cyprus based on a limited set of annual national accounts data only. It is expected that it would draw the attention of policy makers and stimulate further academic initiatives in the same direction. The study is organised into six sections. In Section 2 the statistical data preparation phase of the model is explained briefly. Section 3 presents the general framework of the model, which gives a brief account of how the TRNC economy works. The equations and the logic of the model are explained in Section 4. Section 5 presents the historical simulation results of the model. Section 6 concludes the work. The study was completed in two weeks, in June 2011 when Yinchu Wang visited the European University of Lefke. The first week was allocated for data preparation and the second week for estimating equations, and building and running the model for historical simulation.

2. SOURCE OF DATA

The State Planning Organisation (SPO) is the main institution that collects and collates the basic statistics about the North Cyprus economy. All available data on the national income are published only on annual basis. Quarterly data are not produced yet. There is not a separate statistical institute in this country, but there is a department inside the SPO namely Statistics Directorate assigned to administer the collection and processing of all statistical information. Some data on the North Cyprus economy are available on the website of the State Planning Organisation. Although there is no data concerning input-output tables, there are some basic macroeconomic statistics on this website. Economic and social indicators are the most important data set covering mainly a long enough time series of national income accounts as well as some broad categories of sectoral accounts. In this set of data there are 36 Excel tables from which it was able to identify the variables (series) that formed the basis of the macroeconomic model in this work. Together with some additional sources of data the total number of variables reached 35. Table 1 below shows the names of these variables.

Table 1: List of variables used in Macroeconomic Model for North Cyprus

1	GDP, current and constant (1998 prices)
2	Private disposable income, current and constant
3	Public disposable Income, current and constant
4	Private consumption, current and constant
5	Public consumption, current and constant
6	Private investment, current and constant
7	Public investment, current and constant
8	Inventory change, current and constant
9	Export, current and constant
10	Import, current and constant
11	Export to Turkey, current and constant
12	Export to the EU, current and constant
13	Export to other countries, current and constant
14	Import from Turkey, current and constant
15	Import from the EU, current and constant
16	Import from other countries, current and constant
17	University students, total
18	University students from Turkey
19	Agricultural value added, current and constant
20	Industrial value added, current and constant
21	Construction value added , current and constant
22	Trade and tourism value added , current and constant
23	Transport and communication value added , current and constant
24	Financial institutions value added, current and constant
25	Ownership of dwellings value added, current and constant
26	Business and personal services v.a., current and constant
27	Public services value added, current and constant
28	Import duties, current and constant
29	Total number of tourists
30	Share of Turkey in total tourists
31	Share of other countries in total tourists
32	GDP deflator for North Cyprus
33	GDP deflator for Turkey
34	Nominal exchange rate (TL per US dollar)
35	Real exchange rate (TL per US dollar)

Extraction of data from the source tables was not so simple. During the process it is detected that for the following 7 variables the

GDP deflator is used to convert the current values of these variables to constant values:

1 Private disposable income
2 Public disposable income
3 Private consumption
4 Public consumption
5 Private investment
6 Public investment
7 Inventory changes

Fortunately, the deflators for the value added by sectors are not the same as the GDP deflator. However adding up real value added by sectors does not identically give the real GDP. The discrepancies were eliminated by scaling, assuming that the GDP deflator on its own is the correct one.

To find the real values of export and import data the current dollar values of these variables were first converted to Turkish lira (TL) using the nominal exchange rate. Then by dividing nominal TL values of export and import by the GDP deflator the constant values of export and import were derived.

One final remark about the work of data preparation is that the real GDP and all other real variables in the SPO source tables are based on the 1977 price level. For the data bank it was imperative to shift the base from 1977 to 1998, which is also the base year of the macroeconomic model.

3. BASIC CONSIDERATIONS

A macro model is normally based on a national accounts system. For North Cyprus model, two accounting relationships are used. One is the GDP by expenditure, i.e.:

$$GDP = C + G + I + X - M \tag{1}$$

where C is private household consumption, G is government current expenditures on goods and services; I is total gross investment (i.e., gross capital formation including changes in inventories); X is exports; M is imports.

And another is the GDP by sector, that is:

GDP = $\sum_{i=1}^{n} va_i$ (2)

where va_i value added in sector i. Equation 2 states that GDP is the sum of value added in *n* different economic activities (sectors).

The economic activities, in this model, include 10 sectors which are Agriculture (value added sector 1), Industry (value added sector 2), Construction (value added sector 3), Trade and tourism (value added sector 4), Transportation and communication (value added sector 5), Financial services (value added sector 6), Ownership and dwelling (value added sector 7), Business and personal services (value added sector 8), Public services (value added sector 9) and Import duties (value added sector 10).

For the consumption in Equation (1), there are two parts: private consumption and public consumption. Their behaviour, depending upon private income and public income respectively, will be described by the model.

For the capital formation, there are fixed capital formation and inventory change. Inventory change is a difficult term to be estimated and it is treated as exogenous. For capital formation, there are private investment and public investment. Table 2 shows the ratio between public investment plus public consumption and public income. It can be seen that the public expenditure is much larger than the public income. On the other hand, the public consumption has been treated as endogenous already, so the public investment has to be treated as exogenous. Therefore, there is one behavioural equation for capital formation: private investment which will be described by private income.

Table 2: The ratio between public expenditure and public income (%)

1998	1999	2000	2001	2002	
144.9	130.3	212.1	213.3	532.6	
2003	2004	2005	2006	2007	2008
210.5	174.0	165.6	172.6	164.3	149.0

Imports normally depend on domestic demand. It should be endogenous. On the other hand, export normally is treated as exogenous because it depends upon foreign demand which is beyond the range of the model. However, for the purpose of simulating the economic relationship between North Cyprus and Turkey in the later stage, export is treated endogenous and is described by export to Turkey and export to Europe.

To have GDP from Equation (1), the identity is not used, but through a behavioural equation,

$$GDP = a0 + a1\times(C + G) + a2\times I + a3\times(X - M) \qquad (3)$$

For value added by economic activities, only sector 1 (Agriculture) is treated as exogenous as the normal way in other macro models, and all of the other 9 sectors' value added are endogenous which are described by demand.

The GDP calculated from Equation (1) and Equation (2) will not be identical. They will be adjusted to the same number by scaling the value added by sectors.

To describe the income aspect, it was found, from Table 3, that the sum of the private disposable income plus public income is larger than the GDP in North Cyprus.

Table 3: The Ratio between Income and GDP (%)

1998	1999	2000	2001	2002	
101.0	100.9	100.2	100.1	100.8	
2003	2004	2005	2006	2007	2008
101.6	102.6	102.4	102.8	101.5	101.0

It seems there is some income from outside of North Cyprus. It was decided to treat private income as endogenous and to leave public income as exogenous.

For the price aspect, the most important variable is the GDP deflator. According to the real situation, the relationship between the two GDP deflators was analysed, one for Turkey and one for North Cyprus. Figure 1 shows the comparison. It can easily be seen that the GDP deflator of North Cyprus is higher than that of Turkey and there is an increasing tendency along the timeline. Therefore, a regression of GDP deflator for North Cyprus is carried out and the result is shown in Table 4 and Figure 2. Therefore, the path to have GDP deflator for North Cyprus becomes to use the GDP deflator from Turkey which is exogenous.

Table 4: Regression between two deflators

SEE = 0.33 RSQ = 0.9921 RHO = 0.62 Obser = 11 from 1998.000							
SEE+1 = 0.28 RBSQ = 0.9901 DW = 0.77 DoFree = 8 to 2008.000							
MAPE = 6.06							
Variable name Reg-Coef Mexval Elas NorRes Mean Beta							
0 a.gdpD	- - - - - - - - - - - - - - - - -				6.54 - - -		
1 intercept	-0.57011	28.7		-0.09	218.21		1.00
2 TurkgdpD	0.99165867.2		0.81	6.07		5.32	0.739
3 time	0.30711146.4	0	28	1.00		6.00	0.264

22

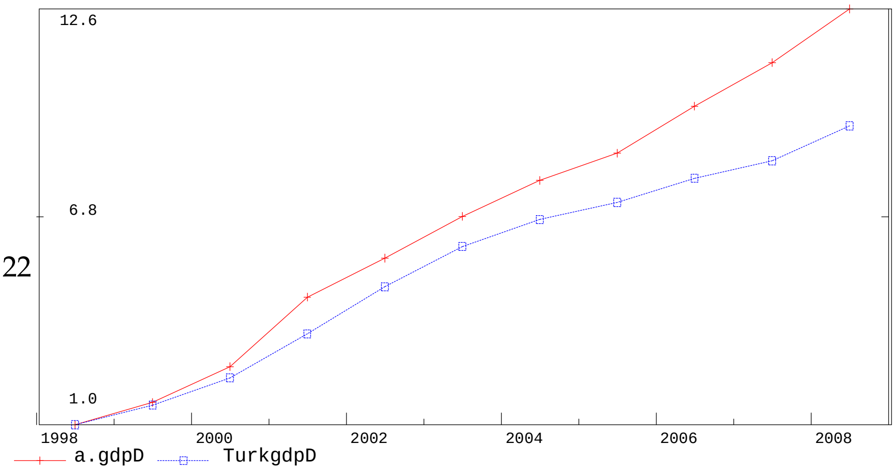


Figure 1: Deflator of Turkey and North Cyprus: Comparison

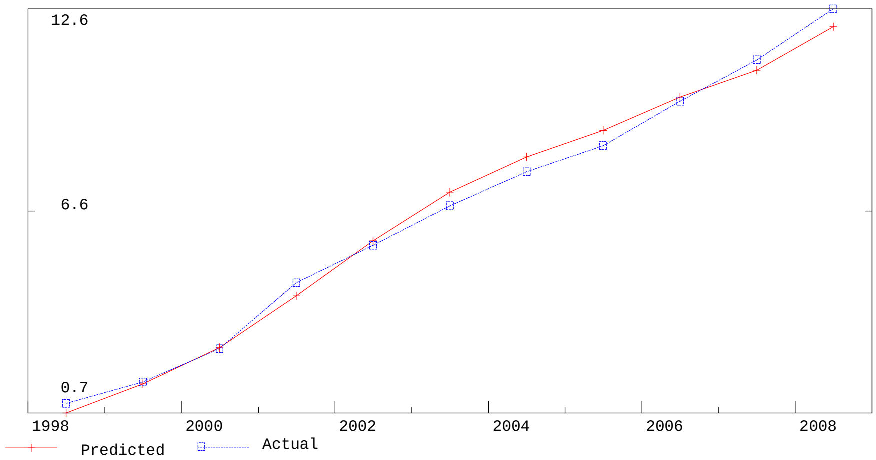


Figure2: Deflator of Turkey and North Cyprus: Regression

According to the considerations above, the exogenous and endogenous variables in this model are determined. They are listed in the following table (Table 5).

Table 5: List of the Variables to be Used in the Model

The endogenous variables (43)		
1	gdpR	GDP in constant price
2	gdpN	GDP in current price
3	gdpD	GDP deflator
4	privincN	Private income, current price
5	privconsN	Private consumption, current price
6	privinvestN	private investment, current price
7	pubconsN	public consumption, current price
8	TotStu	Total number of university students
9	impN	Import, current price
10	expN	Export, current price
11	vadN2	vad sec 2, current price
12	vadN3	vad sec 3, current price
13	vadN4	vad sec 4, current price
14	vadN5	vad sec 5, current price
15	vadN6	vad sec 6, current price
16	vadN7	vad sec 7, current price
17	vadN8	vad sec 8, current price
18	vadN9	vad sec 9, current price
19	vadN10	vad sec 10, current price
20	vadD2	vad deflator, sector 2
21	vadD3	vad deflator, sector 3
22	vadD4	vad deflator, sector 4
23	vadD5	vad deflator, sector 5
24	vadD6	vad deflator, sector 6
25	vadD7	vad deflator, sector 7
26	vadD8	vad deflator, sector 8
27	vadD9	vad deflator, sector 9
28	vadD10	vad deflator, sector 10

29	vadR2	vad sec 2, constant price
30	vadR3	vad sec 3, constant price
31	vadR4	vad sec 4, constant price
32	vadR5	vad sec 5, constant price
33	vadR6	vad sec 6, constant price
34	vadR7	vad sec 7, constant price
35	vadR8	vad sec 8, constant price
36	vadR9	vad sec 9, constant price
37	vadR10	vad sec 10, constant price
38	gdp2N	value added of secondary sector, current price
39	gdp3N	value added of tertiary sector, current price
40	totconsN	total consumption, current price
41	totinvestN	total investment, current price

The exogenous variables (11)		
1	pubincN	public income, current price
2	pubincN	public investment, current price
3	vadN1	value added in agriculture, current price
4	StuFmTurk	Student number from Turkey
5	StuFmTurk	export to Turkey, current price
6	exp2EuN	export to Europe, current price
7	TurkgdpD	gdp deflator of Turkey
8	time	time tendency
9	TouTurk	Tourist number from Turkey
10	TouFor	Tourist number from other foreign countries
11	exrate_NC	exchange rate used by NC

It is observed that in the published data exchange rates in the two countries, NC and Turkey are not the same. Probably the reasons for the differences would be the service charges and other costs of transactions in the foreign exchange markets in both countries.

4. EQUATIONS AND LOGIC OF THE MODEL

In this section, the details of the model's equation system and the calculation logic will be described. The first five equations are the following:

(1) gdp2N = vadN2 + vadN3, value added of manufacture, current price;
(2) gdp3N = gdpN - vadN1 - gdp2N, value added of service, current price;
(3) totconsN = privconsN + pubconsN, total consumption, current price;
(4) totinvestN = privinvestN + pubinvestN, total investment, current price; and
(5) privincN = f(vadN1, gdp2N, gdp3N), private income.

The private income in nominal terms (privincN) depends upon the value added of the primary industry (Agriculture), secondary industry (Manufacture) and tertiary industry (Services), respectively. The regression result is:

Private income, current price

SEE = 49566840.00 RSQ = 0.9986 RHO = 0.13 Obser = 11 from 1998.000
SEE+1 = 49357356.00 RBSQ = 0.9980 DW = 1.75 DoFree = 7 to 2008.000
MAPE = 4.94

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta	t-value	F-Stat
0 privincN	- - - - - - - - - - - - - - - -	------------			1885584346.18	- - - - - -	- - - - -	
1 intercept	5957852.22568	0.2	0.00	712.38	1.00		0.158	
2 vadN1	2.98938	66.5	0.25	54.12	155460872.91	0.214	3.523	1659.89
3 gdp2N	1.07513	14.9	0.21	2.11	366905714.18	0.237	1.495	185.92
4 gdp3N	0.58791	45.1	0.54	1.00	1735688721.45	0.560	2.783	7.74

(6) privconsN = f(privincN, StuFmTurk×gdpD), current price.

The private consumption depends upon the private income. On the other hand, the consumption from foreign students and tourists are also important. Statistical analysis shows that the student number from Turkey is a good representative. Since the number of students is a constant-price-like variable (i. e., a real variable) it was multiplied with the GDP deflator to find its current effect on the private consumption in nominal terms. The regression result is:

Private consumption, current price
SEE = 55758196.00 RSQ = 0.9969 RHO = 0.00 Obser = 11 from 1998.000
SEE+1 = 55758324.00 RBSQ = 0.9962 DW = 2.00 DoFree = 8 to 2008.000
MAPE = 3.84
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value F-Stat
0 privconsN - - - - - - - - - - - - - - - - - 1381926869.82 - - - - - - - - - - -
1 intercept 47540128.40595 9.1 0.03 326.38 1.00 1.236
2 privincN 0.30952 61.7 0.42 4.47 1885584346.18 0.407 3.594 1301.53 3 StuFmTurk×gdpD 4629.68608 111.4 0.54 1.00 162163.32 0.596 5.267 27.74

(7) privinvestN = f(privincN), current price.

Private investment depends upon private income. The regression result is:

Private investment current price
SEE = 50227792.00 RSQ = 0.9707 RHO = 0.53 Obser = 11 from 1998.000
SEE+1 = 44774860.00 RBSQ = 0.9675 DW = 0.94 DoFree = 9 to 2008.000
MAPE = 43.05
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value F-Stat

0 privinvestN - - - - - - - - - - - - - - - - - 344753138.73 - - - - - - - - - - -
1 intercept -67357744.09137 26.2 -0.20 34.14 1.00 -2.311
2 privincN 0.21856 484.3 1.20 1.00 1885584346.18 0.985 17.270 298.25

(8) pubconsN = f(pubincN,TotStu×gdpD), current price.

Public consumption depends upon the public income. Meanwhile, the university system seems to be quite a part of public consumption, which is represented by the product between total number of university students and GDP deflator. The regression result is:

Public consumption, current price
SEE = 39258716.00 RSQ = 0.9919 RHO = -0.03 Obser = 11 from 1998.000
SEE+1 = 39175668.00 RBSQ = 0.9898 DW = 2.06 DoFree = 8 to 2008.000
MAPE = 8.63
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value F-Stat
0 pubconsN - - - - - - - - - - - - - - - 574679051.64 - - - - - - - - - - -
1 intercept 14191024.86988 1.8 0.02 122.90 1.00 0.535
2 pubincN 307 42.9 0.37 3.02 410215005.82 0.419 2.886 487.61
3 TotStu×gdpD 1438.83003 73.8 0.61 1.00 243266.27 0.583 4.021 16.17

(9)TotStu = f(StuFmTurk).

The total number of university students, TotStu, can be described by the students from Turkey, StuFmTurk. The regression result is:

Total number of university students
SEE = 800.22 RSQ = 0.9903 RHO = 0.55 Obser = 11 from 1998.000
SEE+1 = 763.34 RBSQ = 0.9892 DW = 0.90 DoFree = 9 to 2008.000

MAPE = 2.31
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value
F-Stat
0 TotStu - - - - - - - - - - - - - - - - - 32785.09 - - - - - - - - - - -
1 intercept 9447.26960 298.4 0.29 102.58 1.00 11.568
2 StuFmTurk 1.11579 912.8 0.71 1.00 20915.91 0.995 30.236
914.20

(10) impN = f(totconsN, totinvestN), current price.

Import is based on the demand which is represented by total consumption and total investment. The regression result is:

Import in current price
SEE = 110877184.00 RSQ = 0.9797 RHO = 0.45 Obser = 11 from
1998.000
SEE+1 = 99678840.00 RBSQ = 0.9747 DW = 1.10 DoFree = 8 to
2008.000
MAPE = 10.01
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value
F-Stat
0 impN - - - - - - - - - - - - - - - - - 1009351088.73 - - - - - - - - - - -
1 intercept 26543335.13303 0.9 0.03 49.33 1.00 0.378
2 totconsN 0.18352 9.4 0.36 1.73 1956605949.09 0.339 1.254
193.32
3 totinvestN 1.29446 31.5 0.62 1.00 481849757.82 0.654 2.417
5.84

(11) expN = f(exp2TurkN, exp2EuN), current price.

The main export destination countries and regions are Turkey and Europe. The regression result is:

Total export in current price
SEE = 66061468.00 RSQ = 0.9888 RHO = -0.63 Obser = 11 from
1998.000

SEE+1 = 50952244.00 RBSQ = 0.9860 DW = 3.27 DoFree = 8 to 2008.000
MAPE = 5.92
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value F-Stat
0 expN - - - - - - - - - - - - - - - - - 866701606.55 - - - - - - - - - - -
1 intercept -21212186.97293 1.1 -0.02 89.15 1.00 -0.428
2 exp2TurkN 1.38645 210.6 0.67 2.26 421605282.91 0.734 8.318 352.58
3 exp2EuN 1.52212 50.4 0.35 1.00 199314057.82 0.280 3.176 10.09

(12) gdpN = f(totconsN, totinvestN, expN-impN), current price.

This equation comes from the basic national income accounting identity (1) in section 3. The regression result is:

GDP from expenditure, in current price
SEE = 15112011.00 RSQ = 0.9999 RHO = 0.45 Obser = 11 from 1998.000
SEE+1 = 13618137.00 RBSQ = 0.9999 DW = 1.10 DoFree = 7 to 2008.000
MAPE = 0.82
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value F-Stat
0 gdpN - - - - - - - - - - - - - - - - - 2258055306.18 - - - - - - - - - - -
1 intercept -6125117.89173 2.0 -0.00 9999.99 1.00 -0.526
2 totconsN 1.03565 1588.7 0.90 45.98 1956605949.09 0.910 44.601 9999.99
3 totinvestN 0.78091 290.5 0.17 28.91 481849757.82 0.187 9.987 157.44
4 expN-impN 0.97070 437.7 -0.06 1.00 -142649482.18 0.108 13.979 195.40

(13) gdpD = f(TurkgdpD, time).

As mentioned already, the GDP deflator can be explained by Turkey's GDP deflator and a time tendency. The regression result has been described before.

(14) vadN2 = f(totconsN), current price.

This equation says that the value added of sector 2 (Industry) can be explained mainly by total consumption. The regression result is:

Value added of industrial sector, sector 2
SEE = 17059108.00 RSQ = 0.9887 RHO = 0.26 Obser = 11 from 1998.000
SEE+1 = 16871382.00 RBSQ = 0.9874 DW = 1.47 DoFree = 9 to 2008.000
MAPE = 7.45

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta	t-value	F-Stat
0 vadN2	- - - - - - - - - - - - - - - - -				224821762.73 - - - - - - - - - - -			
1 intercept	8278914.40830	4.1	0.04	88.30	1.00		0.863	
2 totconsN	0.11067	839.7	0.96	1.00	1956605949.09	0.994	28.030	785.66

(15) vadN3 = f(TotinvestN), current price.

It is easy to understand that the scale of investment determines the size of the value added of the Construction sector. The regression result is:

Value added in Construction, sector 3
SEE = 23058890.00 RSQ = 0.9700 RHO = 0.61 Obser = 11 from 1998.000
SEE+1 = 19126374.00 RBSQ = 0.9667 DW = 0.78 DoFree = 9 to 2008.000
MAPE = 29.71

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta	t-value	F-Stat

0 vadN3 - - - - - - - - - - - - - - - - - 142083947.09 - - - - - - - - - - -
1 intercept -18393118.14907 12.0 -0.13 33.33 1.00 -1.514
2 totinvestN 0.33304 477.3 1.13 1.00 481849757.82 0.985 17.057 290.93

(16) vadN4 = f ((expN+impN), (TouTurk+TouFor)×gdpD), current price.

Sector 4 is Trade and tourism. So this equation says that the value added of sector 4 is mainly determined by volume of foreign trade (export plus import), and the number of tourists from Turkey and from other foreign countries. To use the GDP deflator is to convert the constant-price-like term (number of tourists) into current price. The regression result is:

Value added in Trade and tourism, sector 4
SEE = 19370746.00 RSQ = 0.9933 RHO = -0.18 Obser = 11 from 1998.000
SEE+1 = 18855542.00 RBSQ = 0.9916 DW = 2.36 DoFree = 8 to 2008.000
MAPE = 11.05
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value F-Stat
0 vadN4 - - - - - - - - - - - - - - - - - 345072866.18 - - - - - - - - - - -
1 intercept 25526371.46892 27.0 0.07 149.55 1.00 2.212
2 (expN+impN) 0.12550 219.9 0.68 2.20 1876052721.45 0.741 8.595 594.20
3 (TouTurk+TouFor)×gdpD 40.884 48.2 0.24 1.00 2057108.11 0.267 3.093 9.56

(17) vadN5 = f(totconsN, vadN2), current price.

The value added of sector 5 (Communication and transportation) can be explained mainly by the situation of total consumption and industry. The regression result is:

Value added in Communication and transportation, sector 5

SEE = 11158362.00 RSQ = 0.9965 RHO = -0.21 Obser = 11 from 1998.000
SEE+1 = 10668577.00 RBSQ = 0.9956 DW = 2.43 DoFree = 8 to 2008.000
MAPE = 6.18

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta	t-value	F-Stat
0 vadN5	- - - - - - - - - - - - - - - - -				260289588.18	- - - - - - - - - - -		
1 intercept	-2757999.72656	1.0	-0.01	287.10	1.00		-0.398	
2 totconsN	0.03053	8.4	0.23	2.91	1956605949.09	0.233	1.186	1144.40
3 vadN2	0.90429	70.6	0.78	1.00	224821762.73	0.767	3.910	15.29

(18) vadN6 = f(vadN2, totconsN), current price.

The value added of sector 6 (Financial) can be explained mainly by the situation of the industry and total consumption. The regression result is:

Value added in Financial, sector 6

SEE = 11830155.00 RSQ = 0.9887 RHO = -0.49 Obser = 11 from 1998.000
SEE+1 = 10140221.00 RBSQ = 0.9859 DW = 2.99 DoFree = 8 to 2008.000
MAPE = 8.24

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta	t-value	F-Stat
0 vadN6	- - - - - - - - - - - - - - - - -				153944032.91	- - - - - - - - - - -		
1 intercept	976271.64219	0.1	0.01	88.55	1.00		0.133	
2 totconsN	0.03958	12.4	0.50	1.23	1956605949.09	0.512	1.450	350.21
3 vadN2	0.33591	11.1	0.49	1.00	224821762.73	0.484	1.370	1.88

(19) vadN7 = f(privinvestN, (TouTurk+TouFor)×gdpD), current price.

The value added of sector 7 (Ownership and dwelling) is highly related to the private investment and also the foreign tourists who require housing supply. To introduce the GDP deflator is for the consideration of the price in both sides of the equation. The regression result is:

Value added in Dwelling, sector 7
SEE = 5938754.00 RSQ = 0.9880 RHO = 0.17 Obser = 11 from 1998.000
SEE+1 = 5883510.50 RBSQ = 0.9850 DW = 1.65 DoFree = 8 to 2008.000
MAPE = 14.61
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value F-Stat
0 vadN7 - - - - - - - - - - - - - - - - - 65723837.86 - - - - - - - - - - -
1 intercept -4940403.93499 11.4 -0.08 83.33 1.00 -1.386
2 privinvestN 0.03343 11.1 0.18 5.82 344753138.73 0.181 1.371 329.33
3 (TouTurk+TouFor)×gdpD 28.749 141.2 0.90 1.00 2057108.11 0.820 6.209 38.55

(20) vadN8 = f(privconsN, pubconsN), current price.

The value added of sector 8 (Private and business services) is described by private and public consumption. The regression result is:

Value added in Private and business services, sector 8
SEE = 21817986.00 RSQ = 0.9847 RHO = 0.04 Obser = 11 from 1998.000
SEE+1 = 21846908.00 RBSQ = 0.9809 DW = 1.93 DoFree = 8 to 2008.000
MAPE = 9.60
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value F-Stat
0 vadN8 - - - - - - - - - - - - - - - - - 230053935.82 - - - - - - - - - - -
1 intercept -6350932.75101 1.4 -0.03 65.56 1.00 -0.476
2 privconsN 0.08628 11.7 0.52 1.26 1381926869.82 0.492 1.410 258.24

3 pubconsN 0.20390 12.2 0.51 1.00 574679051.64 0.502 1.439
2.07

(21) vadN9 = f(totconsN, totinvestN),current price.

The value added of sector 9 (Public service) can be described by private and public consumption. The regression result is:

Value added in Public services, sector 9
SEE = 27561970.00 RSQ = 0.9939 RHO = -0.03 Obser = 11 from
1998.000
SEE+1 = 27549448.00 RBSQ = 0.9923 DW = 2.05 DoFree = 8 to
2008.000
MAPE = 5.90
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value
F-Stat
0 vadN9 - - - - - - - - - - - - - - - - - 475647318.91 - - - - - - - - - - -
1 intercept 4119702.29897 0.3 0.01 162.83 1.00 0.236
2 totconsN 0.21444 131.1 0.88 1.08 1956605949.09 0.878 5.894
647.31
3 totinvestN 0.10783 4.0 0.11 1.00 481849757.82 0.121 0.810
0.66

(22) vadN10 = f(impN), current price.

The value added of sector 10 is the Import duty. Obviously it depends upon the import. The regression result is:

Value added in Import duties, sector 10
SEE = 14814738.00 RSQ = 0.9902 RHO = 0.29 Obser = 11 from
1998.000
SEE+1 = 14429295.00 RBSQ = 0.9891 DW = 1.42 DoFree = 9 to
2008.000
MAPE = 16.93
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value
F-Stat
0 vadN10 - - - - - - - - - - - - - - - - - 204957111.45 - - - - - - - - - - -

1 intercept 12338460.34062 12.2 0.06 101.63 1.00 1.526
2 impN 0.19083 908.1 0.94 1.00 1009351088.73 0.995 30.094
905.65

(23) vadD2=f(gdpD).

The deflator of the value added of sector 2 is described by the GDP deflator. The regression result is:

vadD sector 2
SEE = 67.35 RSQ = 0.9629 RHO = 0.31 Obser = 11 from 1998.000
SEE+1 = 68.65 RBSQ = 0.9588 DW = 1.39 DoFree = 9 to 2008.000
MAPE = 8.46
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value
F-Stat
0 vadD2 - - - - - - - - - - - - - - - - - 594.09 - - - - - - - - - - -
1 intercept -17.62591 0.8 -0.03 26.98 1.00 -0.384
2 gdpD 93.46590 419.4 1.03 1.00 6.54 0.981 15.290 233.80

(24) vadD3=f(gdpD).

The deflator of value added of sector 3 is described by the GDP deflator. The regression result is:

vadD sector 3
SEE = 33.83 RSQ = 0.9911 RHO = -0.01 Obser = 11 from 1998.000
SEE+1 = 33.81 RBSQ = 0.9901 DW = 2.03 DoFree = 9 to 2008.000
MAPE = 5.95
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value
F-Stat
0 vadD3 - - - - - - - - - - - - - - - - - 622.98 - - - - - - - - - - -
1 intercept -12.75552 1.7 -0.02 112.20 1.00 -0.554
2 gdpD 97.13564 959.2 1.02 1.00 6.54 0.996 31.635 1000.80

(25) vadD4=f(gdpD).

The deflator of value added of sector 4 is described by the GDP deflator. The regression result is:

```
                 vadD sector 4
 SEE = 51.67  RSQ = 0.9706  RHO = 0.56  Obser = 11 from 1998.000
 SEE+1 = 45.37  RBSQ = 0.9673  DW = 0.89  DoFree = 9 to 2008.000
 MAPE = 13.36
Variable name  Reg-Coef  Mexval  Elas  NorRes  Mean  Beta  t-value
F-Stat
 0 vadD4              - - - - - - - - - - - - - - - - -   607.11 - - - - - - - - - - -
 1 intercept      78.14340    24.4   0.13   34.00     1.00         2.220
 2 gdpD        80.82266   483.1   0.87    1.00      6.54  0.985  17.233  296.98
```

(26) vadD5=f(gdpD).

The deflator of value added of sector 5 is described by the GDP deflator. The regression result is:

```
                 vadD sector 5
 SEE = 88.24    RSQ = 0.9703  RHO = 0.69  Obser = 11 from 1998.000
 SEE+1 = 67.79  RBSQ = 0.9670  DW = 0.63  DoFree = 9 to 2008.000
 MAPE = 14.36
Variable name  Reg-Coef  Mexval  Elas  NorRes  Mean  Beta  t-value
F-Stat
 0 vadD5              - - - - - - - - - - - - - - - - -   809.75 - - - - - - - - - - -
 1 intercept           -89.19532    11.6  -0.11   33.68      1.00        -1.484
 2 gdpD       137.35210   480.3   1.11    1.00      6.54  0.985  17.150  294.11
```

(27) vadD6=f(gdpD).

The deflator of value added of sector 6 is described by the GDP deflator. The regression result is:

```
                 vadD sector 6
 SEE = 92.41  RSQ = 0.9756  RHO = 0.04  Obser = 11 from 1998.000
 SEE+1 = 92.59  RBSQ = 0.9729  DW = 1.92  DoFree = 9 to 2008.000
 MAPE = 17.04
```

Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value
F-Stat
0 vadD6 - - - - - - - - - - - - - - - - - 900.38 - - - - - - - - - - -
1 intercept -141.56825 25.0 -0.16 41.03 1.00 -2.249
2 gdpD 159.20276 540.6 1.16 1.00 6.54 0.988 18.981 360.28

(28) vadD7=f(gdpD).

The deflator of value added of sector 7 is described by the GDP deflator. The regression result is:

vadD sector 7
SEE = 90.04 RSQ = 0.9697 RHO = 0.75 Obser = 11 from 1998.000
SEE+1 = 68.83 RBSQ = 0.9664 DW = 0.50 DoFree = 9 to 2008.000
MAPE = 22.50
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value
F-Stat
0 vadD7 - - - - - - - - - - - - - - - - - 761.45 - - - - - - - - - - -
1 intercept -146.92381 28.0 -0.19 33.05 1.00 -2.396
2 gdpD 138.79331 474.9 1.19 1.00 6.54 0.985 16.984 288.47

(29) vadD8=f(gdpD).

The deflator of value added of sector 8 is described by the GDP deflator. The regression result is:

vadD sector 8
SEE = 54.04 RSQ = 0.9716 RHO = 0.17 Obser = 11 from 1998.000
SEE+1 = 54.14 RBSQ = 0.9685 DW = 1.66 DoFree = 9 to 2008.000
MAPE = 10.50
Variable name Reg-Coef Mexval Elas NorRes Mean Beta t-value
F-Stat
0 vadD8 - - - - - - - - - - - - - - - - - 609.02 - - - - - - - - - - -
1 intercept 45.55177 8.2 0.07 35.24 1.00 1.238
2 gdpD 86.09423 493.6 0.93 1.00 6.54 0.986 17.553 308.12
(30) vadD9=f(gdpD).

The deflator of value added of sector 9 is described by the GDP deflator. The regression result is:

vadD sector 9
SEE = 70.24 RSQ = 0.9802 RHO = 0.61 Obser = 11 from 1998.000
SEE+1 = 58.00 RBSQ = 0.9780 DW = 0.77 DoFree = 9 to 2008.000
MAPE = 18.20

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta	t-value	F-Stat
0 vadD9	- - - - - - - - - - - - - - - - -				775.22	- - - - - - - - - - -		
1 intercept	-104.79096	23.8	-0.14	50.43	1.00		-2.190	
2 gdpD	134.45925	610.1	1.14	1.00	6.54	0.990	21.092	444.86

(31) vadD10=f(gdpD, Exrate_NC).

The deflator of value added of sector 10 is described by the GDP deflator and the exchange rate (between USD and TL), which is from North Cyprus Statistics. The regression result is:

vadD sector 10
SEE = 21.03 RSQ = 0.9928 RHO = 0.47 Obser = 11 from 1998.000
SEE+1 = 18.91 RBSQ = 0.9910 DW = 1.05 DoFree = 8 to 2008.000
MAPE = 3.76

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta	t-value	F-Stat
0 vadD10	- - - - - - - - - - - - - - - - -				549.74	- - - - - - - - - - -		
1 intercept	-28.99343	11.6	-0.05	139.35	1.00		-1.402	
2 gdpD	33.91194	291.9	0.40	18.73	6.54	0.502	10.717	553.42
3 Exrate_NC	319.49552	332.8	0.65	1.00	1.12	0.558	11.911	141.88

Equations (32)-(40) are identities. They define the value added by economic activities in constant price, through using current price value and the deflator in the corresponding sector, i.e.:

gdpRi = gdpNi/gdpDi, i = 2,……,10

Also there is

(41) gdpR = gdpN/gdpD

The sum of the gdpRi (i=1,2,…,10) needs to be scaled to gdpR, the GDP in constant price.

The main part of the model's structure is shown in Figure 3 below. In this figure, all the exogenous variables are put into ellipse and all the endogenous variables are put into rectangle. The arrow line between two variables represents the explanation of the relationship.

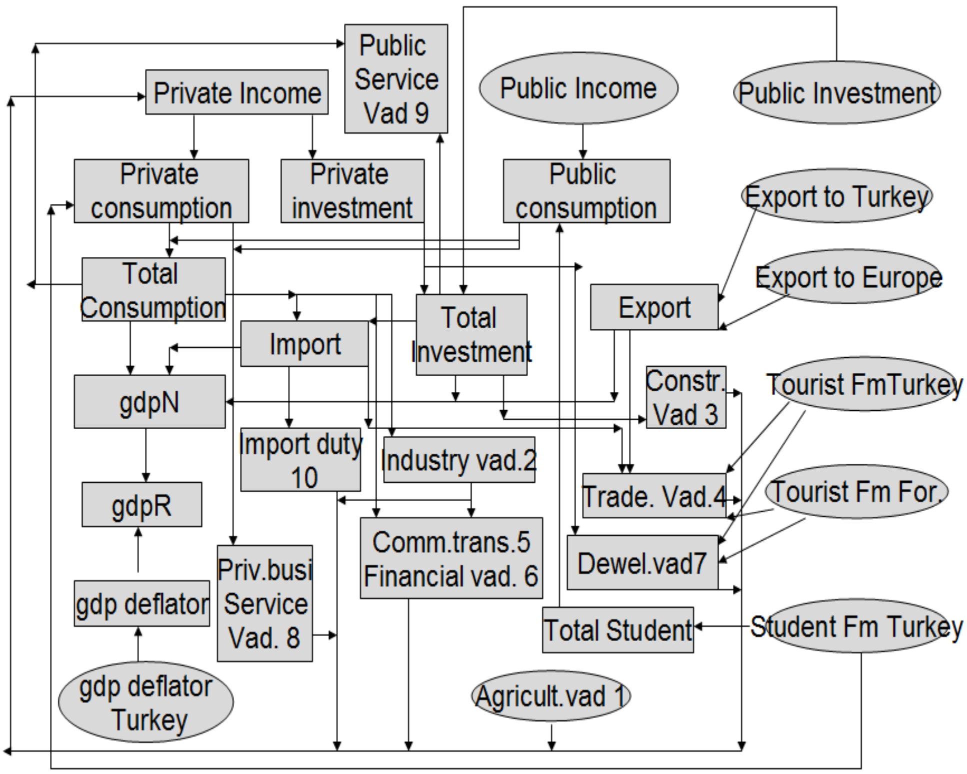


Figure 3: T he Model's Structure

5. THE SIMULATION OF THE MODEL

The historical simulation results from running the model are listed in Table 6 below. In Table 6, for each variable, there are two lines. The first line is the actual historical value of the variable. The second line is the percentage change of the simulated value compared with its historical value. For saving print space, the values are displayed for every two years, from 2000 to 2008.

Table 6: Simulation Results (Percentage change, %)

	2000	2002	2004	2006	2008
GDP in constant price	24883.84	25005.53	31569.88	40489.57	40444.31
	-1.38	-4.01	0.30	2.10	4.89
GDP in current price	64996.44	140770.17	245674.42	398809.97	507990.78
	-0.60	-1.80	0.92	3.32	1.71
GDP deflator	0.00	0.00	0.00	0.00	0.00
	0.80	2.30	0.62	1.20	-3.03
Private income, current price	54611.84	134330.55	209228.42	334538.88	402269.47
	3.54	2.31	6.04	6.40	7.13
Private consumption	38046.87	85073.54	143314.80	238794.78	321368.56
	4.37	3.56	4.98	4.67	7.62
Private investment	6818.23	14585.30	36207.45	70225.66	76811.69
	5.93	4.91	4.28	5.46	6.43
Public consumption	17898.47	32295.98	59795.97	98888.46	136645.63
	-0.37	-3.18	-3.86	2.91	2.31
Total students	25765.00	27748.00	35473.00	38779.00	45634.00
	0.03	-4.40	-2.20	1.68	2.09
Import, current price	26615.64	46658.33	121827.61	198379.22	215717.84
	6.32	4.03	1.63	7.34	8.47
Export, current price	24561.05	48722.99	119814.05	169030.28	165622.83
	4.11	-3.43	-0.27	2.32	-0.76
vad sec 2, current	6838.59	15757.66	23104.66	37750.45	54276.64
	-1.15	-4.97	2.95	4.04	-0.77

vad sec 3, current	2893.43	6201.30	10680.87	31478.53	36221.60
	1.23	2.34	3.28	4.65	2.60
vad sec 4, current	10470.33	21555.36	39122.73	61750.86	72170.91
	0.96	-3.80	4.08	2.82	1.40
vad sec 5, current	8462.17	18526.48	25758.02	43724.27	61452.73
	-1.91	-4.50	3.93	4.87	2.21
vad sec 6, current	4162.03	8995.23	18724.56	25931.60	35783.53
	-0.29	-3.98	-1.23	4.29	2.89
vad sec 7, current	1578.76	4143.19	6159.19	11772.25	17593.85
	0.02	2.87	0.02	0.05	-2.58
vad sec 8, current	5213.45	13886.01	22537.69	44191.96	52520.87
	-0.09	-4.33	-4.53	2.12	3.72
vad sec 9, current	15599.81	27786.71	51039.25	80800.02	110396.71
	-2.35	2.15	-0.96	2.98	2.18
vad sec 10, current	5303.84	11351.34	26248.13	36465.40	41658.51
	1.83	-0.03	1.34	5.31	2.10
vad deflator, sector 2	0.02	0.05	0.07	0.08	0.13
	0.39	-2.16	8.81	7.27	-5.99
vad deflator, sector 3	0.02	0.05	0.07	0.10	0.12
	3.78	0.84	4.88	-1.75	-0.75
vad deflator, sector 4	0.03	0.06	0.07	0.08	0.11
	4.07	-4.43	1.74	4.02	0.88
vad deflator, sector 5	0.03	0.07	0.08	0.12	0.18
	-4.14	2.55	6.52	4.70	-1.60
vad deflator, sector 6	0.02	0.06	0.13	0.15	0.18
	8.56	2.48	-2.43	-2.84	1.03
vad deflator, sector 7	0.02	0.06	0.08	0.12	0.17
	-2.65	3.13	3.61	-0.29	-4.62
vad deflator, sector 8	0.02	0.06	0.07	0.10	0.10
	3.80	-3.21	-3.47	1.34	4.35
vad deflator, sector 9	0.03	0.05	0.09	0.13	0.16
	-4.24	6.03	4.95	-2.71	-1.14
vad deflator, sector 10	0.03	0.06	0.07	0.08	0.08
	2.68	2.89	-4.61	1.30	0.89
vad sec 2, constant	3005.15	2961.09	3519.93	4633.06	4079.49

	-1.89	-4.73	-4.05	-2.69	8.71
vad sec 3, constant	1235.76	1143.98	1571.53	3236.74	3071.75
	-2.81	-0.45	-0.14	6.87	6.47
vad sec 4, constant	3920.58	3789.55	5335.82	7268.23	6851.95
	-3.34	-1.27	3.75	-0.83	3.53
vad sec 5, constant	2613.04	2707.14	3061.36	3576.70	3487.78
	1.96	-8.66	-1.05	0.50	6.98
vad sec 6, constant	1901.76	1406.79	1491.44	1743.18	2011.19
	-8.48	-8.10	2.66	7.70	4.89
vad sec 7, constant	672.62	709.36	742.16	949.26	1008.66
	2.38	-2.17	-2.10	0.67	5.20
vad sec 8, constant	2145.51	2482.73	3298.03	4552.47	5008.50
	-4.09	-3.06	0.30	1.11	2.37
vad sec 9, constant	5256.13	5172.67	5650.05	6362.50	6894.36
	1.60	-5.50	-4.29	6.21	6.46
vad sec 10, constant	2092.17	1802.98	3614.29	4799.03	5291.34
	-1.18	-4.70	7.74	4.31	4.22

The statistics for these 37 endogenous variables' percentage changes during the simulation period (1999-2008, because the software G7 requires the first year, 1998, is the same as the historical value) is listed in Table 7. It can be seen that the fitness ability of the model is considerably high so that it can be used for forecasting or policy analysis.

Table 7: Statistics of Simulation Error

Error Range	<3%	>3% <5%	>5% <10%	>10%	Total
Number	203	105	60	2	370
%	54.86	28.38	16.22	0.54	100

Table 7 shows that there are 370 estimates for 37 variables over 10 years (1998 to 2008) of which only about 17% has error more than 5%. So 83% of the estimated values have less than 5% error. Thus, overall simulation results of the North Cyprus Macroeconomic Model (MMNC) are fairly satisfactory.

6. CONCLUSION

As it is stated in the introduction of the paper the aim was to build a working macroeconomic model for the North Cyprus economy, which mainly can guide the policy makers in their decision making process. Concerning the structure and functioning conditions of the economy four main points can be identified. First, public expenditures exceed public revenues for every year from 1998 to 2008, even more than 100 percent for some years. The deficit should have been financed through excessive external borrowing mainly from Turkey.

Second, total domestic expenditure is also greater than domestic income or GDP by about 1 to 3 percent. The reason for this deviation is the net factor income from the rest of the world which is mainly the income transfers of expatriates living abroad. In terms of national income accounting rules this implies the same difference between GDP and GNP. Since the model centres around the GDP identity by both sectors and expenditures, these small deviations between income and expenditures did not cause any serious estimation problems for behavioural equations.

Third, the price formation equation for the economy detects a strong positive correlation between the general price level in Turkey and that in North Cyprus. This is the result of two-way large trade flows between the two economies. Policy implication of this correlation is that anti-inflationary measures in Turkey should also have a positive effect in controlling the inflationary process in North Cyprus.

Fourth, North Cyprus is called “the island of universities” for there have been more than 40000 students in six internationally recognised universities for many years. More than 80 percent of the student population comes from the mainland Turkey. To capture the effects of this variable on the domestic economy it is included in two regression equations, one for government consumption and one for private consumption. In both cases the total number of university students and the number of students from Turkey appeared with significant parameters.

As for the historical simulation results it is apparent that MMNC produce satisfactory fit with the actual data. Over the 10 years (1998 - 2008) from 370 estimates for 37 endogenous variables about 83.24 percent showed less than 5 percent error and only 0.54 percent showed more than 10 percent error. Therefore, it can be concluded that the model can be employed as a tool for different policy analysis and forecasting, or projections for future planning. Still it must be admitted that it can be improved with additional data and variables.

REFERENCES

ALMON, C. (2008), *The Craft of Economic Modelling,* Part 1, 5/e.

WERLING, J. (2010), Model Specifications with Various Level of Data, *the 18th INFORUM World Conference,* Hikone-Japan.

http://www.devplan.org.

ÖZHAN, G., SALMON, P., ÖZHAN, M. (2010), TINYTRNC: A Tiny Model Based on TRNC Data, First Steps to Building an INFORUM Model (A New Test), *the 16th INFORUM World Conference,* North Cyprus.

THE NEW VERSION OF THE RIM[14] MODEL

ALEXANDER SHIROV[15] AND ALEXEY YANTOVSKY

Abstract
This article is dedicated to the experience of development of the Russian economy's I-O model. In current paper are represented general scheme of calculations as well as specifications for the main model parts. Special attention is paid to the problems of employment and labour productivity forecasting. A possible change in labour productivity and its effects on Russia's economic growth are estimated.
JEL classification: E2, E3
Keywords: I-O models, Russian economy, long term forecast, labour productivity, employment

INTRODUCTION

The first version of the Russian INFORUM-type Model (RIM) was created in 2000. A detailed description of the previous version of the model can be found in Georgy Serebryakov [1] and Marat Uzyakov[2]. This was probably the first dynamic interindustry model of Russian economy developed after the collapse of the Soviet Union. And this, of course, was the first Russian INFORUM-type model. For a long time model RIM has been successfully used for practical calculations on the Russian economy. For example, it was used for the purposes of development of long-term forecasts of the Russian economy, the analysis of the Russian government policy and assessing the impact of Russia's World Trade Organisation (WTO) accession.

---

14 Russian Interindustry Model.
15 Institute of Economic Forecasting of the Russian Academy of Sciences.

But in 2004, the Russian Statistics Service (Rosstat) has changed the basic principles of industrial classification, having harmonised classifications adopted in the European Union. In this regard, Input-Output tables were not being developed in Russia from 2004 until 2011. This posed a clear problem for the development of inter-industry models.

In 2008-2010 in the Institute of economic forecasting of the Russian academy of sciences, the team under the leadership of Marat Uzyakov worked on the creation of symmetric Input-Output tables for 2000-2009. A large quantity of statistical information used in development of the I-O tables enabled the creation of balance sheets in 45 sectors of classification.

Development of an adequate statistical base allowed a move to the development of a new version of the RIM model. In addition, special attention was given to the behavioural models in the system of the macroeconomic calculations used in the Institute. For complex macro-economic research it is not enough to have one particular model. Complex models are needed which complement each other's capabilities. In this combination of complex models, the RIM model represents the top-level of the modelling process, defining the main parameters of the forecast, forming key restrictions for economic development.

More specific objectives and detailed forecasts are calculated at lower levels. It uses another inter-industry model, named CONTO, as well as models of separate sectors or regions. Some of the tasks of short- and medium-term forecasts are solved by means of macroeconomic models. The task of developing and matching the key parameters of the scenario (external economic conditions, exchange rates etc.) can be solved on the basis of specific models.

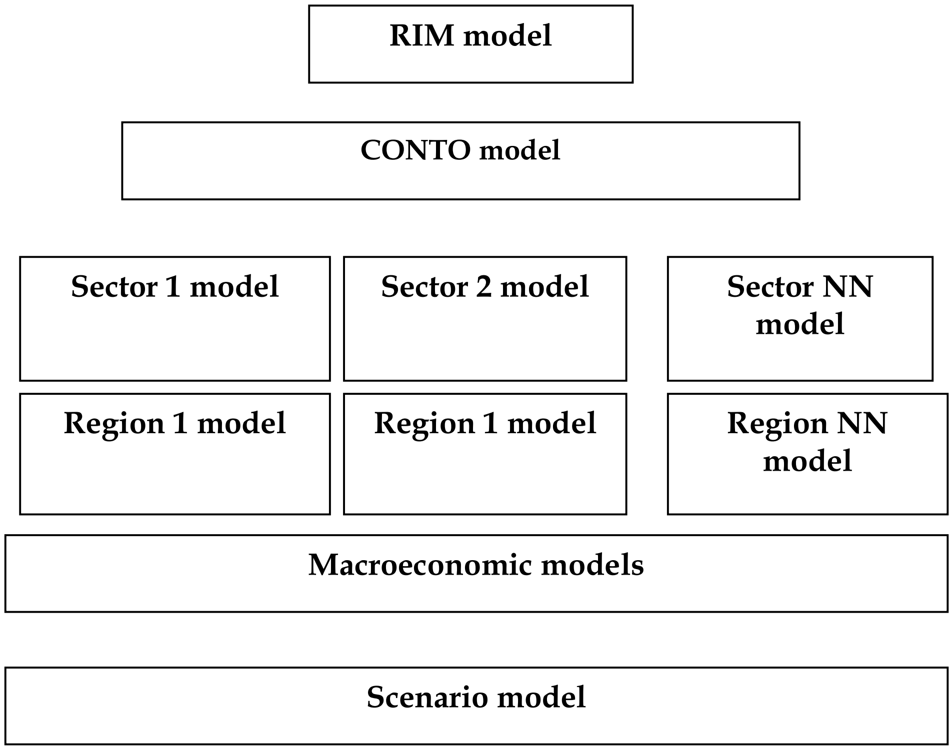


Figure 1: Current system of IEF RAS models

The Statistical base of the RIM model are rows constructed of I-O tables of the Russian economy in constant and current prices for the years 1980-2009. These tables were developed in the Institution of Economic Forecasting, from data provided by the Russian Federal State Statistics Service, customs statistics about foreign trade, statistical documents describing the structure of production costs and other sources. Additional sources included the national accounts for the years 2002-2009, institutional accounts for 2002-2009, matrixes of trade and transport margins, a tax matrix, matrices of sector investment and estimations of fixed capital, and consolidated budget data. In the model the whole economy is divided in 45 sectors, represented in Table 1, below.

Table 1: Economic Sectors in the RIM

1	Agriculture	24	Automobiles, highway transport equipment
2	Petroleum extraction	25	Sea transport equipment and its repair
3	Natural gas extraction	26	Airplanes, rockets, and repair
4	Coal mining	27	Railroad equipment and its repair
5	Other Fuels, incl. nuclear	28	Recycling
6	Ores and other mining	29	Electric, gas, and water utilities
7	Food, beverages, tobacco	30	Construction
8	Textiles, apparel, leather	31	Wholesale and retail trade
9	Wood and wood products	32	Hotels and restaurants
10	Paper and printing	33	Transport and storage
11	Petroleum refining	34	Communication
12	Chemicals	35	Finance and insurance
13	Pharmaceuticals	36	Real estate
14	Plastic products	37	Equipment rental
15	Stone, Clay, and Glass products	38	Computing service
16	Ferrous metals	39	Research and development
17	Non-ferrous metals	40	Other business services
18	Fabricated metal products	41	Government, defence, social insurance
19	Machinery	42	Education
20	Computers, office machinery	43	Health services
21	Electrical apparatus	44	Other social and personal services
22	Radio, television, communication equipment	45	Private households with employed persons
23	Medical, optical, and precision instruments		

The general algorithm of the model consists of an iterative procedure of calculations in steps of one year. For each year, a cycle of calculations is repeated until convergence criteria are met. Before the start of the iterative process, each endogenous variable is assigned a value, acquired from the previous step. In the first step elements of final demand are calculated in constant prices. Using a price index acquired on previous iteration the respective vectors are calculated in current prices. In the next step gross outputs for every industry are estimated by the Leontivian model. Then production capacities are calculated from volumes of investment, and obtained outputs are verified not to be exceeding restrictions imposed by fixed capital. In a further step of calculations the elements of gross value-added are estimated, such as salaries and wages, profits and taxes. Next, using the Leontivian model, current prices are calculated. Further incomes of households, business and government are estimated and used for calculation of final demand. Thereby closing a cycle of calculation. Before starting a next cycle, the convergence criteria, such as the difference of GDP amounts obtained from two successive iterations, are verified.

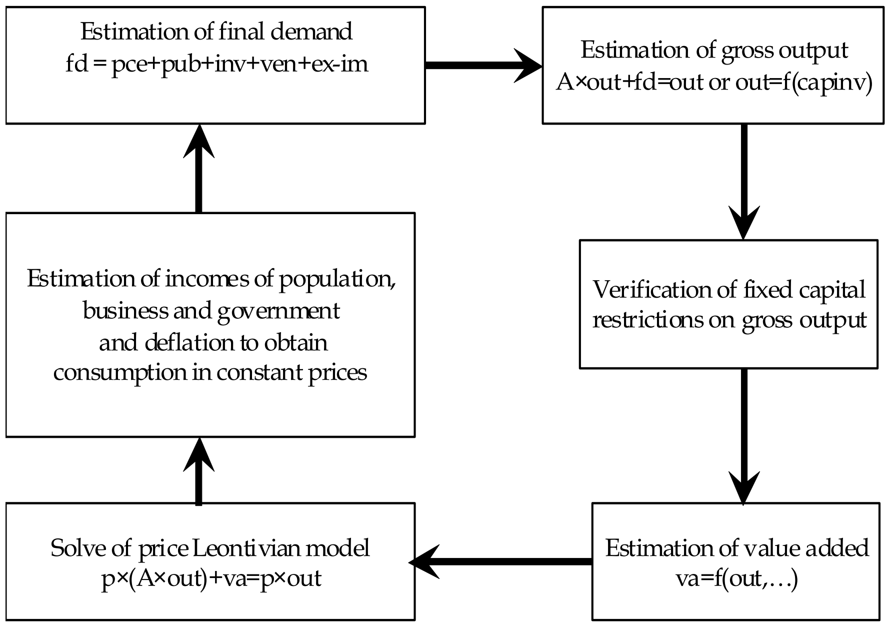


Figure 2: The principal scheme of the algorithm

This scheme is rather general for I-O models and the main interest lies in ways of forecasting separate elements of the model. The core of the model consists of calculations of final demand and value added. These blocks of the model have endured much discussion before a current scheme of calculations was arrived at.

As households' consumption, personal consumption per capita is forecasted, which is multiplied by the population. Personal consumption of some industries' goods is predicted as a function of total personal consumption, population income per capita, relative prices and the difference in the level of income between present and previous years. But, the choice of such a set of factors for regression equations, as well as, the period of 2000-2010 years for estimation of equations coefficients, has a certain drawback. More precisely it causes excessive growth in consumer demand of food and textile industry goods. It seems that the structure of households' consumption should be changing towards an increase in the share of services and durable goods. To solve this problem the intuition is to implement a saturation function for personal consumption forecasting. By usage of such functions more plausible dynamics of households' consumption structures can be received. Parameters of these saturation functions are estimated by comparisons of international data about personal consumption and income levels.

pceRpc[i] =a1 +a2×pceRTpc + a3×dinc+a4×moneyinc+a5×rprices;
where moneyinc = population incomes per capita, and
rprices = relative prices.
pceRTpc = pceRT/pop – total personal consumption per capita;
dinc = pceRTpc - pceRTpc[1]- increase in personal consumption per capita in comparison with previous year.

Governmental consumption still remains one of the most unfinished sections of the model. At present it is assumed that the product structure of government consumption is set exogenously or remains constant for the whole forecast period. The total amount of government expenditure depends on tax incomes. Along with estimation of budget incomes the amount of tax payments is estimated, which are transferred into reserve funds. In the current version reserve funds are replenished from mineral extraction tax payments and export duties on oil. Financial assets, accumulated in the reserve fund, are available for usage in later periods if needed. These are determined by special exogenous parameter, which has the meaning of a minimal level of governmental expenditure. If the current budget income is lower than this preset value and there is also a positive amount of money in reserve funds, a deficient amount is transferred from reserves into budget. This function allows obtaining more smooth dynamics in the event of abrupt changes in external prices and export amounts.

For forecasting the fixed capital a somewhat complex scheme is used. The amount of investments made by purchases is calculated in constant prices and after which in the investment bridge matrix to allocate the product composition of the investment. The values obtained are aggregated across sectors and the vector of investment by products made. For calculation of investment by purchaser regression equations are used. A set of factors in these equations include the amount of replacement of retired fixed capital, first difference of industry's output, profits and percentage of used depreciation production capacities. The following equations explain the forecasting of fixed capital namely:

capinv = a ×replace +a2× dif +a3×profit/invD +a4×out/capstock;
where replace=replaceRate×capstock –replacements of retired fixed capital;
dif =outR[t]-outR[t-1] - first difference of the industry's output;
outR/capstock = level of production capacity usage;
profit = amount of received profits in given industry;
invD = invT[t]/invRT[t] – index of prices on investment assets;
invT = investment in current prices; and
invRT = investment in constant prices.

The amount of replacement depreciation is calculated from capital stock by an exogenously set of depreciation rates. The ratio between output and fixed capital stock allows estimating the level of production capacities usage and thus necessity for investment in the given sector. Achieved profits describe in the first place, the amount of financial resources available for financing of investments and secondly the interest in the given sector's development. After estimation of investments made by the given sector as purchaser, the obtained amount is apportioned to capital assets using the matrix of the investment's technological structure by sectors. This structure consists of construction, machinery and equipment and other sectors (for example, the structure of capital investments in oil extraction is 32%

construction, 23% machinery, 44% others). Elements of technological structure are aggregated across sectors and the amount of investment expenditures on construction, machinery and other sectors in the whole economy is obtained. Each of these elements in turn has its own products structure. By summing them a vector is finally obtained of investments by product:

inv[i] = ∑j (capinv[j] × ∑ InvTS[j][n]×InvEl[i][n]);
where InvTS = matrix of technological structure of investment made by purchaser, and
InvEl = matrix of coefficients, which shows the product structure of construction, machinery and production of other investment goods.

Inventory changes are calculated from output amounts. This block remains the second undeveloped part of the model. The assumption, that inventory changes can be calculated as shares of outputs in the whole of the forecasting period, is an arguable one. Another considered method of receiving inventory changes is to exogenously set their amounts. Currently the choice is in favour of the former way.

Exports are forecasted from outputs, volume of internal consumption and world economy growth rate, which is an exogenous variable.

exR=a1+a2×outR + a3×intCons+ a4×exR[1]×worldrate;
where worldrate = world economy growth rate, and
intCons = internal consumption.

For several industries, such as oil and gas extraction, ferrous and non-ferrous metals production and chemicals production, the amount of exports is determined as the residue between outputs (domestic production and imports) and domestic consumption. This is possible because outputs for these industries are calculated by production functions rather than by the Leontivian model.

As for imports a share of import goods in domestic consumption is calculated. This variable depends on its value in the previous year, exchange rate and share of new production capacities in fixed capital stock. The purpose of the latter factor is to describe the decrease of the share of imports for domestic consumption as economy growth and bind it to a variable with economic meaning, instead of using simple time dependency. In this case it is assumed that newly created production will be competitive with foreign producers, at least on the domestic market.

ImShare = ImShare[1](a1+a2×rateusd/rateusd[1]+a3×capinv[1]/capstock[1]);
where capinv[1]/capstock[1]= share of new facilities in fixed capital, and
rateusd = exchange rate.

The exchange rate in turn depends on the ratio between exports and imports, the consumer price index and external oil prices.

rateusd[t]=rateusd[t-1]×(1+a1×(CPI[t]-brent[t]/brent[t-1])+a2×(imT[t]/exT[t] -1)

Outputs for most industries are calculated using the Leontivian model with the exception of oil and gas extraction, ferrous and non-ferrous metals production and chemicals production. For the mentioned industries outputs are estimated by means of the production function. For example, output of oil extraction is calculated by the function:

outR[2]=0.94×outRlag[1][2]+(0.11×capinv[2]+0.27×capinvlag[1][2])× /capintensity [t];
where outRlag[1][2]= output of oil extraction in previous year,
capinv[2]= investment made by oil extraction as purchaser, and
capintensity= capital intensity of oil extraction, which depends on accumulated output of oil extraction.
Output of ferrous metals production is estimated via the function:
outR[16] = 0.97×outRlag[1][16]+(0.08×capinv[16]+0.18×capinvlag[1][16])

A similar method is used for determining current prices. For some industries, which are oriented on export, for example oil and gas extraction, or are natural monopolies, such as transport and power generation, prices are set exogenously. For other industries prices are determined by solving the Leontivian price model. These other industries preliminary estimate elements of gross value added are needed. Wages are calculated from outputs in current prices, resulting from previous iterations, and the consumer price index. For industries with exogenously set prices, profits are calculated as the difference between income gains and costs. Industries with unfixed prices try to achieve the level of profitability determined by special regression equation or simply inherited from previous iterations. Taxes are calculated from amount of outputs, exports and profits, depending on the type of tax. Besides taxes on products, which are calculated as a share of outputs in current prices, the model includes value added tax, mineral extraction tax, export duties and profit tax.

Estimation of the gross value added and its elements enables the determination of current prices and the income of population, government and business. The latter values are used, from calculation of final demand elements.

Along with the described main cycle of calculations, there are several important features, which also influence model results. First are productivity functions. These functions are used in the model as upper constraints for gross outputs. The main factors used in these functions are the amount of fixed capital, investments and exogenously set efficiency of primary resources usage.

The point of view is that the efficiency of primary resources usage is an important element reflecting key technology changes. Primary resources are all sets of raw materials used for manufacturing. These are energy resources and products of metallurgy, woodworking and chemistry. Efficiency of primary resources usage is measured as a ratio of total output and used primary resources costs. The higher its value, the more its share of value added by manufacturing. The given indicator shows a level of economic and technological development of the economy. An increase in efficiency of primary resources usage may be caused by fixed capital assets. High enough investment behaviour provides achievement of a more effective technological structure of production and reduction of intermediate consumption of primary resources, first of all which is energy.

The next feature of the model regards functions of labour productivity and employment. Changes of labour productivity forecasts are firstly caused by optimisation of structural and organisational components and secondly, by improvement in technologies used due to assets of fixed capital. The former factor is exogenous and based on estimations derived from labour productivity comparisons between different countries, such as Russia, United States, Japan, Germany and the Czech Republic. Improvement in used technologies due to assets of fixed capital, is calculated inside the model with the help of regression equations, which use amounts of fixed capital and investments as factors.

Thereupon, employment is calculated as ratio of gross output and labour productivity. Growth of labour productivity may cause a significant decrease in employment. To avoid this problem professor Clopper Almon suggested the use of regression equations, forecasting the logarithm of the employment/output ratio as a function of time and the change in the logarithm of output.

The model is used to make a forecast and estimate possible restrictions of labour on economic growth. It showed that in the scenario of average economic growth of 6 per cent, several manufacturing industries will encounter deficits of available labour resources in 2020-2022. These industries are in the first place that of machinery, electrical apparatus, radios, television, communication equipment and vehicles. Partly this is caused by the fact that the given industries need highly skilled specialists. Their shortage could not been compensated by attraction of migrants. Slowdown of machinery growth complicates build up of investments in the economy. It leads to a decrease in growth rates of the whole economy.

Not only do the amounts of required labour resources change, but also their structure. The share of specialists increases by 50% and that of maintenance and scientific personnel almost triples. At the same time the percentage of skilled workers and operators of plant and equipment slightly decreases, whereas the shares of executive officers and unskilled workers are reduced by half.

The availability of a working version of the model has made possible a number of practical calculations. In particular, a forecast was made of possible dynamics of employment and labour productivity in the Russian economy until 2030. For assessing the prospects for Russian economic development, its transient nature should be taken into account. At present the distinctive features of the Russian economy include the following:

- For a long period in the past the Russian economy could grow in GDP without a high share of investments (in 1999-2006 about 16% of GDP);
- In the period 2000-2008 the Russian economy had an average growth rate in GDP of about 7%;
- This growth was based on the use of the old Soviet capital;
- The old capital was created in old conditions: chip energy, low restrictions for labour forces etc. and old plants keep old systems of management.

The presence in the economy of a large amount of production capacities, which were created in the planned economy and are characterised by low efficiency values, is a certain restriction for economic development. This problem can be solved in two ways. Firstly by investments in fixed capital and secondly by application of new methods in management. The second way is not as expensive and allows increased efficiency of production quickly enough. For example, growth of labour productivity in the last years was connected with changing in structure of business and not so much depended on technological changes. This factor has to be taken into account in the models and forecasts.

At the same time some guidance is needed for a possible increase in production efficiency, which could be used in forecasting. Thinking about how to actually measure the productivity of labour, many questions arise immediately.

For example, direct comparisons of productivity levels between Russia and other countries lead to disappointing results.

Table 2: Labour productivity in different countries

Country	Labour productivity in Russia in 2008 compared with labour productivity in selected countries in the following years	Comparison with labour productivity in USA (year 2007 = 100%)
USA	before 1970	100
Australia	before 1970	80
Japan*	before 1970	76
Germany	before 1970	95
France	before 1970	99
Italy	before 1970	74
Netherlands	before 1970	101
Belgium	before 1970	111
Spain	before 1970	76
Finland	before 1970	80
Sweden	before 1970	85
UK	before 1970	79
Czech Rep.	1995	46
Slovak	1995	54
Poland*	1995	44
Slovenia*	1995	58
Korea	1996	41
Ireland	1971	89
Portugal*	1988	44
Russia	2008	25

** - 2006*
Sources: EU KIEMS Project, Rosstat

Thus, labour productivity in developed countries is more than 3 times higher than in Russia. However, does this estimate reflect a real gap in the efficiency of labour resources usage?

In general, productivity describes the relationship between output and resources necessary for production.

More efficient use of labour resources is the basis for raising incomes and improving the common welfare of the state. Low productivity growth limits the growth of incomes and exacerbates conflict in the distribution of social product.

Understanding of reasons of the productivity growth must precede the attribution of the changes to the influence of any factor.

In the economies of developed countries the employment situation is predictable. It operates in a fairly rigid connection between economic growth and the increase in the quantity of jobs. As the Russian economy is a transition economy, it has a number of features:

Active use of production capacity created during the Soviet era has been one of the main reasons for the rapid economic growth in 1999-2007. However, it is understood that the emphasis on the use of old production facilities are naturally conserved cost structure characteristics of the Soviet economy.

Low-cost labour and energy resources in the Soviet period defined the requirements for low productivity in the creation of industrial enterprises. In recent years, the exhaustion of growth reserves of idle capacities, adjustment of global and domestic energy prices and rising labour costs made the productivity lag of Russian enterprises one of the key containments of economic development.

Growth of labour productivity in the Russian economy is not only a result of modernisation and investment, but a natural consequence of the formation of a new corporate environment. Convergence rates of labour productivity with Western guidelines should be seen not only in terms of the impact of labour but also in terms of equalisation of labour costs. At the same time, the transition to more efficient use of labour policy should encourage the development of small business in the most promising areas for economic development (service and technical support of large and medium-sized businesses) due to the withdrawal of outsourcing non-core functions.

For example, the level of productivity in the Russian car industry (measured as the ratio of cars to the number of employees) is behind the respective numbers for Eastern Europe by 2 times and in comparison with countries such as Germany, Japan, the United States by 4-8 times. In this case, despite all the imperfections in technology used in Russia, the level of productivity in comparison with, for example, the Czech Republic, is clearly not twice lower.

In this connection it is necessary to consider two main aspects of the dynamics of labour productivity:

a) Organisational (associated with the imperfection of corporate management and excess employment in a number of processes);

b) Institutional (associated with a real gap in development of technologies).

It should be noted that due to the organisational components, productivity can be increased significantly and, of particular importance, it can be done quickly.

However, for practical calculations in the RIM model a technique should by created that enables separation of the dynamics of productivity at the individual components.

The most difficult issue is the assessment of the technological components of the labour productivity dynamics. Prediction of technological development of the economy as a whole and its individual branches is one of the most important and most difficult problems of long-term forecasting. A huge number of different technologies and innovations used in the economy make the direct measurement and tabulation of their use hardly possible. In addition, for purposes of forecasting it is extremely important to have quantitative characteristics of the level of technological development.

The technological component of labour productivity can be estimated by comparing the level of costs of primary resources (3). The efficient use of materials and supplies (electricity, oil, gas, petroleum, metals, chemical products and wood) largely reflects the technological development of the economy. Qualitative changes in the economy, associated with technological upgrade of production, are also reflected in the productivity of primary resources. The more the economy is able to produce goods and services from the same number of primary resources, the more effective it is.

The institutional employment component's economic effect can be interpreted as excess employment associated with the imperfection of the organisational structure of enterprises and employment requirements. Logical calculation was performed to assess the excess employment in the industries on the basis of comparisons of productivity and primary resources consumption in Russian and Japanese economies.

As an example, a comparison between two scenarios can be presented. In the first scenario, named “Inertial”, it is assumed that productivity of primary resources remains equal to its value in the year 2010. In the second scenario, called “Innovation”, productivity of primary resources increases with rates taken from dynamics of productivity in the Japanese economy from the year 1970, when its value was comparable, with current value in the Russian economy. The greatest effects of primary resources productivity growth are in the manufacturing sector. Thus, the difference in output of production of electrical apparatus between the scenarios, in year 2030, is about 35%. Output of aircraft and spacecraft production in the second scenario increases by 44% compared to the inertial scenario.

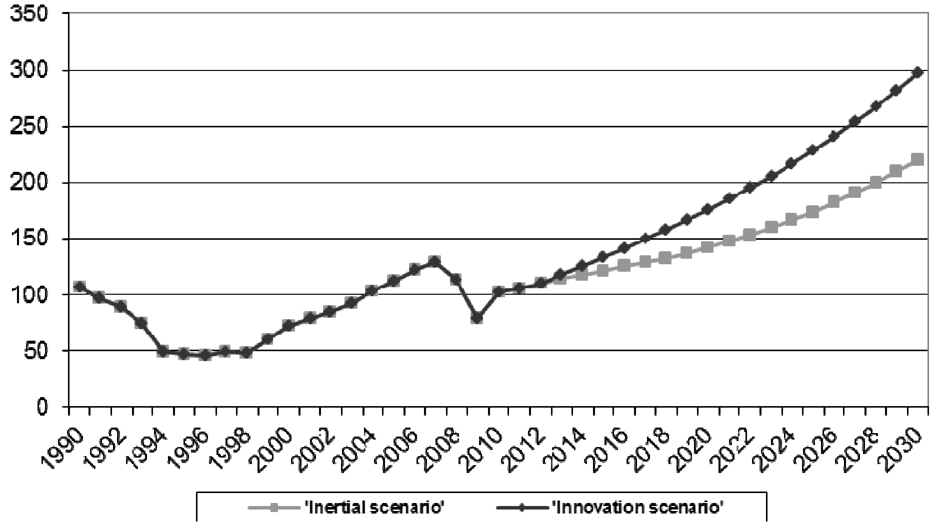


Figure 3: Output of electrical apparatus production, in constant prices (year 2010), (bln. rubl.)

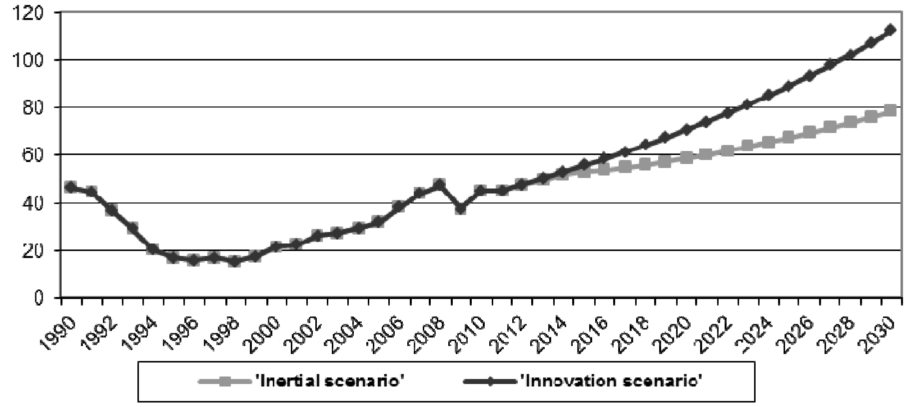


Figure 4: Output of air– and spacecraft production, in constant prices (year 2010), (bln. rubl.)

At the first stage (years 2011-2015) of the forecast labour productivity growth is caused mainly by the organisational component, in the next stage (year 2016-2030) – by technological improvement. Also the labour productivity is affected by the dynamics of the efficiency of primary resources usage.

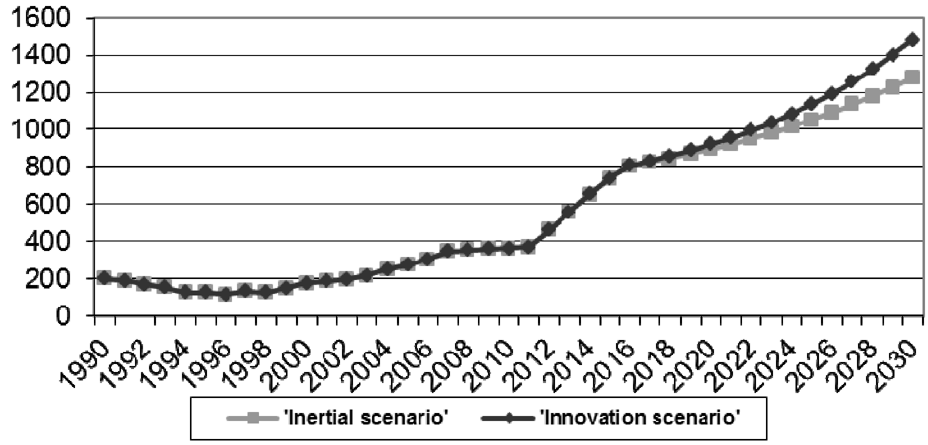


Figure 5: Labour productivity in electrical apparatus production, in constant prices (year 2010), (thd. rubl.)

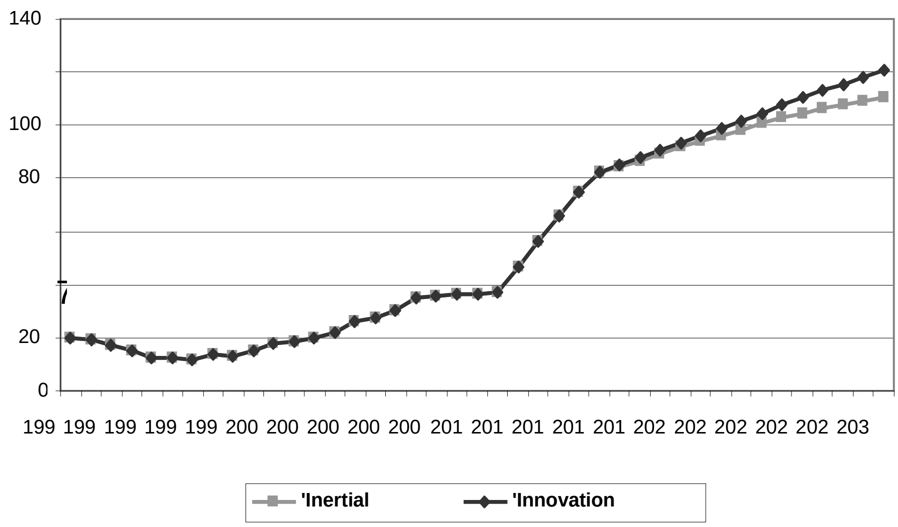


Figure 6: Labour productivity in air- and spacecraft production

According to the calculation, the increase in labour productivity, caused by a change in productivity of primary resources by 9%, in production of electrical apparatus, is about 16% in year 2030 and 10% in production of air and spacecraft.

REFERENCES

G.R. SEREBRYAKOV (2000). Building a Dynamic Interindustry Equilibrium Model of the Russian Economy. *Studies on Russian Economic Development* vol. 2.

M.N. UZYAKOV (2000). Problems of Building an Interindustry Equilibrium Model for the Russian Economy. *Studies on Russian Economic Development* vol. 2.

M.N. UZYAKOV (2011). Usage efficiency of primary resources as an indicator of technological development: A retrospective analysis and forecast. *Studies on Russian Economic Development* vol. 2.

CONSTRUCTING INDUSTRY EMPLOYMENT AND OCCUPATIONAL PROJECTION MODELS[16]

JEFFREY F. WERLING[17]

Abstract:
This report provides a description of possible procedures, structures, and other considerations for constructing labour market projection models for developing countries. The main objectives for these models will be to project through time the sectoral and occupational labour requirements given assumed economic growth rates and expenditure allocations. After some general comments concerning model objectives and specification and data availability, it presents draft specifications for models at three levels of sophistication: Rudimentary (Basic), Intermediate, and Extensive (Sophisticated). For any given modelling project, the level of sophistication among these three levels would be dictated mostly by data availability.
JEL Classification: C51 - Model Construction and Estimation; C52 -Model Evaluation, Validation, and Selection; C53 - Forecasting Models; Simulation Methods; C54 - Quantitative Policy Modelling; C67 - Input-Output Models; C68 -Computable General Equilibrium Models; C82 - Methodology for Collecting, Estimating, and Organizing Macroeconomic Data; Data Analysis; E0l - Measurement and Data on National Income and Product Accounts and Wealth; Environmental Accounts; E6 -Macroeconomic Policy, Macroeconomic Aspects of Public Finance, and General Outlook

---

16 Presented at the 18th INFORUM International Conference Hikone, Japan.
17Executive Director, Inforum/Department of Economics, University of Maryland College Park. Inforum would wish to thank the International Labour Organization for support for developing models of Ukraine and Vietnam, and for writing this paper.

Key Words: Multisector models, Macroeconomic interindustry models, Input-output tables, National income accounts, Growth models, Employment projections, Occupational projections, Dynamic general equilibrium models

1. INTRODUCTION

In addition to economic growth, successful developing countries experience sustained structural change. Structural change is manifested in several phenomena, including changes in demographics, urbanisation, marketisation, and consumption patterns. Some of the most important changes occur in the sectoral (industrial) allocation of trade, production, and employment, including the occupational make-up of the labour force. In some cases, such as China and India, structural changes are occurring at an especially rapid pace, at least compared to the historical experience through the mid-twentieth century.

Indeed, as growth proceeds, a developing economy moves up the economic value ladder and its production and employment patterns will change dramatically. Economic growth and structural change, however, can become constrained by the capability of the labour force to adapt to these changes. Anticipating the labour requirements and planning ahead can help ensure that constraints are not binding. Therefore, as development proceeds, governments are interested in acquiring tools that can help their analysis of and planning for such structural change.

Quantitative labour market analysis is an important tool for policy makers and planners to use as a guide for investments in education and training, as well as an important public information resource for schoolteachers, counsellors, and for the students who are the workforce of the future. The ILO has been instrumental in developing this type of analysis in many countries throughout the world, through missions offering on-site assistance, as well as the Global Employment Trends (GET) and Key Indicators of the Labour Market (KILM).

The INFORUM group at the University of Maryland is a team specialising in the development of interindustrial macroeconomic models. These structural models track demand patterns and industry interactions, and are able to illustrate changing industrial patterns and the employment composition through time. INFORUM has been developing such models for over 40 years. Starting with a large-scale model of the U.S., the current system of models is linked through bilateral trade flows, and includes large countries such as China, Germany, France, Italy, Spain, the U.K., Japan, South Korea, Canada, Mexico and others. INFORUM has also built or helped to build models of Russia, Poland, Qatar and Ukraine. The models are constructed using a common software framework called Interdyme, used by INFORUM partners in over 20 countries.

This report provides a description of possible procedures, structures, and other considerations for constructing labour market projection models for developing countries. The main objectives for these models will be to project through time the sectoral and occupational labour requirements given assumed economic growth rates and expenditure allocations. After some general comments concerning model objectives and specification and data availability, it presents draft specifications for models at three levels of sophistication: Rudimentary (Basic), Intermediate, and Extensive (Sophisticated). For any given modelling project, the level of sophistication among these three levels would be dictated mostly by data availability. However, the time frame and scope of a particular project might also constrain complexity, as when a model is needed within a month or so to address a specific topic.

2. GENERAL OBSERVATIONS ON MODEL OBJECTIVES AND SPECIFICATIONS

The development and use of empirical economic models must be derived and implemented to facilitate the mission of the model's users. For this purpose, the models have at least three very practical applications:

1. Economic models provide a useful venue for assembling economic and social data -- the raw material for reports and studies -- in a comprehensive databank used for assessment and analysis.

2. Economic models can assist the construction of economic projections. They help leverage the historic record to determine future trends, and they provide a comprehensive and consistent framework to assess the assumptions and structures underlying an economic forecast.

3. Using the historical record or a baseline forecast as context, economic models are used for simulation and counterfactual analysis to produce alternate projections and/or to evaluate policy measures or exogenous economic shocks.

For current purposes, the interest is in developing models designed to show plausible paths for industrial structure, employment patterns and occupational makeup over a long-run time period of ten to thirty years. Therefore, macroeconomic assumptions concerning population, labour force, productivity growth, and exports that are largely exogenous. At the outset, several salient features of the models described here should be stressed:

1. Labour projection models can be very simple or very elaborate. Very often, model sophistication and structure is constrained and even determined by data availability and quality. Every economy is a special case in data availability and in economic characteristics. While this paper provides some general model templates which depend on data availability, the ultimate specification of any particular economic model would be unique.

2. The models will track the economy over time on an annual basis. That is, time paths for both exogenous and endogenous variables will be determined year-by-year both over historical periods and forecast horizons. This distinguishes them from static CGE models that solve for various states without a specific time frame.

3. These models are not econometric forecasting models per se. The models themselves will have a very limited capability to independently predict the course of GDP and its components over time. Rather, economic growth and expenditure patterns will be determined through exogenous assumptions on population and labour force

growth, aggregate and relative productivity (labour and/or total factor), and international trade.

This is not to say that these models cannot be further developed into forecasting models, or even dynamic general equilibrium models. Indeed, to the extent that the modelling process collects and analyzes available data in a coordinated effort, much of the spade work for developing more sophisticated models would be accomplished. But given that the uses for the labour projection models are more limited and that users would typically have limited experience with more complex models, the scope of the current models is limited to the task at hand.

4. The models should be structured and embedded in software so scenario modelling capability that is extensive and flexible. Indeed, it is anticipated that users will find the development of exogenous growth projections and experiments with alternatives to be one of the more useful features of structural models.

5. The models will be updatable and scalable, that is, they can be upgraded as more data becomes available for each country.

3. DATA CONSIDERATIONS

Any empirical modelling process requires a detailed and ongoing inventory and analysis of the available data. In this context, the following general observations concerning macroeconomic, industry-level, and labour force/employment data for developing countries is offered.

1. For most countries, data availability, consistency, and accuracy problems are the rule rather than the exception. Moreover it is rare that the economic analyst is in the position to offer alternative values for fundamental data. It is often necessary, however, for modellers to work within the given data to estimate and configure data, especially at the industrial level, in order to develop a coherent picture for the given

economy. There are standard methodologies that can be used to make such estimates consistent with published aggregates or other data.

2. Most developing nations now have, at the least, the basic national account data for expenditure and value added by major sector (usually 7-12 sectors), in nominal and real terms, across twenty or more years of time. Such data can often be leveraged to develop the rudimentary macroeconomic, multisectoral model of the economy explained below.

3. Unfortunately, the availability of employment data at a comparative level of sector detail is a problem for many of the low-income developing economies of Africa and Asia. Sometimes there is data for the more easily documented sectors such as manufacturing, utilities and government, but even these data are restricted to the formal portion of those sectors. In other cases cross-economy employment data is available through a labour market or economic census, but is limited to the one or two annual survey observations and these might be quite dated. Indeed, the lack of comprehensive sectoral employment data is the biggest constraint for developing employment projection models.

4. Occupational data is also sparse for low income countries. However, this constraint is less of a concern because the occupational composition by major economic sectors may be similar across similar economies. Therefore, an occupational matrix for, say, Ghana, might be used for Liberia.

5. International trade and physical production data for detailed products is generally available at some level for most countries. These can help guide the elaboration of historic data detail beyond what is available from the national accounts, and, in turn, aid the modelling and projection of output and employment. For instance, the growth prospects and labour and occupational requirements for oil exporters will be quite different than for agricultural or manufacturing exporters. Moreover, the production and employment patterns within manufacturing can be derived from examining the relative size of industries with the overall sector.

Notwithstanding typical data difficulties, it is rarely appropriate to assert that no useful model can be constructed for a given typical country. Rather, the modeller must work with the hand he is dealt and adapt the effort to data conditions.

However, it is noted that the "availability conditions" of the data is often an important bottleneck expanding the time frame for constructing a model. For example, electronically accessible data in spreadsheet of ASCII files require much less effort to translate into a data bank. Hard copy or pdf formatted data can take much longer to process. In addition, changes to the base-year, the benchmark year, and/or the conceptual definitions of data also prolong the modelling effort as suitable linkages of data across time will need to be developed. Indeed, in some modelling efforts – especially for more elaborate models – it was found that data compilation and development can require 60-80 percent of the total effort.

Appendix A offers a list of economic data concepts that one would one to have to initiate an inventory of country data to build a labour market model. This summary was compiled as part of a project for Bosnia-Herzegovina, and, therefore, contains relevant comments for that country. It was chosen to include these comments to illustrate some typical issues that one might come up with for any given country.

4. MODEL STRUCTURE WITH BASIC (RUDIMENTARY) DATA AVAILABILITY

In this case, it is anticipated to have only the following data over a period of time:

1. Supply: GDP by sector in current and constant prices for 7-10 major sectors.
2. Demand: GDP by expenditure in current and constants prices.
3. Employment by major sector.
4. Total population and economically active population.

5. Sectoral employment-occupation matrix for subject economy or borrowed from similar economy, probably for one or two nonadjacent years.

Table 1 indicates a typical structure for the supply and demand side of the national accounts[18]. On that table and throughout this paper, the following conventions for variable names (mnemonics) were adapted. The stems of variable names are in lower case. A suffix of upper case R indicates a real variable, and a suffix of upper case D denotes a deflator. Any variable without an upper case suffix is a nominal variable. A lagged value for a variable is indicated by putting the degree of lag in square brackets after the variable. For example, "gdpR[1]" means "real GDP lagged once". The value of a variable for a specific year is indicated by following the variable name with curly braces which enclose the year. For example, "gdpR{2007} indicates "gdpR for 2007."

Ideally, data would be available for at least 20 years, but it is known that often, only shorter series are available. Sometimes, time series are limited by the fact that national accounts are rebased periodically. Some analysts are hesitant to link such discontinuous data, but it was found that such linkages work well for structural modelling purposes. Such data work, however, is skilled-labour intensive.

Another consideration that might lead to the construction of a model with this minimal specification is time. Typically, such a model could be set up in week or so, depending on the conditions of the data availability.

As mentioned above, it appears that the absence of employment by industry data across time is potentially major constraint for employment models. It is often possible to construct a "synthetic" account of sectoral employment across time using one or two years of

18 Most countries have national account sectoral data for activities conforming to the ISIC (International Standard for Industry Classification). It is most likely that any given country provides a breakdown significantly less granular that the major sector specified by the ISIC (A-X "tabulation categories"). For example, Education is tabulation category M and Health and social services are category N. Most developing countries will have a single sector these activities, or even morel likely, will lump them into the Services category.

comprehensive employment data from a labour survey or economic census. In this case, aggregate labour could be spread across industries using the national account data. Note that this technique implies that the historic labour productivity trends are imposed using informed judgment. As will be seen below, the historic labour productivity trends are one of the more important parameters that should be derived from historic data. However, specifying productivity means that this key information for making employment projections is specified ex-ante by the model builder. Obviously, then, it is much more desirable to have an independent estimates of employment by sector.

In any case, the "minimum-data models" will be rudimentary structural models that will nonetheless be able to illustrate the structural and employment evolution of an economy through time. The general flow of an annual loop of such a model is displayed by Figure 2. Economists often describe the economy as a circular flow of expenditure and income between the demand and supply sides of the economy. Empirical models are also structured in this way. The circular movement of economic activity is represented by the links between the boxes in the figure where the lines moving from block to block indicate the major flows of information between the blocks. The model consists of two major but interdependent blocks: the demand block and the supply block.

Though many details might vary from model to model, a solution iteration in any given year would proceed as follows[19]. At the beginning of an annual loop, the model starts at the upper left corner of Figure 1 to determine an explicit supply-side constraint for the economy. In the most basic form, the supply side constraint will be "potential GDP," where it is defined either exogenously or

19 The identities and behavioral functions and displayed here are meant to be examples of simple equations that might be used in a model of the type being described. In practice, functions will have to be adapted to data availability and the specific characteristics of the economy being modeled. In addition, the level-on-level equations shown here should not be taken as representative of the functional forms that might ultimately be used. Log-on-log, difference equations, and nonlinear functions might be used where appropriate.

endogenously. Specifically, potential GDP (gdpS) can be specified as one of at least three functions:

Exogenous time trend: gdpS = f (time) (1)

Harrod-Domar Growth model: gdpS = f (kor, kstock) (2)

Solow Growth Model gdpS = f (a, b*kstock, c*labforce) (3)

In practice, the most basic models will specify trend growth exogenously (equation 1), or possibly as a function of capital (equation 2). However, as the sophistication of the models presented here is increased, a more comprehensive function for potential output is likely[20]. Indeed, for some economies it would be advantageous to specify potential output for multiple sectors even for the most basic model. This option would be especially helpful for resource-dependent economies where exports of primary products are an important determinant of overall growth. In those cases, potential supply could be determined for the resource sector, the industrial sectors, and the service sector.

In any of the previous cases, 1, 2 or 3, the potential GDP is predetermined for the annual loop since time, capital stock, labour force and productivity are predetermined from exogenous variables, or variables determined in the previous period, such as investment. It will be seen below how potential GDP is used to help determine domestic prices and to close the model.

Once aggregate potential GDP is computed, the model turns to the demand block at the upper right hand corner of Figure 1 and proceeds counter-clockwise. It is useful to recall that in the national accounts, final demand corresponds to the definition of GDP = C + G + I + X – M, where C is personal consumption, G is government consumption, I is fixed investment, V is inventory change, X is exports

---

20 An interesting summary of the advantages and disadvantages for different methods of estimating potential GDP can be found in a paper by the Congressional Budget Office, A Summary of Alternative Methods for Estimating Potential GDP, March 2004. http://www.cbo.gov/ftpdocs/51xx/doc5191/03-16-GDP.pdf

and M is imports. The model computes initial estimates for endogenous constant price final demand variables using the quantities for the variables exogenous to the demand block from the previous solution (for the first iteration of a given year, the last period quantities).

Real per capita personal consumption (pceR) is a function of personal disposable income (dpi) in per capita terms (pop is population) and deflated with the personal consumption deflator (pceD):

$$pceR / pop = a + b*(dpi / pceD)/pop \qquad (4)$$

Government consumption can be specified exogenously or as a function on specific income flows such as natural resource revenue, export receipts, or household income:

$$gceR = a + b * (taxrate * dpi / gceD) + c * (ogi / gceD) \qquad (5)$$

where ogi is other government income. Aggregate real fixed capital investment is determined by replacement investment (dr is the depreciation rate) and economic growth:

$$invR = a + b * (dgdpR[t]) + c * (dr * kstock[1]) \qquad (6)$$

Inventory investment is a function of overall domestic demand.

Exports of other merchandise and the exports of services, on the other hand, depend on potential domestic supply relative to demand, and relative prices:

$$expR = a + b * (gdpG) + c * (expD / impD) \qquad (7)$$

Total imports, which could be allocated among goods and services, are determined by relative prices and domestic demand:

$$impR = a + b * (pceR + gceR + invR) + c * (gdpG) + d * (impD / gdpD) \qquad (8)$$

Note that foreign trade is the first area where the GDP gap (gdpG see the computation below) and, therefore, potential supply, becomes an important factor, either directly or through its effects on prices as described below.

Once constant price final demand (C + I + G + X - M) is computed, the model determines the "demand" for real GDP by sector using an index of the most relevant components of final demand, and perhaps the supply for other sectors, on the right hand side of a behavioural regression equation. For instance, depending on the country, the demand for agriculture will depend on personal consumption, or if available, nondurable consumption and/or exports. If relevant, mining demand might also depend on exports but also construction and/or manufacturing supply. To use a more specific example, real manufacturing value added may be dependent on consumption, capital formation, and net exports:

$$vamfgR = a + b*pceR + c*invR + d * (expR - impR) \quad (9)$$

Real value added for services would be dependent on personal and government consumption:

$$vasrvR = a + b*pceR + c*gceR \quad (10)$$

The first "guesses" for real value added by sector would then be added and then scaled to sum to the real GDP on the expenditure side. The resulting sectoral figures are the "actual" supply in terms of real GDP by valued added.

The sum of the real value added is then compared to the potential GDP computed in the first step to determine the "demand-supply balance." The difference between the two, in proportion to total GDP, is termed the GDP gap:

$$gdpG = (gdpR - gdpS) / gdpR \quad (11)$$

This variable, a measure for the tightness in an economy, plays a key role for the determination of prices and foreign trade. For instance, if the gap is positive, then there is excess demand in the economy and, therefore, upward pressure on domestic prices. If the gap is negative, inflationary pressure recedes. The output gap also exerts direct influences on foreign trade. Excess demand stimulates imports and restricts exports.

Next, employment by sector is determined using:

$$emp = vaR / prdv \tag{12}$$

where emp is the vector of employment per sector, vaR is real value added in each sector, and prdv is a vector of exogenous productivity ratios. These productivity ratios, which are obviously a very important parameter for the employment projections, are forecasted using historical trends, other information and judgment. As a matter of course, these parameters can be varied to illustrate the sensitivity of projections to the underlying assumptions.

A key component of the model is the price determination block. The basic idea is to project two major deflators: one for the GDP deflator (gdpD) and the import deflator (impD). The former is a function of time, which will be affected over the short run mainly by the GDP gap or, possibly, the unemployment rate:

$$gdpD = a + b * gdpG + c * unemp + d * time \tag{13}$$

The latter will be related an index of foreign prices times the exchange rate.

$$impD = a + b * (pworldD * rex) \tag{14}$$

These two deflators will then be used in weighted indices to drive the final demand prices. For instance, while the import deflator will be important for private consumption and investment, the government deflator would primarily use the GDP price. An export price deflator equation might have a small import component.

With prices determined the model can move to determine nominal and real income variables such as the national and household income and the balance of payments. Sectoral employment can be multiplied by an occupational coefficient matrix, if available, to obtain total employment by occupation by industry.

After any given iteration of the annual loop, the income and prices determined feed back to the beginning of the loop to affect the real expenditure components of the model. For instance, if the real GDP implied by the previous iteration is substantially higher than the potential GDP computed for the specific year, then upward price pressure will tend to dampen real income and competitiveness, reducing consumption and net trade and pushing the solution closer to the equilibrium between supply and demand. A shortfall of demand has the opposite effect. Equality is not imposed between potential supply and aggregate demand, and actual output can deviate from potential in any given year. However, the model will display a strong tendency to follow the potential output trend established by the interaction between labour force growth, capital formation and the productivities of these factors.

This closing mechanism is common to each of the model types. However, it is likely that the rudimentary model will have only a single GDP-linked constraint, while the more disaggregated models will have mismatches of supply and demand affecting prices at some level of granularity.

5. MODEL STRUCTURE WITH MEDIUM DATA AVAILABILITY

In addition to the major national accounts and sectoral employment data identified in the previous section, there are three other important items that might be available for a given country:

1. Gross output and corresponding employment by sector across time.

2. Production prices per sector or product across time.

3. An input-output table for one or more years.

4. A sectoral employment-occupational matrix specific for the subject economy for at least one recent year.

Possibly, a country with this level of data might have other useful data sets such as consumer prices, consumer expenditures by product, a breakdown of fixed investment between equipment and structures, and even some detail concerning value added per sector such as compensation and producers' surplus. Moreover, gross output and input-output tables normally have more disaggregated accounting per sector than the ten or so sectors typical in national accounts national accounts. All of this information may be leveraged in constructing a more comprehensive model.

Nonetheless, it is the availability of the more basic ingredients enumerated in the list above that provide a much firmer basis for developing the employment projections model. Specifically, gross output and employment data allows construction of a better accounting for output, employment and labour productivity per sector. This fact needs further elaboration.

In the rudimentary model, real value added is used as the measure of sectoral production volume. It is important to remember, however, that real value added is not the same concept as output volume. Instead, it is a residual resulting from subtracting real inputs from real gross output. And while it conceivably eliminates the double-counting for intra-industry inputs, it also reflects several other factors such as changes in technology, input use, and industry terms of trade. This is why, for any given sector, the rate of growth of real value added can be very different than the rate of growth of gross output. Real gross output, on the other hand, is equal to the shipment revenue of any given industry or product sector, deflated by a product or industry specific price index. It is a much better proxy for output volume, and, therefore, the ratio of gross output to employment is a better indicator of labour productivity.

In addition, the availability of gross output allows construction of a much better linkage of the dependence of sectoral output on final demand through full input-output accounting. This is indicated by the annual model loop displayed by Figure 2. The model structure is similar to the rudimentary model described above with several important differences, which are pointed out below.

The annual loop is started at the same point as in the rudimentary model, determining the potential supply in the upper left hand corner. Unlike the basic model, which computed potential supply in terms of real GDP, potential supply is modelled in terms of gross output by sector. Manufacturing potential output (qmfgS), for example, would be equal to:

$$qmfgS = kstmfg[1] \;/\; kormfg \qquad (15)$$

Often, the sector list modelled at this stage is dictated by data available or structural considerations, and they might not line up one-to-one with the demand sectors. Nonetheless, a more granular accounting for potential supply allows for a richer decomposition of the industrial sources of growth.

The next stop on the annual loop is the upper right hand side where final demand is computed as a function of income, relative prices and other relevant variables such as demographics. While the general forms of these equations would be similar to those of section 1, more detail might be expected at this level as well. For example, many economies might have disaggregation of personal consumption among nondurables, durables and services. Fixed investment might be split between structures and equipment. Any detail in this area will help allocate final demand among productive sectors. Table 4 shows a typical breakdown for expenditure data that might be found in this type of model.

Once final demand is computed, the model progresses leftward on figure 2 to translate final demand into gross output per sector via the input-output identity:

$$q = (I - A)^{-1} f \tag{16}$$

where q is output, f is total final demand, A is the matrix of input-output coefficients, and I is the identity matrix. Once again, this measure of "gross" output includes intermediate consumption as well as value added. Accounting for intermediate demand means that a more accurate measure of sectoral output is obtained and, therefore, a better basis for computing employment.

Much of the rest of the intermediate model proceeds in a similar fashion to the basic model described above. The supply-demand balance is determined in terms of gross output to account for economic slack as an input into the domestic price equation. The model computes employment by industry as a function of actual output and exogenous productivity. It multiplies employment by industry by the industry-occupation matrix to produce employment by occupation. The model is closed by determining and allocating income among consumers and government, which will then be deflated and used by the final demand equations.

Note that price determination is still at a relatively high level of aggregation. Price computation at the sectoral level has not yet been specified even though it was assumed that such prices were available. This is for two reasons. First, a key variable for driving such prices would be sectoral capital stock. Most countries at this level of data sophistication and aggregation would not have investment by sector. Moreover, at the intermediate level of data availability, industry price indices are often inaccurate measures of actual industry inflation and may have little correlation with aggregate inflation. Since the primary objective is to project employment, not prices, it is probably most prudent to leave this component to the final type of model.

6. MODEL STRUCTURES WITH EXTENSIVE DATA AVAILABILITY

In addition to the national accounts, gross output and prices by sector, input-output tables, and sectoral employment and occupational data identified in the previous sections, there are three other important items that might be available for a given country:

1. Disaggregated final demand (consumption, investment, government and trade) with associated bridge tables to translate the specific sectors. A typical level of availability is seen in Table 6.

2. Full value added accounts, which are labour compensation, net indirect taxes and producers' surplus for each industry.

3. Fixed investment by industry across a long enough time frame to create real capital stock per sector.

The availability of these data allows getting much closer to the dynamic general equilibrium type model. The model flow is shown in Figure 3. Several modifications from Figure 2 are evident.

First of all, on the production side a more detailed disaggregation is anticipated to, say, around 100 sectors depending on the availability of data and the input-output data. The total number of sectors is represented by n in Figure 3, and Table 5 depicts the ISIC categories which might make up an ideal disaggregation for production sectors. Moreover, more granularity is also expected on the supply side. The detail for supply constraints would be dictated by the disaggregation of investment data by producer, which may not be the same as the demand side disaggregation.

Moreover, greater detail on goods and services for private consumption and trade would also be expected, and perhaps, for fixed capital formation. Each of these final demand items would have fairly sophisticated forecasting systems that would take into account how rising incomes and changing relative prices would affect the demand for goods and services relative to each other. For example, if consumers see the price of fuel climbing relative to public transit, then consumer functions would tend to push the budget share of mass transit up at the expense of fuel and motor vehicles.

The models could then determine the vector of total final demand by sector, fdvn, by adding a series of vectors of final demand by each industry. In the case of consumption and fixed investment, the industry final demand vectors are formed by multiplying each of the final demand goods or service vectors by bridge matrices that allocate the goods and services to production sector. That is:

$$\text{fdvn} = \text{pcecn x i} \times \text{pcei} + \text{gcecn x j} \times \text{gcej} + \text{invcn x k} \times \text{invk} + \text{vencn} \times \text{ven} + \text{expn} - \text{impn} \qquad (17)$$

Where, for example, pcec represents a n x i bridge matrix allocating the goods and services purchased by consumers to their production sectors. Similar bridge matrices typically exist for government consumption and investment, but exports and imports are normally modelled by production sector.

Once again, the advantage of greater detail is a more precise computation of gross output per sector given the more detailed estimates of final demand. In turn, better estimation of gross output provides a more rich and accurate depiction of sectoral employment.

7. DETAILED SPECIFICATION TABLES

Appendix B contains tables that describe the variable determination of a fairly sophisticated model specification[21]. The first column of each table contains the data series title or concept, the second column indicates whether the variable is exogenous (EX), determined via a stochastic (ST) regression equation, or determined as an identity (ID).

The third column is the mnemonic or name of the series, as it might be accessed by a data base/modelling application program. The fourth column shows how the variable is determined in the model. For

21 It should again be stressed that there is no "generic" model specification since every model structure have be adapted to data availability and the economic characteristics of the economy in question. Nonetheless, these tables illustrate the detailed connections among model blocks described in this paper.

the stochastic variables, it is displayed which other model variables are on the right hand side of the regression function determining the variable. For identities, the simple equation is displayed.

Some of the expressions in the final column include the "sum()" function, indicating that the variable is the summation of several sectoral variables with the same name. A lagged value for a variable is indicated by putting the degree of lag in square brackets after the variable. For example, "gdpR[1]" means "Real GDP lagged once". The value of a variable for a specific year is indicated by following the variable name with curly braces which enclose the year. For example, "gdpR{2007} indicates "gdpR for 2007."

It is interesting and important to note that the model structure indicated by the tables in Appendix B are of a similar structure that one would find in the national accounts and in other information sources. Moreover, a model's results tables should be structured in the same manner. In other words, the arrangement of model information (by variables and by tables) reflects the fundamental structure of the original data and model itself. This same structure is also the presentation of the model that users would seek to understand and use.

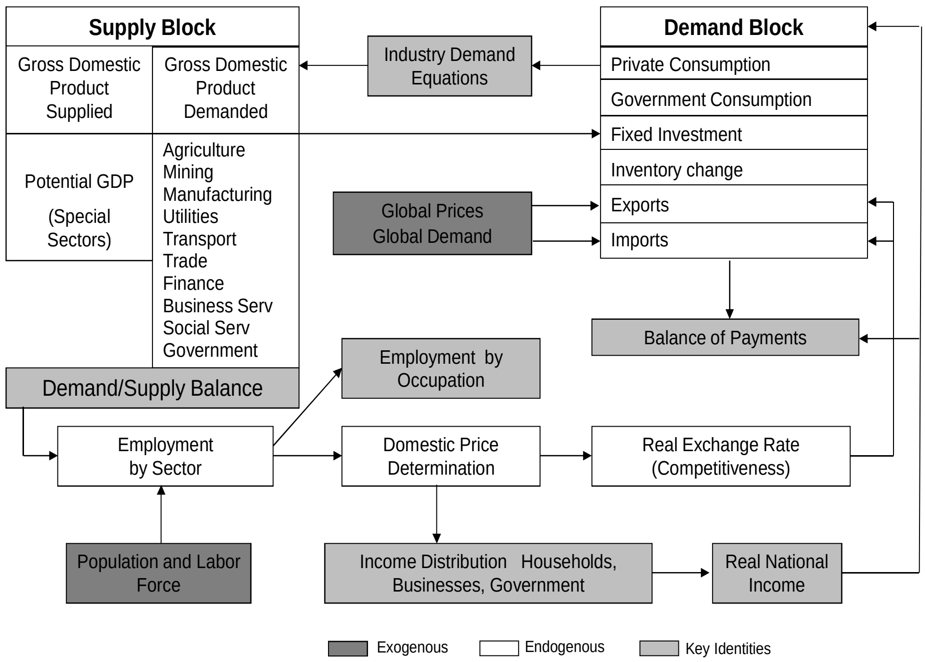


Figure 1: Model Flow Diagram for Basic Data Model

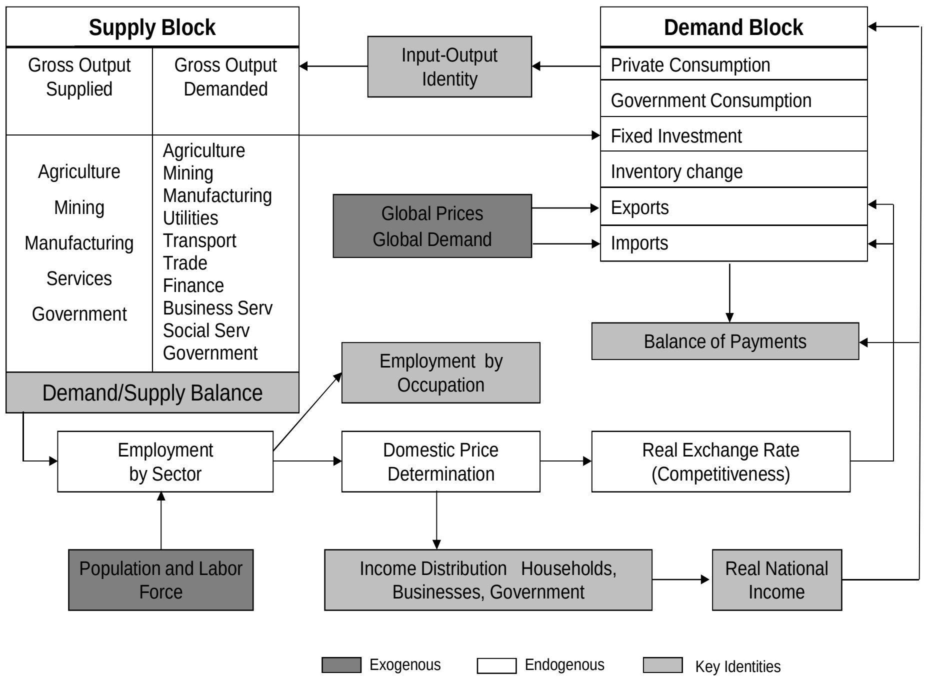


Figure 2: Model Flow Diagram for Intermediate Data Model

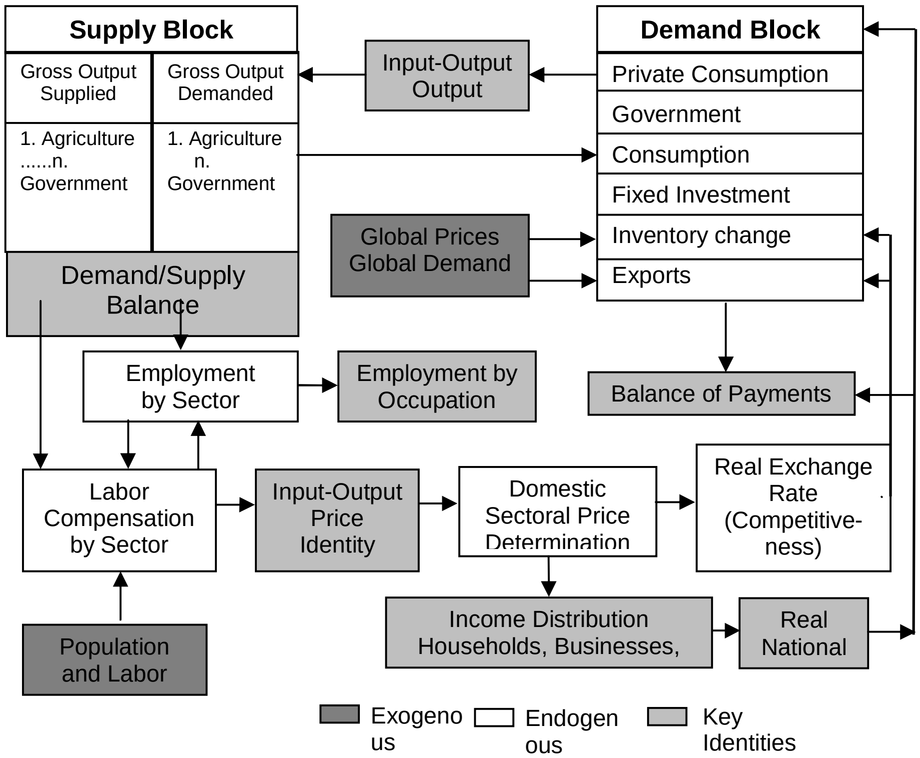


Figure 3: Model Flow Diagram for Extensive Data Model

Table 1: Typical Presentation of GDP by Sector -- Basic Model

Real GDP by Economic Activity
(Current Prices, Constant Prices and Implied
GDP at Market Prices

1. Agriculture and Fishing
2. Mining and Quarrying
3. Manufacturing
4. Electricity, Gas and Water Supplies
5. Construction
6. Trade, Restaurants, and Hotels
7. Transportation and Communication
8. Financial Intermediation and Insurance
9. Real Estate and Business Services
10. Social Services
11. Government
12. Households Services

Less: Imputed Bank Service Charges
Plus: Import Duties

Table 2: Typical Presentation of GDP by Expenditure Category -- Basic Model

	gdpR	Gross domestic Product (real)
=	pceR	Final consumption of households
+	gceR	Final consumption of government
+	invR	Gross fixed capital formation
+	venR	Change in inventories
+	expR	Exports
-	impR	Imports

Table 3: Typical Presentation of GDP by Sector -- Intermediate Model

Real GDP by Economic Activity
(Current Prices, Constant Prices and Implied Deflator)
GDP at Market Prices
Economic Activity

1. Agriculture, Hunting and Forestry
2. Fishing
3. Mining and Quarrying
   Petroleum and Natural Gas
   Other Mining
4. Manufacturing
   Nondurables
   Materials and Metal Products
   Equipment
5. Electricity, Gas and Water Supply
6. Construction
7. Hsehold Goods
8. Hotels and Restaurants
9. Transport, Storage and Communications
   Transport
   Communications
10. Financial Intermediation
11. Real Estate, Renting and Business Activities
12. Public Administration and Defense
13. Education
14. Health and Social Work
15. Other Community,Social and Personal Service Activities
16. Private Households with Employed Persons
17. Extra-Territorial Organizations and Bodies
   Less: Imputed Bank Service Charges
   Plus: Import Duties

Table 4: Typical Presentation of GDP by Expenditure Category – Intermediate Model

	gdpR	Gross domestic Product (real)
=	pceR	Final consumption of households
		Nondurables
		Durables
		Services
+	gceR	Final consumption of government
		Salaries
		Goods
		Services
+	invR	Gross fixed capital formation
		Equipment
		Structures
+	venR	Change in inventories
+	expR	Exports
		Raw materials
		Manufactures
		Services
-	impR	Imports
		Raw materials
		Manufactures
		Services

Table 5: Typical Presentation of GDP by Sector – Extensive Model

01. Agriculture, Hunting and related service activities
02. Forestry, Logging and related service activities
05. Fishing, Operation of Fish Hatcheries and Fish Farms; Service activities incidental to Fishing
10. Mining of Coal and Lignite; Extraction of Peat
11. Extraction of Crude Petroleum and Natural Gas; Service activities incidental to Oil and Gas extraction, excluc
12. Mining of Uranium and Thorium Ores
13. Mining of Metal Ores
14. Other Mining and Quarrying
15. Manufacture of Food Products and Beverages
16. Manufacture of Tobacco Products
17. Manufacture of Textiles
18. Manufacture of Wearing Apparel; Dressing and Dyeing of Fur
19. Tanning and Dressing of Leather; Manufacture of Luggage, Handbags, Saddlery, Harness and Footwear
20. Manufacture of Wood and of Products of Wood and Cork, except Furniture; Manufacture of articles of Straw
21. Manufacture of Paper and Paper Products
22. Publishing, Printing and Reproduction of Recorded Media
23. Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel
24. Manufacture of Chemicals and Chemical Products
25. Manufacture of Rubber and Plastics Products
26. Manufacture of Other Non-Metallic Mineral Products
27. Manufacture of Basic Metals
28. Manufacture of Fabricated Metal Products, except Machinery and Equipment
29. Manufacture of Machinery and Equipment NEC **
30. Manufacture of Office, Accounting and Computing Machinery
31. Manufacture of Electrical Machinery and Apparatus NEC **
32. Manufacture of Radio, Television and Communication Equipment and Apparatus
33. Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks
34. Manufacture of Motor Vehicles, Trailers and Semi-Trailers
35. Manufacture of other Transport Equipment
36. Manufacture of Furniture; Manufacturing NEC **
37. Recycling
40. Electricity, Gas, Steam and Hot Water Supply
41. Collection. Purification and Distribution of Water
45. Construction
50. Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Automotive Fuel
51. Wholesale Trade and Commission Trade, except of Motor Vehicles and Motorcycles
52. Retail Trade, except of Motor Vehicles and Motorcycles; Repair of Personal and Household Goods
55. Hotels and Restaurants
60. Land Transport; Transport via Pipelines
61. Water Transport
62. Air Transport
63. Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
64. Post and Telecommunications
65. Financial Intermediation, except Insurance and Pension Funding
66. Insurance and Pension Funding, except Compulsory Social Security
67. Activities auxiliary to Financial Intermediation
70. Real Estate activities
71. Renting of Machinery and Equipment without Operator and of Personal and Household Goods
72. Computer and related activities
73. Research and Development
74. Other Business activities
75. Public Administration and Defence; Compulsory Social Security
80. Education
85. Health and Social Work
90. Sewage and Refuse Disposal, Sanitation and similar activities
91. Activities of Membership Organizations NEC
92. Recreational, Cultural and Sporting activities
93. Other Service activities
95. Private Households with Employed Persons
99. Extra-Territorial Organizations and Bodies

Additional category X: Not classifiable by economic activity

Notes

* For full details see United Nations: *Statistical Papers*, Series M, No. 4/ Rev. 3 (New York, 1990).

** Not elsewhere classified.

Table 6: Typical Presentation of GDP by Expenditure Category – Extensive Model

	gdpR	Gross domestic Product (real)				
=	pceR	Final consumption of households				
			Nondurables			
				By good: food, clothing, etc.		
			Durables			
				By good: Motor vehicles, Furniture, appliances, etc.		
			Services			
				By service: Repairs, Health, Education, etc.		
+	gceR	Final consumption of government				
			Salaries			
			Goods			
			Services			
+	invR	Gross fixed capital formation				
			Residential (housing, etc.)			
			Nonresidential			
				Equipment		
					By purchasing sector	
				Structures		
					By purchasing sector	
				Government		
					Equipment	
					Structures	
+	venR	Change in inventories				
+	expR	Exports				
			Raw materials			
				Oil and gas		
				Other		

Manufactures
By good
Services
By service
- impR Imports
Raw materials
Oil and gas
Other
Manufactures
By good
Services
By service

8. APPENDIX A

Labour Market Model Economic Data Inventory
(With some specific comments concerning Bosnia-Herzegovina)

This report provides a "check-list" summary of the information concerning the data that is used to construct interindustry macroeconomic models. Data availability will have a large role to play in determining the ultimate structure and dynamic properties of any model. Therefore, an ongoing data inventory procedure is essential for planning the specification and construction of the model.

Specific comments concerning Bosnia-Herzegovina are largely drawn from examination or the Statistical Yearbook and other publications available on the Internet.

National Accounts

1. Production Approach: Sectoral GDP or value added (Agriculture, Mining, Manufacture, etc.) Current prices, constant prices and implicit deflators

2. Expenditure Approach: (C+I+G+X-M)
Current prices, constant prices and implicit deflators

3. Income approach by factor (labour, capital, net indirect taxes), nominal values only

4. Income approach by "institutions" (household, government, corporate), nominal values only

- The United Nations National Accounts has the value added and expenditure accounts, but the on-line statistical abstracts have only the production method. The expenditure side does not appear to be readily available from B&H sources on the Internet. Determining the status of this data should be a top priority.

Foreign Trade

1. Merchandise exports – usually available by product (HS classification), fob in current prices

2. Merchandise imports – usually available by product (HS classification) cif in current prices

- B&H data here appears to be extensive. At the aggregate levels, they even have prices.

Input/Output (IO) Table

- It is known that a formal I-O table for Bosnia does not exist. However, there is some information from 2007 for gross output, intermediate consumption and value added. This would be a starting point for compiling a table, though this is a very involved undertaking. Final demand by industry is more problematic, but household expenditure surveys are available, which help with personal consumption expenditures.

Time series for Gross Output in nominal and real terms, implied output deflators

- According to data on the construction of the national accounts, constant price value added is determined with the single deflation method using either an output price index or a volume indicator extrapolation[22]. This technique assumes that the value added to gross output ratio (which is known from 2007) is constant through time in both real and nominal terms. While these are not particularly good assumptions, time series could be formed for gross outputs under these assumptions.

---

22 ICON-INSTITUT Public Sector GmbH, Description *of Sources and methods, Bosnia and Herzegovina,* The European Union's IPA 2007 programme.

- There may be some other data, notably industrial production indices and some physical production data that might help with validating real quantities and therefore, by implications, goods prices. On the service side, the options are limited. However, it may be possible to do something with the wage and employment data derived from the industry survey data.

Capital expenditures by industry

- There is extensive data on capital expenditures by buyer 2009 Statistical Abstract. These data can be leveraged in a variety of ways.

Population and aggregate labour force and employment

- Population census and inter-annual updates exist. Aggregate labour force and employment exist for last several years.

Total employment, employment by sector

- The sectoral employment data across several years is available.

Skill-level and education breakdown by sector

- This data is drawn from a 2008 labour force survey, which can be used to compile occupational matrices.

Consumer and Production Price Indices

- CPIs are available, did not see PPIs

Monthly average net wages per person by activities

- Available in statistical yearbook.

Balance of Payment, Money, and Credit

- Central Bank has standard data.

Government revenue by source and expenditure by type

- Central Bank has some data.

Sectoral Data: Economic Surveys and other Statistics

- The Statistical Yearbook indicates collections of industry-level data. It would be useful to obtain an inventory of publications available for this data.

9. APPENDIX B: SAMPLE SPECIFICATION FOR ADVANCED INTERINDUSTRY MACROECONOMIC MODEL

Table B1.1: Real GDP by Final Expenditure, Millions of 2001 $x

Variable	**Type**	**Mnemonic**	**Specification**
GDP at Market Prices	ID	gdpR	gdpR = tddR + nexR
Consumption	ID	tceR	tceR = pceR + gceR
Private	ST	pceR	log(pceR/pop) = f(log((pdi-opsnog)/pceD/pop), log(opsnong/pceD/pop))
Government	ST	gceR	gceR = f((.25*trg+.50*trg[1]+.25*trg[2])/gceD)
Fixed Investment	ID	invR	invR = invmaqR + invgosR + invnogR
Changes in Stocks	ST	venR	venR = f(dif(gdpR[1]), gdpR[1])
Total Domestic Demand	ID	tddR	tddR = tceR + invR + venR
Net Exports	ID	nexR	nexR = expR - impR
Exports of goods and services	ID	expR	expR = sum (expvR, 1-13)
Imports of goods and services	ST	impR	log(impR) = f(log(tddR), log(impD/psds))

Table B1.2: Nominal GDP by Final Expenditure, Millions of $x

Variable	Type	Mnemonic	Specification
GDP at Market Prices	ID	gdpN	gdpN = tddN + nexN
Consumption	ID	tceN	tceN = pceN + gceN
Private	ID	pceN	pceN = pceR * pceD
Public	ID	gceN	gecN = gceR * gceD
Fixed Investment	ID	invN	invN = invmaqN + invgosN + invnogN
Changes in Stocks	ID	venN	venN = venR * venD
Total Domestic Demand	ID	tddN	tddN = tceN + invN + venN
Net Exports	ID	nexN	nexN = expN - impN
Exports of goods and services	ID	expN	expN = sum (expvN, 1-13)
Imports of goods and services	ID	impN	impN = sum(impvN, 1-13) - imdN

Table B1.3: GDP Deflator by Final Expenditure, 2001=100

Variable	Type	Mnemonic	Specification
GDP at Market Prices	ID	gdpD	gdpD = gdpN / gdpR
Consumption	ID	tceD	tceD = tceN / tceR
Private	ST	pceD	log(pceD) = f(log(psds), log(impD))
Public	ST	gceD	log(gceD) = f(log (gdpD12))
Fixed Investment	ST	invD	log(invD) = f(log(gdpD4), log(gdpD7), log(impD))
Changes in Stocks	ID	venD	venD = tddD
Total Domestic Demand	ID	tddD	tddD = tddN / tddR
Exports of goods and services	ID	expD	expD = expN / expR
Imports of goods and services	ID	impD	impD = impDW * rexind

Table B2.1: Real GDP by Economic Activity, Millions of 2001 $x

Variable	Type	Mnemonic	Specification
GDP at Market Prices	ID	gdpR	gdpR = tddR + nexR = gdpteaR - ibsR + imdR
Total Economic Activities	ID	gdpteaR	gdpteaR = gdpmaqR + gdpgosR + gdpnogR
Mining and Quarrying	ID	gdpmaqR	gdpmaqR = sum(gdpR, 2-4)
Non-oil and Non-government	ID	gdpnogR	gdpnogR = sum(gdpR,1,5-11,13)
Government	ID	gdpgosR	gdpgosR = gdpR12
Less: Imputed Bank Service Charges	ST	ibsR	log(ibsR) = f(log(gdpR - imdR))
Plus: Import Duties	ST	imdR	imdR = f(impR)
Industry Detail			
1. Agriculture and Fishing	ID	gdpR1	gdpR1 = gvavR1 = outR1 / gvac1
2. Oil and NG extraction	ID	gdpR2	gdpR2 = gvavN2 / gdpD2
3. Other mining and quarrying	ID	gdpR3	gdpR3 = gvavR3 = outR3 / gvac3
4. Mining Services	ID	gdpR4	gdpR4 = gvavR4 = outR4 / gvac4
5. Manufacturing	ID	gdpR5	gdpR5 = gvavR5 = outR5 / gvac5
6. Electricity and Water	ID	gdpR6	gdpR6 = gvavR6 = outR6 / gvac6
7. Building and construction	ID	gdpR7	gdpR7 = gvavR7 = outR7 / gvac7
8. Trade, Restaurants, and Hotels	ID	gdpR8	gdpR8 = gvavR8 = outR8 / gvac8
9. Transportation and Communication	ID	gdpR9	gdpR9 = gvavR9 = outR9 / gvac9
10. Finance, Insurance, Real Estate	ID	gdpR10	gdpR10 = gvavR10 = outR10 / gvac10 + ibsR
11. Social Services	ID	gdpR11	gdpR11 = gvavR11 = outR11 / gvac11
12. Government	ID	gdpR12	gdpR12 = gvavR12 = outR12 / gvac12
13. Households Services	ID	gdpR13	gdpR13 = gvavR13 = outR13 / gvac13

Table B2.2: Nominal GDP by Economic Activity, Millions of $x

Variable	Type	Mnemonic	Specification
GDP at Market Prices	ID	gdpN	gdpN = tddN + nexN
Total Economic Activities	ID	gdpteaN	gdpteaN = gdpmaqN + gdpgosN + gdpnogN
Mining and Quarrying	ID	gdpmaqN	gdpmaqN = sum(gdpN, 2-4)
Non-oil and Non-government	ID	gdpnogN	gdpnogN = sum(gdpN,1,5-12,13)
Government	ID	gdpgosN	gdpgosN = gdpN12
Less: Imputed Bank Service Charges	ID	ibsN	ibsN = ibsR * ibsD
Plus: Import Duties	ID	imdN	imdN = impR * imdD
Industry Detail			
1. Agriculture and Fishing	ID	gdpN1	gdpN1 = gdpR1 * gdpD1
2. Oil and NG extraction	ID	gdpN2	gdpN2= gdpR2 * gdpD2
3. Other mining and quarrying	ID	gdpN3	gdpN3 = gdpR3 * gdpD3
4. Mining Services	ID	gdpN4	gdpN4 = gdpR4 * gdpD4
5. Manufacturing	ID	gdpN5	gdpN5 = gdpR5 * gdpD5
6. Electricity and Water	ID	gdpN6	gdpN6 = gdpR6 * gdpD6
7. Building and construction	ID	gdpN7	gdpN7 = gdpR7 * gdpD7
8. Trade, Restaurants, and Hotels	ID	gdpN8	gdpN8 = gdpR8 * gdpD8
9. Transportation and Communication	ID	gdpN9	gdpN9 = gdpR9 * gdpD9
10. Finance, Insurance, Real Estate	ID	gdpN10	gdpN10 = gdpR10 * gdpD10
11. Social Services	ID	gdpN11	gdpN11 = gdpR11 * gdpD11
12. Government	ID	gdpN12	gdpN12 = gdpR12 * gdpD12
13. Households Services	ID	gdpN13	gdpN13 = gdpR13 * gdpD13

Table B2.3: GDP Deflators by Economic Activity, 2002=200

Variable	Type	Mnemonic	Specification
Non-oil domestic supply price 1/	ST	psds	log(psds) = log(psds[1]), gdpnogGP, log((m2+m2[1]+m2[2])/3)
GDP at Market Prices	ID	gdpD	gdpD = gdpN /gdpR
Total Economic Activities			
Mining and Quarrying	ID	gdpmaqD	gdpmaqD = gdpmaqN/gdpmaqR
Non-oil and Non-government	ID	gdpnogD	gdpnogD = gdpnogN / gdnogR
Government	ID	gdpgdpD	gdpgosD = gdpgosN / gdpgdpR
Less: Imputed Bank Service Charges	ST	ibsD	ibsD = f(gdpD10)
Plus: Import Duties	ID	imdD	imdD = impD
Industry Detail			
1. Agriculture and Fishing	ST	gdpD1	log(gdpD1) = f(log(psds))
2. Oil and NG extraction	ST	gdpD2	gdpD2 = f(outNgas+outNoil)/(outRgas+outRoil)
3. Other mining and quarrying	ST	gdpD3	log(gdpD3) = f(log(psds))
4. Mining Services	ST	gdpD4	log(gdpD4) = f(log(psds))
5. Manufacturing	ST	gdpD5	log(gdpD5) = f(log(psds), log(gdpD2))
6. Electricity and Water	ST	gdpD6	log(gdpD6) = f(log(psds), log(gdpD2))
7. Building and construction	ST	gdpD7	log(gdpD7) = f(log(psds))
8. Trade, Restaurants, and Hotels	ST	gdpD8	log(gdpD8) = f(log(psds))
9. Transportation and Communication	ST	gdpD9	log(gdpD9) = f(log(psds))
10. Finance, Insurance, Real Estate	ST	gdpD10	log(gdpD10) = f(log(psds))
11. Social Services	ST	gdpD11	log(gdpD11) = f(log(psds))
12. Government	ST	gdpD12	log(gdpD12) = f(log(psds))
13. Households Services	ST	gdpD13	log(gdpD13) = f(log(psds))

Table B3.1: Real Gross Investment by Major Production Sector, Millions of 2001 $x

Variable	Type	Mnemonic	Specification
Total Investment	ID	invR	invR = invmaqR + invgosR + invnogR
Mining and Quarrying	ST	invmaqR	invmaqR = replmaq, gdpN[1]/invD[1], gdpN2[2]/invD[2]
Government	ST	invgosR	invnogR = f(replgos, (rcf[1]+rcf[2]+rcf[3])/3, invD/gdpD12)
Non-oil and Non-government	ST	invnogR	invnogR = f(replnog, (rcf[1]+rcf[2]+rcf[3])/3, invD/gdpnogD)

Table B3.2: Nominal Gross Investment by Major Production Sector, Millions of $x

Variable	Type	Mnemonic	Specification
Total Investment	ID	invN	invN = invmaqN + invgosN + invnogN
Mining and Quarrying	ID	invmaqN	invmaqN = invmaqR * invD
Government	ID	invgosN	invgosN = invgosR * invD
Non-oil and Non-government	ID	invnogN	invnogN = invnogR * invD
Addenda:			
Investment Deflator, 2001=100	ST	invD	log(invD) = f(log(gdpD4), log(gdpD7), log(impD))

Table B3.3: Replacement Investment by Major Production Sector, Millions of 2001 $x

Variable	Type	Mnemonic	Specification
Mining and Quarrying	ST	replmaq	replmaq = drmaq * ksmaq[1]
Government	ST	replgos	replgos = drgos * ksgos[1]
Non-oil and Non-government	ST	replnog	replnog = drnog * ksnog[1]

Table B3.4: Capital Stock, Depreciation Rate and Capital-Output Ratio

Mining and Quarrying	Type	Mnemonic	Specification
Real Adjusted Capital Stock, Mill. of 2001 $x	ID	ksmaq	ksmaq = (uksmaq/cafmaq)/drmaq
Real Unadjusted Capital Stock, Mill. of 2001 $x	ID	uksmaq	uksmaq = invmaqR + uksmaq[1] * (1 - drmaq)
Depreciation Rate, %	EX	drmaq	drmaq = 0.05
Capital Stock Adjustment Factor	ID	cafmaq	cafmaq = cafmaq[1] * (1-drmaq) + 1
Trend Capital Output Ratio, Oil	EX	koroilb	historical trend
Trend Capital Output Ratio, Gas	EX	korgasb	historical trend
Non-oil and Non-government			
Real Adjusted Capital Stock, Mill. of 2001 $x	ID	ksnog	ksnog = (uksnog/cafnog)/drnog
Real Unadjusted Capital Stock, Mill. of 2001 $x	ID	uksnog	uksnog = invnogR + uksnog[1] * (1 - drnog)
Depreciation Rate, %	EX	drnog	drnog = 0.05
Capital Stock Adjustment Factor	ID	cafnog	cafnog = cafnog[1] * (1-drnog) + 1
Trend Capital Output Ratio, nog	EX	kornog	historical trend
Government Services			
Real Adjusted Capital Stock, Mill. of 2001 $x	ID	ksgos	ksgos = (uksgos/cafgos)/drgos
Real Unadjusted Capital Stock, Mill. of 2001 $x	ID	uksgos	uksgos = invgosR + uksgos[1] * (1 - drgos)
Depreciation Rate, %	EX	drgos	drgod = 0.05
Capital Stock Adjustment Factor	ID	cafgos	cafgos = cafgos[1] * (1-drgos) + 1

Table B3.5: Potential Non-Oil GDP and Excess Demand

Variable	Type	Mnemonic	Specification
Non-oil and Non-government			
Potential GDP, Mill. of 2001 $x	ID	gdpnogS	gdpnogS = ksnog[1] / kornog
Excess Demand (GDP Gap) , %	ID	gdpnogGP	gdpnogGP = (gdpnogR - gdpnogS) / gdpnogS * 100

Table B4.1: Real Foreign Trade by Sector, Millions of 2001 $x

Variable	Type	Mnemonic	Specification
Real net exports	ID	nexR	nexR = expR - impR
Real Exports of goods and services	ID	expR	expR = sum (expvR, 1-5,7-11)
PNG Exports	ID	expvR2	expvR2 = expRoil + expRgas
Crude oil exports	ID	expRoil	expRoil = expNoil / expDoil
Natural gas exports	ID	expRgas	expRgas = expNgas / expDgas
Other Merchandise	ST	expmernogR	expmernogR = f(ksnog[1], expmernogD/impD)
1. Agriculture and Fishing	ID	expvR1	expvR1 = expc1 * expmernogR
3. Other mining and quarrying	ID	expvR3	expvR3 = expc3 * expmernogR
4. Mining services	ID	expvR4	expvR4 = expc4 * expmernogR
5. Manufacturing	ID	expvR5	expvR5 = expmernogR - expvR1 - expvR3 - expvR4
Services	ST	expsernogR	expmernogR = f(ksnog[1], expsernogD/impD)
8. Trade, Restaurants, and Hotels	ID	expvR8	expvR8 = expc8 * expmernogR
9. Transport, Communic	ID	expvR9	expvR9 = expc9 * expmernogR
10. Finance	ID	expvR10	expvR10 = expc10 * expmernogR
11. Social Services	ID	expvR11	expvR11 = expsernogR - expvR8 - expvR9 - expvR10
Real Imports of goods and services	ST	impR	log(impR) = f(log(tddR), log(impD/psds))
Other Merchandise	ST	impmerRtt	log(impmerRtt) = f(log(impR1), log(impD/psds))
1. Agriculture and Fishing	ID	impvR1	impvR1 = impmerRtt - impvR3 - impvR4 - impvR5
3. Other mining and quarrying	ID	impvR3	impvR3 = impc3 * impmerRtt
4. Mining services	ID	impvR4	impvR4 = impc4 * impmerRtt
5. Manufacturing	ID	impvR5	impvR5 = impc5 * impmerRtt
Services	ID	impserRtt	impserRtt = impR + imdR - impmerRtt

8. Trade, Restaurants, and Hotels	ID	impvR8	impvR8 = impc8 * impserRtt
9. Transport, Communic	ID	impvR9	impvR9 = impc9 * impserRtt
10. Finance	ID	impvR10	impvR10 = impc10 * impserRtt
11. Social Services	ID	impvR11	impvR11 = impserRtt - impvR8 - impvR9 - impvR10

Table B4.2: Nominal Foreign Trade by Sector, Millions of $x

Nominal net exports	ID	nexN	nexN = expN - impN
Nominal Exports of goods and serv	ID	expN	expN = sum (expvN, 1-5,7-11)
PNG Exports	ID	expvN2	expvN2 = expNoil + expNgas
Crude oil exports	ID	expNoil	expNoil = f(expoilqr)
Natural gas exports	ID	expNgas	expNgas = f(expgasqr)
Other Merchandise	ST	expmernogN	expmernogN = sum(expvN, 1,3-5)
1. Agriculture and Fishing	ID	expvN1	expvN1 = expR1 * expD1 ; expD1 = gdpD1
3. Other mining and quarrying	ID	expvN3	expvN3 = expR3 * expD3 ; expD3 = gdpD3
4. Mining services	ID	expvN4	expvN4 = expR4 * expD4 ; expD4 = gdpD4
5. Manufacturing	ID	expvN5	expvN5 = expR5 * expD5; expD5 = gdpD5
Services	ST	expsernogN	expsernogN = sum(expvN, 8-11)
8. Trade, Restaurants, and Hotels	ID	expvN8	expvN8 = expR8 * expD8 ; expD8 = gdpD8
9. Transport, Communic	ID	expvN9	expvN9 = expR9 * expD9 ; expD9 = gdpD9
10. Finance	ID	expvN10	expvN10 = expR10 * expD10 ; expD10 = gdpD10
11. Social Services	ID	expvN11	expvN11 = expR11 * expD11 ; expD11 = gdpD11
Nominal Imports of goods and serv	ST	impN	impN = sum(impvN, 1-11) - imdN
Other Merchandise	ST	Impmer	impmer = sum(impvN, 1,3-5)
1. Agriculture and Fishing	ID	impvN1	impvN1 = impvR1 * impD
3. Other mining and quarrying	ID	impvN3	impvN3 = impvR3 * impD
4. Mining services	ID	impvN4	impvN4 = impvR4 * impD
5. Manufacturing	ID	impvN5	impvN5 = impvR5 * impD
Services	ID	Impser	imser = sum(impvN, 8-11)
8. Trade, Restaurants, and Hotels	ID	impvN8	impvN8 = impvR8 * impD
9. Transport, Communic	ID	impvN9	impvN9 = impvR9 * impD

10. Finance	ID	impvN10	impvN10 = impvR10 * impD
11. Social Services	ID	impvN11	impvN11 = impvR11 * impD
Addenda:			
World Prices in $ Terms, 2001=100	EX	impDW	

Table B5.1: Balance of Payments, Millions of $x

Variable	Type	Mnemonic	Specification
Current Account Balance	ID	Cab	cab = nexmer + nexser + nexinc + ntr
As a % of GDP	ID	cab%gdp	cab%gdp = cab / gdpN * 100
Trade Balance	ID	Nexmer	nexmer = expmer - impmer
Exports (F.O.B)	ID	Expmer	expmer = sum(expvN,1-5)
Crude Oil and Natural Gas	ID	expNoil	expv2N = expNoil + expNgas
Other Merchandise	ID	expmernogN	expmernogN = sum(expvN,1,3,4,5)
Imports (F.O.B)	ID	Impmer	impmer = sum(expvN,1-5)
Services Balance	ID	Nexser	nexser = expser - impser
Services (Credit)	ID	Expser	expser = exptrv + exptrn + expsot
Travel	ID	Exptrv	exptrv = expvN8
Transportation	ID	Exptrn	exptrn = expvN9
Others	ID	Expsot	expsot = expvN10 + expvN11
Services (Debit)	ID	Impser	impser = imptrv + imptrn + impsot
Travel	ID	Imptra	imptrv = impvN8
Transportation	ID	Imptrn	imptrn = impvN9
Others	ID	Impost	impsot = impvN10 + impvN11
Income Balance	ID	Nfi	nexinc = expinc - impinc
Income Received (credit)	ST	Expinc	expinc = f(daf$*(usrff/100)*rex)
Income Paid (debit)	ST	Impinc	log(impinc) = f (log(opstt))
Net Transfers Received	ID	Ntr	ntr = ntrwor + ntroth

Workers Remittances	ST	Ntrwor	log(-ntrwor) = log(nemtt)
Others (Net)	EX	Ntroth	after 2007 = 0.0
Capital & Financial Account			
Capital Account	EX/ST	Cap	log(cap*(-1)) = f(log(ntrwor*(-1)))
Financial Account (Net)	EX	Fin	fin = f(-1*cab)
Net Errors & Omissions	EX	Neo	after 2007 = 0.0
Overall Balance	ID	Ovb	ovb = cab + cap + fin + neo
Overall Balance, Mill. $	ID	ovb$	ovb$ = ovb / rex
Stock Variables			
Stock of Domestic Assets Abroad	ID	daf$	daf$ = ovb$ + daf$[1] * .9
Total Reserves Minus Gold	ID	rmg$	rmg$ = rmg$[1] + ovb$ + vaa$
Valuation adjustment	EX	vaa$	
Total Reserves Minus Gold	ID	Rmg	rmg = rmg$/rex
Addenda:			
Exchange Rate, Riyals/$	EX	Rex	
Exchange Rate Index	ID	Rexind	rexind = rex/3.64
Current Account Balance, Mill. US$	ID	cab$	cab$ = cab / rex
World Prices in $ Terms, 2001=100	EX	impDW	

Table B6.1: Real Output by Economic Activity, Millions of 2001 $x

Variable	Type	Mnemonic	Specification
1. Agriculture and Fishing	EX	outvR1	outvR1 = f(timet)
2. Mining and Quarrying	ID	outvR2	outvR2 = outRoil + outRgas
Crude Oil	ID	outRoil	outRoil = outNoil / outDoil
Natural Gas	ID	outRgas	outRgas = outNgas / outDgas
3. Other Mining	ST	outvR3	outvR3 = f($\Sigma a_{3j}q_j + fd_3$) -- io computation
4. Mining Services	ST	outvR4	outvR4 = f($\Sigma a_{4j}q_j + fd_4$)
5. Manufacturing	ST	outvR5	outvR5 = f($\Sigma a_{5j}q_j + fd_5$)
6. Electricity and Water Utilities	ST	outvR6	outvR6 = f($\Sigma a_{6j}q_j + fd_6$)
7. Building and Construction	ST	outvR7	outvR7 = f($\Sigma a_{7j}q_j + fd_7$)
8. Trade, Restaurants & Hotels	ST	outvR8	outvR8 = f($\Sigma a_{8j}q_j + fd_8$)
9. Transport and Communic	ST	outvR9	outvR9 = f($\Sigma a_{9j}q_j + fd_9$)
10. Finance, Insu. , RE, & Busi. Services	ST	outvR10	outvR10 = f($\Sigma a_{10j}q_j + fd_{10}$)
11. Social Services	ST	outvR11	outvR11 = f($\Sigma a_{11j}q_j + fd_{11}$)
12. Government Services	ST	outvR12	outvR12 = f(gceR)
13. Household Services	ST	outvR13	outvR13 = f($\Sigma a_{13j}q_j + fd_{13}$)

Table B6.2: Nominal Output by Economic Activity, Millions of $x

Variable	Type	Mnemonic	Specification
1. Agriculture and Fishing	ID	outvN1	outvN1 = outvR1 * outvD1
2. Mining and Quarrying	ID	outvN2	outvN2 = outNoil + outNgas
Crude Oil	ST	outNoil	outNoil = f(prooilqr)
Natural Gas	ST	outNgas	outNgas = f(progasqr)
3. Other Mining	ID	outvN3	outvN3 = outvR3 * outvD3
4. Mining Services	ID	outvN4	outvN4 = outvR4 * outvD4
5. Manufacturing	ID	outvN5	outvN5 = outvR5 * outvD5
6. Electricity and Water Utilities	ID	outvN6	outvN6 = outvR6 * outvD6
7. Building and Construction	ID	outvN7	outvN7 = outvR7 * outvD7
8. Trade, Restaurants & Hotels	ID	outvN8	outvN8 = outvR8 * outvD8
9. Transport and Communic	ID	outvN9	outvN9 = outvR9 * outvD9
10. Finance, Insu. , RE, & Busi. Services	ID	outvN10	outvN10 = outvR10 * outvD10
11. Social Services	ID	outvN11	outvN11 = outvR11 * outvD11
12. Government Services	ID	outvN12	outvN12 = outvR12 * outvD12
13. Household Services	ID	outvN13	outvN13 = outvR13 * outvD13

Table B6.3: Output Price Deflator by Economic Activity, 2001 = 1.0

Variable	**Type**	**Mnemonic**	**Specification**
1. Agriculture and Fishing	ID	outvD1	outvD1 = gdpD1
2. Mining and Quarrying	ID	outvD2	outvD2 = gdpD2
3. Other Mining	ID	outvD3	outvD3 = gdpD3
4. Mining Services	ID	outvD4	outvD4 = gdpD4
5. Manufacturing	ID	outvD5	outvD5 = gdpD5
6. Electricity and Water Utilities	ID	outvD6	outvD6 = gdpD6
7. Building and Construction	ID	outvD7	outvD7 = gdpD7
8. Trade, Restaurants & Hotels	ID	outvD8	outvD8 = gdpD8
9. Transport and Communic	ID	outvD9	outvD9 = gdpD9
10. Finance, Insu. , RE, & Busi. Services	ID	outvD10	outvD10 = gdpD10
11. Social Services	ID	outvD11	outvD11 = gdpD11
12. Government Services	ID	outvD12	outvD12 = gdpD12
13. Household Services	ID	outvD13	outvD13 = gdpD13

Table B7.1: Population and Employment

Variable	Type	Mnemonic	Specification
Population, Mid-year	ID	pop	pop = qpop + npop
National population	EX	qpop	qpop
Non-national population	ID	npop	npop = ndr * nemtt
Non-national dependency ratio	EX	ndr	Non-National population / Non-National employment
Employment	ID	emptt	emptt = empmaq + empnog + empgos
Mining and Quarrying	ID	empmaqR	empmaqR = sum(emp, 2-4)
Government	ID	empgosR	empgosR = emp12
Non-oil and Non-government	ID	empnogR	empnogR = sum(emp,1,5-12,13)
National employment	EX	qemtt	
Non-National employment	ID	nemtt	nemtt = sum(nem, 1-13)
Industry Detail - Total Employment			
1. Agriculture and Fishing	ID	emp1	emp1 = outvR1 / prdc1
2. Mining and Quarrying	ID	emp2	emp2 = outvR2 /prdc2
3. Other mining and quarrying	ID	emp3	emp3 = outvR3 /prdc3
4. Mining Services	ID	emp4	emp4 = outvR4 /prdc4
5. Manufacturing	ID	emp5	emp5 = outvR5 /prdc5
6. Electricity and Water	ID	emp6	emp6 = outvR6 /prdc6
7. Building and construction	ID	emp7	emp7 = outvR7 /prdc7
8. Trade, Restaurants, and Hotels	ID	emp8	emp8 = outvR8 /prdc8
9. Transportation and Communication	ID	emp9	emp9 = outvR9 /prdc9
10. Finance, Insurance, Real Estate	ID	emp10	emp10 = outvR10 /prdc10
11. Social Services	ID	emp11	emp11 = outvR11 /prdc11
12. Government	ID	emp12	emp12 = outvR12 /prdc12
13. Households Services	ID	emp13	emp13 = outvR13 /prdc13

Table B7.2: National/Non-National Employment

National employment	**EX**	**qemtt**	
Industry Detail - National Employment scaled to equal exogenous total			
1. Agriculture and Fishing	ID	qem1	qem1 = qemc1 * emp1
2. Mining and Quarrying	ID	qem2	qem2 = qemc2 * emp2
3. Other mining and quarrying	ID	qem3	qem3 = qemc3 * emp3
4. Mining Services	ID	qem4	qem4 = qemc4 * emp4
5. Manufacturing	ID	qem5	qem5 = qemc5 * emp5
6. Electricity and Water	ID	qem6	qem6 = qemc6 * emp6
7. Building and construction	ID	qem7	qem7 = qemc7 * emp7
8. Trade, Restaurants, and Hotels	ID	qem8	qem8 = qemc8 * emp8
9. Transportation and Communication	ID	qem9	qem9 = qemc9 * emp9
10. Finance, Insurance, Real Estate	ID	qem10	qem10 = qemc10 * emp10
11. Social Services	ID	qem11	qem11 = qemc11 * emp11
12. Government	ID	qem12	qem12 = qemc12 * emp12
13. Households Services	ID	qem13	qem13 = qemc13 * emp13
Non-National employment	**ID**	**nemtt**	**nemtt = sum(nen, 1-13)**
Industry Detail - Non-National Employment			
1. Agriculture and Fishing	ID	nem1	nem1 = emp1 - qem1
2. Mining and Quarrying	ID	nem2	nem2 = emp2 - qem2
3. Other mining and quarrying	ID	nem3	nem3 = emp3 - qem3
4. Mining Services	ID	nem4	nem4 = emp4 - qem4
5. Manufacturing	ID	nem5	nem5 = emp5 - qem5
6. Electricity and Water	ID	nem6	nem6 = emp6 - qem6
7. Building and construction	ID	nem7	nem7 = emp7 - qem7
8. Trade, Restaurants, and Hotels	ID	nem8	nem8 = emp8 - qem8
9. Transportation and Communication	ID	nem9	nem9 = emp9 - qem9

10. Finance, Insurance, Real Estate	ID	nem10	nem10 = emp10 - qem10
11. Social Services	ID	nem11	nem11 = emp11 - qem11
12. Government	ID	nem12	nem12 = emp12 - qem12
13. Households Services	ID	nem13	nem13 = emp13 - qem13

Table B8.1: Real Value Added by Economic Activity, Millions of 1001 $x

Variable	**Type**	**Mnemonic**	**Specification**
1. Agriculture and Fishing	ID	gvavR1	gvavR1 = outvR1 / gvac1
2. Mining and Quarrying	ID	gvavR2	gvavR2 = outvR2 / gvac2
3. Other Mining	ID	gvavR3	gvavR3 = outvR3 / gvac3
4. Mining Services	ID	gvavR4	gvavR4 = outvR4 / gvac4
5. Manufacturing	ID	gvavR5	gvavR5 = outvR5 / gvac5
6. Electricity and Water Utilities	ID	gvavR6	gvavR6 = outvR6 / gvac6
7. Building and Construction	ID	gvavR7	gvavR7 = outvR7 / gvac7
8. Trade, Restaurants & Hotels	ID	gvavR8	gvavR8 = outvR8 / gvac8
9. Transport and Communic	ID	gvavR9	gvavR9 = outvR9 / gvac9
10. Finance, Insu. , RE, & Busi. Services	ID	gvavR10	gvavR10 = outvR10 / gvac10
11. Social Services	ID	gvavR11	gvavR11 = outvR11 / gvac11
12. Government Services	ID	gvavR12	gvavR12 = outvR12 / gvac12
13. Household Services	ID	gvavR13	gvavR13 = outvR13 / gvac13
Note: gvac 1- 13 are exogenous trends.			

Table B8.2: Nominal Value Added by Economic Activity, Millions of $x

Variable	Type	Mnemonic	Specification
1. Agriculture and Fishing	ID	gvavN1	gvavN1 = gdpN1
2. Mining and Quarrying	ID	gvavN2	gvavN2 = gdpN2
3. Other Mining	ID	gvavN3	gvavN3 = gdpN3
4. Mining Services	ID	gvavN4	gvavN4 = gdpN4
5. Manufacturing	ID	gvavN5	gvavN5 = gdpN5
6. Electricity and Water Utilities	ID	gvavN6	gvavN6 = gdpN6
7. Building and Construction	ID	gvavN7	gvavN7 = gdpN7
8. Trade, Restaurants & Hotels	ID	gvavN8	gvavN8 = gdpN8
9. Transport and Communic	ID	gvavN9	gvavN9 = gdpN9
10. Finance, Insu. , RE, & Busi. Services	ID	gvavN10	gvavN10 = gdpN10 - ibsN
11. Social Services	ID	gvavN11	gvavN11 = gdpN11
12. Government Services	ID	gvavN12	gvavN12 = gdpN12
13. Household Services	ID	gvavN13	gvavN13 = gdpN13

Table B8.3: Labour Compensations by Economic Activity, Millions of $x

Variable	Type	Mnemonic	Specification
1. Agriculture and Fishing	ID	lab1	lab1 = lr1 * gdpN1
1. Mining and Quarrying	ID	lab1	lab1 = lr1 * gdpN1
3. Other Mining	ID	lab3	lab3 = lr3 * gdpN3
4. Mining Services	ID	lab4	lab4 = lr4 * gdpN4
5. Manufacturing	ID	lab5	lab5 = lr5 * gdpN5
6. Electricity and Water Utilities	ID	lab6	lab6 = lr6 * gdpN6
7. Building and Construction	ID	lab7	lab7 = lr7 * gdpN7
8. Trade, Restaurants & Hotels	ID	lab8	lab8 = lr8 * gdpN8
9. Transport and Communic	ID	lab9	lab9 = lr9 * gdpN9
10. Finance, Insu. , RE, & Busi. Services	ID	lab10	lab10 = lr10 * gdpN10
11. Social Services	ID	lab11	lab11 = lr11 * gdpN11
12. Government Services	ID	lab12	lab12 = lr12 * gdpN12
13. Household Services	ID	lab13	lab13 = lr13 * gdpN13
note: lr (1-13) are exogenous trends			

Table B8.4: Indirect Taxes by Economic Activity, Millions of $x

Variable	Type	Mnemonic	Specification
1. Agriculture and Fishing	ID	tax1	tax1 = taxc1 * outvN1
1. Mining and Quarrying	ID	tax1	tax1 = taxc1 * outvN1
3. Other Mining	ID	tax3	tax3 = taxc3 * outvN3
4. Mining Services	ID	tax4	tax4 = taxc4 * outvN4
5. Manufacturing	ID	tax5	tax5 = taxc5 * outvN5
6. Electricity and Water Utilities	ID	tax6	tax6 = taxc6 * outvN6
7. Building and Construction	ID	tax7	tax7 = taxc7 * outvN7
8. Trade, Restaurants & Hotels	ID	tax8	tax8 = taxc8 * outvN8
9. Transport and Communic	ID	tax9	tax9 = taxc9 * outvN9
10. Finance, Insu. , RE, & Busi. Services	ID	tax10	tax10 = taxc10 * outvN10
11. Social Services	ID	tax11	tax11 = taxc11 * outvN11
12. Government Services	ID	tax12	tax12 = taxc12 * outvN12
13. Household Services	ID	tax13	tax13 = taxc13 * outvN13
note: taxc (1-13) are exogenous trends			

Table B8.5: Subsidies by Economic Activity, Millions of $x

Variable	Type	Mnemonic	Specification
1. Agriculture and Fishing	ID	sub1	sub1 = subc1 * outvN1
1. Mining and Quarrying	ID	sub1	sub1 = subc1 * outvN1
3. Other Mining	ID	sub3	sub3 = subc3 * outvN3
4. Mining Services	ID	sub4	sub4 = subc4 * outvN4
5. Manufacturing	ID	sub5	sub5 = subc5 * outvN5
6. Electricity and Water Utilities	ID	sub6	sub6 = subc6 * outvN6
7. Building and Construction	ID	sub7	sub7 = subc7 * outvN7
8. Trade, Restaurants & Hotels	ID	sub8	sub8 = subc8 * outvN8
9. Transport and Communic	ID	sub9	sub9 = subc9 * outvN9
10. Finance, Insu. , RE, & Busi. Services	ID	sub10	sub10 = subc10 * outvN10
11. Social Services	ID	sub11	sub11 = subc11 * outvN11
12. Government Services	ID	sub12	sub12 = subc12 * outvN12
13. Household Services	ID	sub13	sub13 = subc13 * outvN13
note: subc (1-13) are exogenous trends			

Table B8.6: Gross Operating Surplus by Economic Activity, Millions of $x

Variable	Type	Mnemonic	Specification
1. Agriculture and Fishing	ID	ops1	ops1 = gvavN1 - lab1 - tax1 - sub1
1. Mining and Quarrying	ID	ops1	ops1 = gvavN1 - lab1 - tax1 - sub1
3. Other Mining	ID	ops3	ops3 = gvavN3 - lab3 - tax3 - sub3
4. Mining Services	ID	ops4	ops4 = gvavN4 - lab4 - tax4 - sub4
5. Manufacturing	ID	ops5	ops5 = gvavN5 - lab5 - tax5 - sub5
6. Electricity and Water Utilities	ID	ops6	ops6 = gvavN6 - lab6 - tax6 - sub6
7. Building and Construction	ID	ops7	ops7 = gvavN7 - lab7 - tax7 - sub7
8. Trade, Restaurants & Hotels	ID	ops8	ops8 = gvavN8 - lab8 - tax8 - sub8
9. Transport and Communic	ID	ops9	ops9 = gvavN9 - lab9 - tax9 - sub9
10. Finance, Insu. , RE, & Busi. Services	ID	ops10	ops10 = gvavN10 - lab10 - tax10 - sub10
11. Social Services	ID	ops11	ops11 = gvavN11 - lab11 - tax11 - sub11
12. Government Services	ID	ops12	ops12 = gvavN12 - lab12 - tax12 - sub12
13. Household Services	ID	ops13	ops13 = gvavN13 - lab13 - tax13 - sub13

Table B9.1: National Income Account byType of Income, Millions of $x

Variable	Type	Mnemonic	Specification
GDP	ID	gdpN	gdpN = labtt + opstt + taxtt + subtt + imdN
Compensation of Employees	ID	labtt	labtt = sum(lab,1-13)
Gross Operating Surplus	ID	opstt	opstt = sum(ops, 1-13)
Indirect Tax	ID	taxtt	taxtt = sum(tax, 1-13)
Subsidies	ID	subtt	subtt = sum(sub,1-13)
Import Duties	ID	imdN	imdN = impR * imdD
Mining and Quarrying			
Compensation of Employees	ID	labmaq	labmaq = sum(lab,2-4)
Gross Operating surplus	ID	opsmaq	opsmaq = sum(ops,2-4)
Net Indirect Tax Minus Subsidies	ID	nismaq	nismaq = sum(tax,2-4) + sum(sub,2-4)
Value-added	ID	gdpmaqN	gdpmaqN = sum(gdpN, 2-4)
Non-oil Non-government			
Compensation of Employees	ID	labnog	labnog = sum(lab,1,5-11,13)
Gross Operating surplus	ID	opsnog	opsnog = sum(ops,1,5-11,13)
Net Indirect Tax Minus Subsidies	ID	nisnog	nisnog = sum(tax,1,5-11,13) + sum(sub,1,5-11,13)
Value-added	ID	gdpnogN	gdpnogN = sum(gdpN, 1,5-11,13)
Government			
Compensation of Employees	ID	labgos	labgos = lab12
Gross Operating surplus	ID	opsgos	opsgos = ops12
Net Indirect Tax Minus Subsidies	ID	nisgos	nisgos = tax12 + sub12
Value-added	ID	gdpgosN	gdpgosN = gdpN12

Table B9.2: Personal Disposable, Millions of $x

Variable	Type	Mnemonic	Specification
Average Wage Rate (thous $x/yr)	ID	wtt	wtt = labtt / emptt
Mining and Quarrying	ID	wmaq	wmaq = sum(lab,2-4) / sum(emp,2-4)
Government Services	ID	wgos	wgos = lab12 / emp12
Non-oil & Non-government	ID	wnog	wmaq = sum(lab,1,5-11,13) / sum(emp,1,5-11,13)
Compensation of Employees	ID	labtt	labtt = sum(lab,1-13)
+ Gross Operating Surp, NOG	ID	opsnog	opsnog = sum(ops,1,5-11,13)
+ Net Remittances of Employees	ST	ntrwor	ntrwor = f (nemtt)
+ Net Other Transfers	EX	ntroth	
= Personal Disposable Income	**ID**	**pdi**	**pdi = com + opsnog + ntrwor + ntroth**
Real Personal Disposable Income	**ID**	**pdiR**	**pdiR = pdi/pceD**
Real PDI per capita	**ID**	**pdiRpc**	**pdiR = pdiR/pop**

Table B9.3: Gross National Disposable Income

Variable	Type	Mnemonic	Specification
GDP at Market Prices	ID	gdpN	gdpN = tddN + nexN
Net Foreign Income	ID	nfi	nfi = expinc – impinc
Receipts	ST	expinc	expinc = f (cum(fin[t-n]))
Payments	ST	impinc	impinc = f (opstt)
Gross National Income	**ID**	**gni**	**gni = gdpN + nfi**
Net Transfers Received	ID	ntr	ntr = ntrwor + ntroth
Workers Remittances	ST	ntrwor	-1*ntrwor = f (nemtt)
Others (Net)	EX	ntroth	= 0.0 from 2007
Gross National Disposable Income	**ID**	**gndiN**	**gndiN = gni + ntr**
Domestic Demand Deflator	ID	tddD	tddD = (tceN+invN+venN)/(tceR+invR+venR)
Real Gross National Disp Income	**ID**	**gndiR**	**gndiR = gndiN/tddD**

Table B10.1: Public Finance, Millions of $x

Variable	Type	Mnemonic	Specification
Total Revenues	ID	trg	trg = rgoil + rgnoil
Hydrocarbon Revenues	ST	rgoil	rgoil = f(gdpN2)
Non-hydrocarbon Revenues	ST	rgnoil	rgnoil = f(pdi)
Total Government Expenditure	ID	teg	teg = ceg + invgosN
Current Government Expenditure	ID	cego	ceg = gceN + cego
Public consumption	ID	gceN	gecN = gceR * gceD
Other current expenditures	ST	cego	cego = f(rgoil)
Govt investment expenditures	ID	invgosN	invgosN = invgosR * invD
Surplus Or Deficit	ID	gbal	bal = trg – teg
As a % of GDP	ID	bal_gdp	bal_gdp = bal / gdpN * 100
Addenda: Effective Tax Rates			
Oil Related Revenues	ID	troil	troil = rgoil/gdpN2
Non-hydrocarbon Related Revenue	ID	trnoil	trnoil = rgnoil/pdi

Table B10.2: Financial Sector

Variable	Type	Mnemonic	Specification
Interest Rates			
QCB Lending Rate	ST	qcblr	qcblr - usrff = f((pceD-pceD[1])/pceD[1] *100)
US Federal Funds Rate	EX	usrff	
Money Supply, M2	ST	m2	log(m2/gdpN) = f(qcblr, rmg/1000)
Exchange Rate, x/US	EX	rex	
Exchange Rate Index	ID	rexind	rexind = rex / rex{2001}
Real Exchange Rate, Non-oil deflator	ID	rrex_nog	rrex_nog = rexind * impDW / gdpnogD
Real Exchange rate, GDP deflator	ID	rrex_gdp	rrex_gdp = rexind * impDW / gdpD

ECONOMIC FORECASTING AND ANALYSIS OF MULTI-SECTORAL MACROECONOMIC MODELS

THE MEASUREMENT OF PRODUCTIVITY: CONTRIBUTIONS TO THE ANALYSIS FROM I-O ECONOMICS

ROSSELLA BARDAZZI[23]

Abstract
This paper is devoted to the study of labour productivity at the sectoral level. I-O concepts and tools may prove to be very important when outsourcing and vertical integration take place but, generally, statistics at sectoral level largely disregard this information and neoclassical growth models usually ignore intermediate goods and analyse economic growth entirely in terms of value added. Assumptions implied in conventional indicators to measure productivity, as well as the concept of real value added are discussed. An empirical application is provided to compare between productivity indexes rooted in growth accounting methodology and measures computed by the I-O approach and underline the shortcomings of the most popular indicators at the industry level. According to the I-O method, labour requirements used to compute factor productivity indexes take into account the direct and indirect labour used in the production of final output by sector and offer a perspective of studying trends in productivity, which is missing in traditional methods considering indirect effects. Results show that these effects are relevant in some economic sectors where either the share of intermediates is large or outsourcing is taking place.
JEL Classification: O47, C67
Keywords: Labour productivity, input-output

23 University of Florence, Italy.

1. INTRODUCTION

This paper is devoted to the study of labour productivity at the sectoral level by comparing two different methods which may be used to measure the content of labour per unit of output. This topic is part of the broader issue of understanding the drivers of economic growth, therefore an extensive literature on productivity measurement has been produced and statistical institutes and international organisations have published large manuals to explain how to compute meaningful productivity indices and statistics. [24]

The aim of this work is to emphasise the assumptions of using some specific variables to measure productivity which are not novel but are usually disregarded in empirical work. A simple example with a comparison between the index produced by statistical offices will be provided and a measure of labour requirements based upon the I-O approach will be computed to underline the shortcomings of the most popular indicators at the sectoral level.

1. PRODUCTIVITY INDICATORS: SOME PROBLEMATIC ISSUES

Productivity measurement poses a problem of valuation both in the framework of consistent KLEMS calculations and in the value added based measures as "productivity is commonly defined as a ratio of a *volume* measure of output to a *volume* measure of input use" (OECD, 2001, italics ours).

The first approach is theory-based as it dates back to the seminal article by Jorgenson and Griliches (1967), then extended by other studies later on. This approach assumes the existence of a production function where gross output by industry is a function of capital, labour, intermediate inputs and technology. Under the assumptions of competitive factor markets, constant returns to scale and full utilisation of inputs, the growth of industry output is expressed as the cost-share

24 For example, the OECD (2001) Productivity Manual is widely considered an authoritative collection of the problems and practical solutions in the field of productivity measurement. Therefore, this manual is often referred to throughout this paper.

weighted growth of inputs and technological change. This implies the computation of multifactor productivity measures as shown in the figure below:

Type of output measure	*Type of input measure*			
	Labour	*Capital*	*Capital and labour*	*Capital, labour and intermediate inputs (energy, materials, services)*
Gross output	Labour productivity (based on gross output)	Capital productivity (based on gross output)	Capital-labour MFP (based on gross output)	KLEMS multifactor productivity
Value added	Labour productivity (based on value added)	Capital productivity (based on value added)	Capital-labour MFP (based on value added)	-
	Single factor productivity measures		*Multifactor productivity (MFP) measures*	

Source: OECD Productivity Manual (OECD, 2001).

Figure 1: Overview of the main productivity measures

Other productivity indicators refer to single production input, among these labour related to a measure of output is the most frequently computed productivity index.

At the more aggregate level, the value added measures of labour productivity are to be preferred over indicators based on gross output because they are less sensitive to outsourcing intensity and to the degree of vertical integration[25]. In this case, when labour is replaced by the use of intermediate inputs, this in itself would raise labour productivity but, at the same time, value added will fall and this change will partially or completely offset the rise in productivity. On the contrary, gross output-based labour productivity changes when the ratio of intermediates to labour varies for reasons – such as outsourcing – unrelated either to technology shifts or to efficiency gains.

25 The opposite is true if one considers the multi-factor productivity measures: in this case, if outsourcing and vertical integration are taking place, value-added based measures rise faster than gross-output based MFP, because the use of primary factors is substituted by intermediate inputs.

At the industry or firm level, gross output single factor productivity measures should be preferred. In this case, from the producers' perspective the production decisions for primary and intermediate inputs are taken at the same time, then substitution can occur and this makes them non-separable. However, even at the industry level, the most generally used concept of output is value added although, to give an interpretation to the productivity measures based on value added, the existence of industry value-added functions is required. This assumption is very strict and will be discussed further. In summary, real value added is the most widely used concept by national statistical institutes and other international statistical agencies to determine both the relative growth of different industries and the industry single factor productivity measures[26].

The basic difference between output measured as value added or as gross output is the treatment of intermediate goods. GDP is a value added measure and it excludes intermediate inputs whereas a gross output measure includes the value of goods and services used in the production process. This difference is not very relevant at the national level where the two measures differ only as far as intermediate inputs are part of international trade. However, changes in intermediate usage can affect productivity: a substitution between labour and intermediates can occur as a result of outsourcing and off shoring. Gains in efficiency due to some practices can reduce the use of intermediates as well as working hours thus increasing productivity. As argued by Diewert and Nakamura (2007), gross output directly takes into account intermediate goods as a source of growth while value added reflects the effect of intermediates on productivity indirectly as "real value added per unit of primary input rises when unit requirements for intermediate inputs are reduced" (p.4550).

Moreover, beside the definition of the measure of output, there is a problem concerning valuation as the volume of output is needed in computing a productivity index. The deflation of gross output is more straightforward as it requires only price indices on gross output, while the deflation of value added suffers from several theoretical and practical drawbacks since it involves double deflation. As simply stated

---

26 For a comprehensive survey of the history of value-added concept both in the practice of statistical organizations and in the literature see Meade (2007).

by Schreyer (2001) "value-added is not an immediately plausible measure of output: contrary to gross output, there is no physical quantity that corresponds to a volume measure of value-added" (p.41).

Therefore, the choice between value added and gross output depends on the level of analysis – disaggregate or aggregate level – and on data availability as value added series are often longer and more accessible than gross output and intermediate inputs series.

2. STANDARD APPROACH TO LABOUR PRODUCTIVITY ANALYSIS

EU KLEMS is a project aimed at building a comparable dataset for empirical and theoretical research in the field of productivity growth for European countries[27]. As stated by O'Mahony and Timmer (2009) the 'organising principle' behind the database is the growth accounting methodology. However, it is claimed that much of the variables of the EU KLEMS growth and productivity accounts are independent of this method such as the 'basic' series which contain all the data necessary to construct productivity measures at the industry and aggregate level across Europe. Distinguishing features of this database are the harmonised industry detail, the differences in the composition of each input such as levels of worker skills or types of capital goods and the breakdown of intermediate inputs into energy, materials and services. Timmer et al. (2007) assert that "the main building block of a KLEMS account is a series of input-output tables in which inter-industry flows are recorded in a consistent way" (p.19). Indeed, from supply and use tables industry output, intermediate inputs and value added can be obtained. Then additional statistical information is taken from National Accounts. These statistics represent the 'basic' productivity variables of the database followed by a group of growth accounting variables which are of analytical nature as they are obtained in a framework rooted in production functions requiring additional assumptions such as those mentioned in the previous paragraph (competitive factor markets, full inputs utilisation and constant returns to scale). However, it is important to underline that in this first group of basic variables one can

27 This research was founded by the European Commission under the Sixth Framework Programme. The project was carried out by a consortium of 24 research institutes and national statistical institutes (www.euklems.net).

find the price and volume indices of gross value added which require specific theoretical assumptions. In the methodology report accompanying the dataset it is explained that "in this database it was chosen to report industry-level value added volume indices for each country based on the national accounts methodology of that particular country. This methodology differs across countries (...). This choice is driven by the fact that for many countries value added volume series are often longer and have more industry detail than the gross output and intermediate inputs series." (Timmer et al. 2007, p. 21). These words confirm the motivation of 'data availability' behind the choice of relying more on value added than on gross output to measure productivity at the industry level, albeit the caveats stated above and the implicit assumptions that will be described in the following. In fact, to produce the volume measure of value added (real value added) firstly it is necessary to assume the existence of industry-level value added function as a function of only capital, labour and time as:

$$VA_J = V^j\left(L_j,K_j,t\right).$$

This function links technological change exclusively to real value added and primary inputs, therefore implying that it is a sub function of an industry-level production function which is value-added separable:

$$Y_j = F\left(V^j\left(L_j,K_j,t\right),M_j\right)$$

where Yj is the maximum quantity of gross output of industry j that can be produced by all inputs: intermediate inputs (Mj), labour (Lj), and capital (Kj). In order to define this sub function it is assumed that intermediate inputs are separable from primary inputs, so that intermediate inputs' prices do not matter when the producer makes his choices for all its production inputs simultaneously. It must be stressed that the volume and price indices of value added can be computed even if the separability assumption is violated although this index would be meaningless.

When the production function is assumed separable in intermediate inputs and value added, the quantity of value added can be derived as a

Tornqvist index for gross output then rewritten in terms of value added as:

$$\Delta \log VA_{jt} = \frac{1}{s_{VA}}(\Delta logY_{jt} - s_M \Delta \log M_{jt})$$

where s_{VA} is the share of value added in gross output and s_M is the share of intermediate inputs in gross output defined as $(1-s_{VA})$ [28]. Therefore, the volume change of value added is defined as an average of the volume change of output Yj and the volume change of intermediate inputs weighted by their share in gross output. The expression is multiplied by the inverted share of value added on gross output.

Because the volume change for value added involves the volume change for output and intermediate inputs, it implies a process of double deflation. This may be empirically approximated by using fixed-weight Laspeyres quantity indices where constant-price value added is a difference between the constant price index of gross output and the constant price index of intermediate inputs with weights expressed in prices of the base period. Otherwise the Tornqvist version of double-deflation can be applied with geometric weights expressed in current prices and averaged across periods.

One clear advantage of this productivity measure based on value added is that the aggregate overall productivity level is obtained by the weighted aggregation of industry-level productivity where weights are simply each industry’s current price share in total value added.

When all hypotheses are met, the nominal measure of value added is defined as:

$$P_j^V VA_j = P_j^Y Y_j - P_j^M M_j$$

where P_V is the price index of value added.

---

28 In this equation the separability holds if the share s_{VA} does not depend on the intermediate inputs M.

To sum up, the measurement of factor productivity at industry level requires a volume measure of output. Albeit gross output is regarded as the preferred concept to measure single factor productivity, value added is generally used. In order to obtain a quantity measure of value added the existence of industry value added functions is required: to define this function a separability condition must hold otherwise the volume and price index of value added would be meaningless. This condition is generally violated as shown by Jorgenson, Gallop and Fraumeni (1987)[29]. Moreover, as stressed by Meade (2007) and Almon (2009) the double deflated value added which is obtained by this procedure is a purely fabricated quantity with no economic meaning: it represents the value added that would have resulted in industry j if prices had remained constant after the base year. As stated by Almon (2006) "it is, in fact, what would have been left over for paying primary factors, had producers, contrary to economic theory, gone right on producing with the previous period's inputs after prices have changed. That is certainly no measure of "real value added," for it is not, in all probability, what producers did." (p.4).

The volume of value added computed with double deflation is problematic particularly when sectors experience (a) large relative price changes, (b) large changes in factor shares or (c) large changes in the value of inputs relative to output. In case (a) intermediate input substitution occurs, in case (b) substitution occurs between primary production factors, in case (c) if the price development of intermediates is very different from the price development of output – and intermediates are a large share of production – then unrealistic results for the quantity of value added are likely to be obtained.

3. THE ALTERNATIVE I-O APPROACH: MEASURING HOW EFFICIENT IS THE ECONOMY IN PRODUCING VARIOUS FINAL PRODUCTS

All the reasons above suggest not using the volume measure of value added at the industry level to study sectoral factor productivity. An alternative method to the conventional approach may be derived within

29 In their well-known study the authors find that separability does not hold in 40 out of 45 industries (see Jorgenson Gallop and Fraumeni (1987), p. 242).

the input-output framework. This method is not particularly novel or mathematically sophisticated and has been applied within the I-O community for several studies[30]. It is based upon I-O tables and the computation of Leontief inverse matrix. Through this system the so-called factor requirements or factor intensity coefficients, both direct and indirect, may be computed and they give an important contribution to the analysis of productivity. Although the derivation of these coefficients is rather straightforward for I-O practitioners, here follows a brief description of their computation based on Almon (2009).

Let's assume that A_t is defined as the input-output coefficient matrix of year t, and similarly v_t is defined as the vector of real input – such as labour – per unit of output q in the same year, where each element is

$$v_j = y_j / q_j$$

and y_j is the payment to that primary factor by industry j. Finally p_t is the vector of prices in year t; in the base year, all prices are 1.0. Then as the column j of the Leontief inverse, $(I - A)^{-1}$, shows the outputs necessary, directly and indirectly, to produce one unit of final demand of product j, by premultiplying the matrix with the transpose of vector v_t one obtains x_t the vector of inputs per unit of final demand in year t:

$$x_t = v_t' \, (I - A_t)^{-1}.$$

The unit of final demand is expressed in current prices, then to convert the x vector to a constant unit, it must be multiplied element-by-element by the price index vector, p_t. Therefore vector z_t is given by

$$z_t = x_t * p_t$$

30 Pasinetti (1973) defines the concept of vertically integrated sector (VIS) as a section of industries able to produce all the inputs necessary to come up with the final good. In this context total labour productivity is computed including not only workers directly employed in the production of final goods, but also those employed in the firms producing the inputs, the inputs of the inputs, and so forth. An application of this index for Spain is in De Juan and Febrero (2000).

and it represents the real inputs needed to produce a (constant-sized) unit of final demand. If the primary factor considered is labour, z_t measures the labour direct and indirect requirements to produce a unit of final product. Therefore, the reciprocal of these labour requirements are labour productivity indexes as they show the use of labour in the inter-industry relationships encapsulated in the Leontief inverse besides the labour intensity of sector j. The resulted employment required in the production of the sector's final output may be different from the labour intensity of the sector itself: labour productivity depends on efficiency in labour use throughout the whole production process.

One may wonder why this simple relationship is not used to analyse productivity, especially at the sectoral level, while input-output tables are used only as a coherent accounting framework to collect sectoral data to be used for studying productivity. Indeed, input-output calculations may offer a perspective of studying trends in productivity which is missing in traditional methods not taking into account indirect effects.

4. AN EMPIRICAL APPLICATION TO ITALY

In order to compare the standard approach to measure labour productivity at the sectoral level with the I-O relationships the Italian economy is considered.

Two sets of sectoral data have been used. The first one refers to the EUKLEMS database already mentioned in Section 2. Then Supply and Use Tables and National Accounts for the Italian economy produced by the National Statistical Office (ISTAT) have been considered. In the first database, sectoral detail is based upon a common classification and harmonised data is available in the same format for all European countries. The second source of statistical data allows more detail and longer time series although in slightly different sectoral classification which has been reconciled with EU KLEMS in order to compare the results.

EUKLEMS database allows producing an index of labour productivity based upon real value added according to the theoretical assumptions described in Section 2. In general industry-level value added volume indices for each country are derived using double deflation but every country may have used a different methodology.

National data for Italy has been used to apply the I-O method described in Section 3. Sectoral labour productivity indexes have been obtained as the reciprocal of the labour requirements by industry. In this application imports are assumed to be produced with the same input patterns as domestic products and moreover the adjustment of employment for quality is not considered. These assumptions should be removed in a further development of this work.

In the series of graphs here below (Figures 2, 3, 4) these indexes – represented by the lines with plus signs – are compared with the index of labour productivity – the lines with squares – usually computed as the volume of labour per unit of the volume of value-added based upon the EUKLEMS data sets.

To compare the different set of labour productivity indicators a common classification of selected sectors between the national Italian classification and the EUKLEMS database has been built. Here results for these sectors are presented to give some insights of the main findings.

First of all, one can observe that there are some sectors where the two indexes show only minor differences: this is the case of Construction, Trade, Financial intermediation, Education, Health and Social work.

In other industries labour productivity implied by taking into account the I-O structure of the whole economy is performing better than what is shown by the sectoral value added productivity index: these are Food, beverages and tobacco, Textiles and wearing apparel, Wood and paper, Machinery and equipment, Electric and electronic equipment, Chemicals, Real estates and business activities. In this case the standard labour productivity index underestimates the reduction of labour per unit of output produced by those sectors. The economy as a whole has been progressively more efficient in producing the output than what is measured looking only at the labour factor used in that industry.

Finally, for some industries the trend in labour productivity is worse when one looks at how efficiently – in terms of the use of labour – the whole economy is producing a unit of final demand by that sector than looking at the value added per unit of labour of that specific sector. These industries are Agriculture, forestry, and Hunting, Electrical energy, gas and water, Transports, Mining and quarrying. In this case the sector is using progressively less labour per unit of output in the decade considered but – as the reciprocal of labour requirements may suggest – the economy as a whole is not saving as much in producing that output: that industry may have externalised some of its producing process to other industries, therefore the reduction of labour used is only apparent as only the direct and not the indirect labour content has been reduced.

A possible explanation of these results may be found if the structure of intermediate consumption of the economy is observed. In Table 1 the sectoral shares of intermediate inputs over gross output for selected sectors are shown. In Table 2 the difference of output and intermediate price growth rates by industry is presented.

The first group of industries where there are minor differences between the two labour productivity indicators generally present shares of intermediates over output below average (which is 55.5) and stable across the time period: this is the case of Financial intermediation, Education, Health and Social work. Therefore, even if the price development of intermediates may be different from the price development of production this may not be very problematic in the computation of the volume of value added as intermediates are not a large share of production. Likewise the eventual indirect labour content in their production is not expected to be significant. On the other hand for Trade and Construction while the intermediate share is higher the price dynamics of inputs and output is rather similar.

For the other industries where results diverge, a very large share of intermediates over output is observed – for Food and beverages, Basic metals and machinery – and in some cases increasing over time – such as for Agriculture, Chemicals, Electricity, Mining --. This evidence may have created changes in the labour requirements along the production chain which are not allocated in the industry itself. These indirect effects are captured by the I-O methodology and therefore the results may differ from the standard index of labour productivity. Moreover, in certain cases large differences in intermediate and output price growth may be observed – for instance in Agriculture and Electricity, Gas, Water – which make problematic to compute real value added by double deflation.

5. CONCLUSIONS

In this paper the theoretical and empirical characteristics of two alternative methods for computing labour productivity indicators at the industry level have been analysed. The empirical application shows that there are cases where the two procedures produce different results. This finding may be explained by the fact that in case of the I-O method the labour requirements used to compute a factor productivity index take into account the direct and indirect labour used in the production of final output by sector. According to this method it can be evaluated how efficient is the whole economy in producing a unit of final good. It can be concluded that this procedure avoids the theoretical assumptions which must be assumed by the traditional approach based upon double deflated value added and is more comprehensive in measuring the factor used in the industry production process. This approach may be further investigated by removing some working assumptions of this application, such as those concerning imports, the quality of labour, and by applying this procedure not only to study labour productivity but also the capital requirements of production which pose more difficulties in finding the appropriate variables for this methodology.

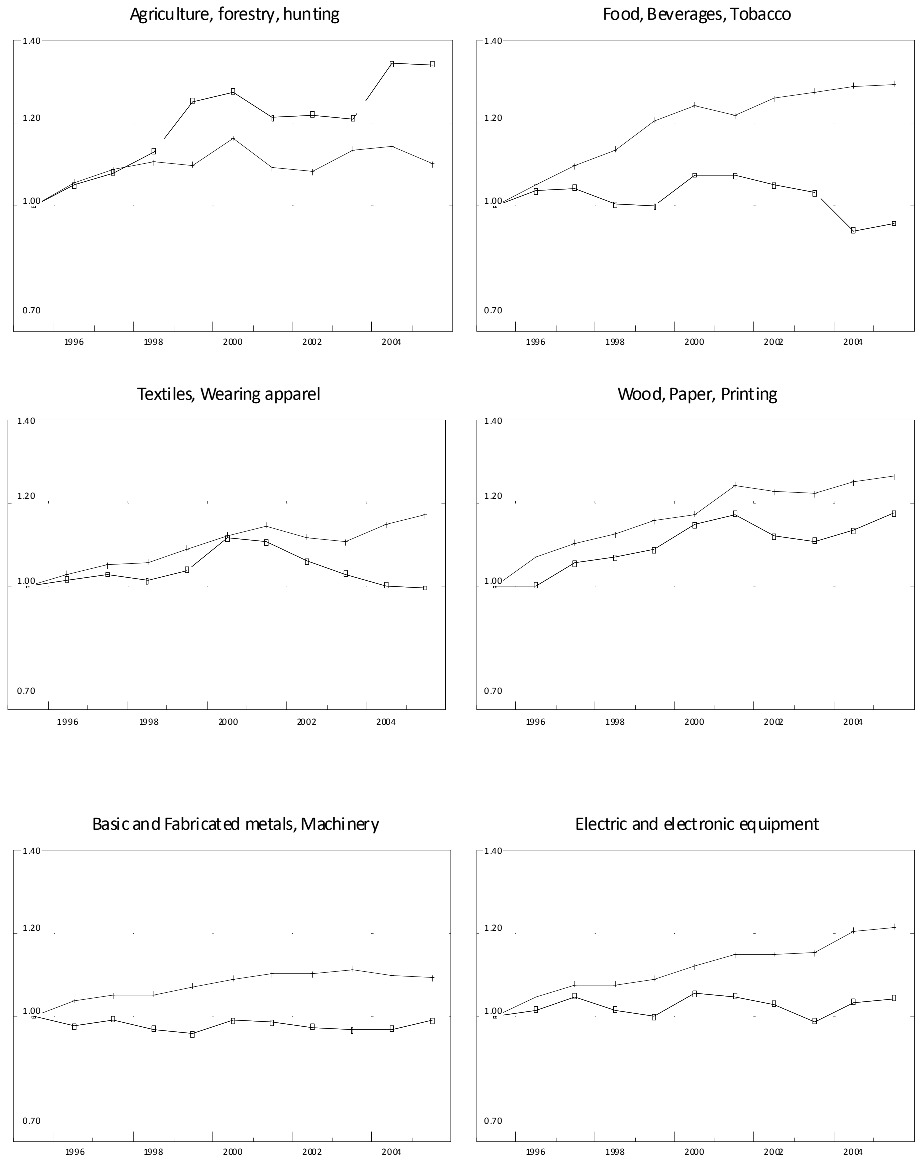


Figure 2: Labour productivity indexes (1995=1)

Notes: lines with plus signs, I-O indexes; lines with squares, EUKLEMS indexes.

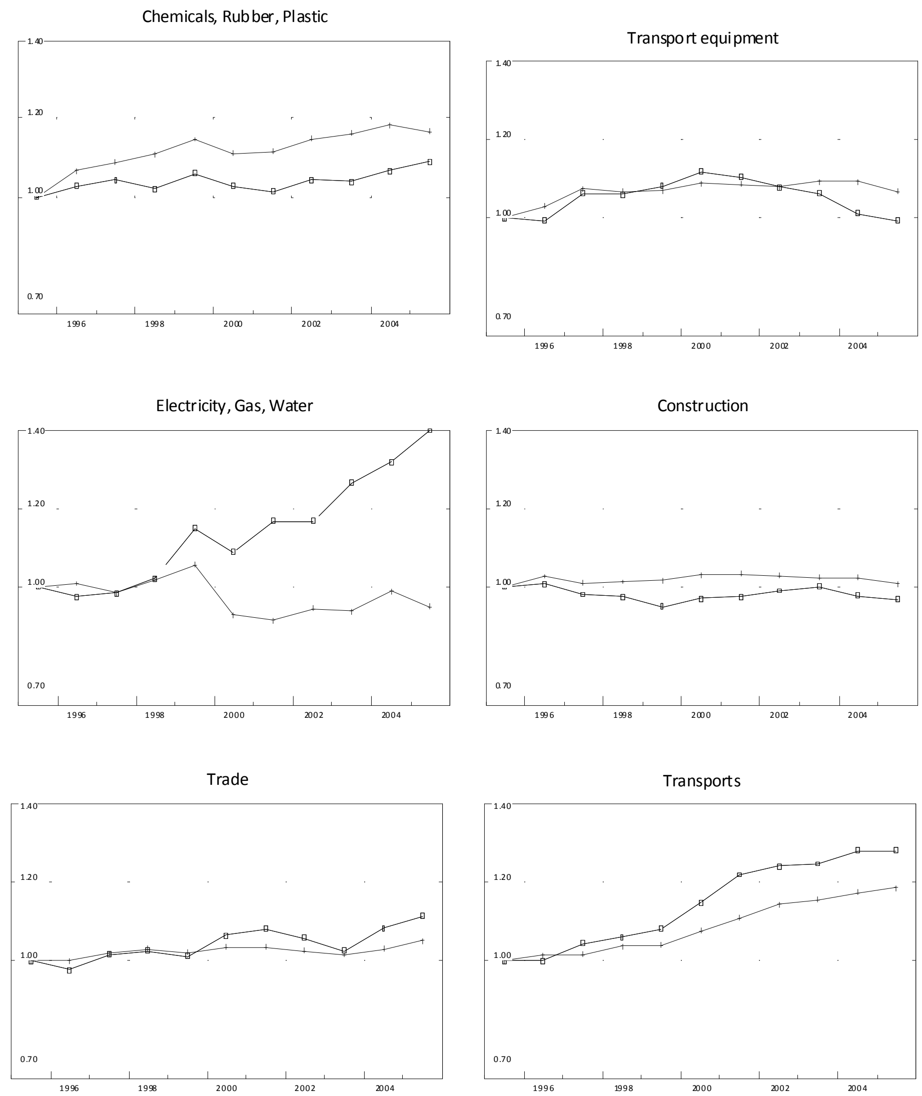


Figure 3: Labour productivity indexes (1995=1)
Notes: lines with plus signs, I-O indexes; lines with squares, EUKLEMS indexes.

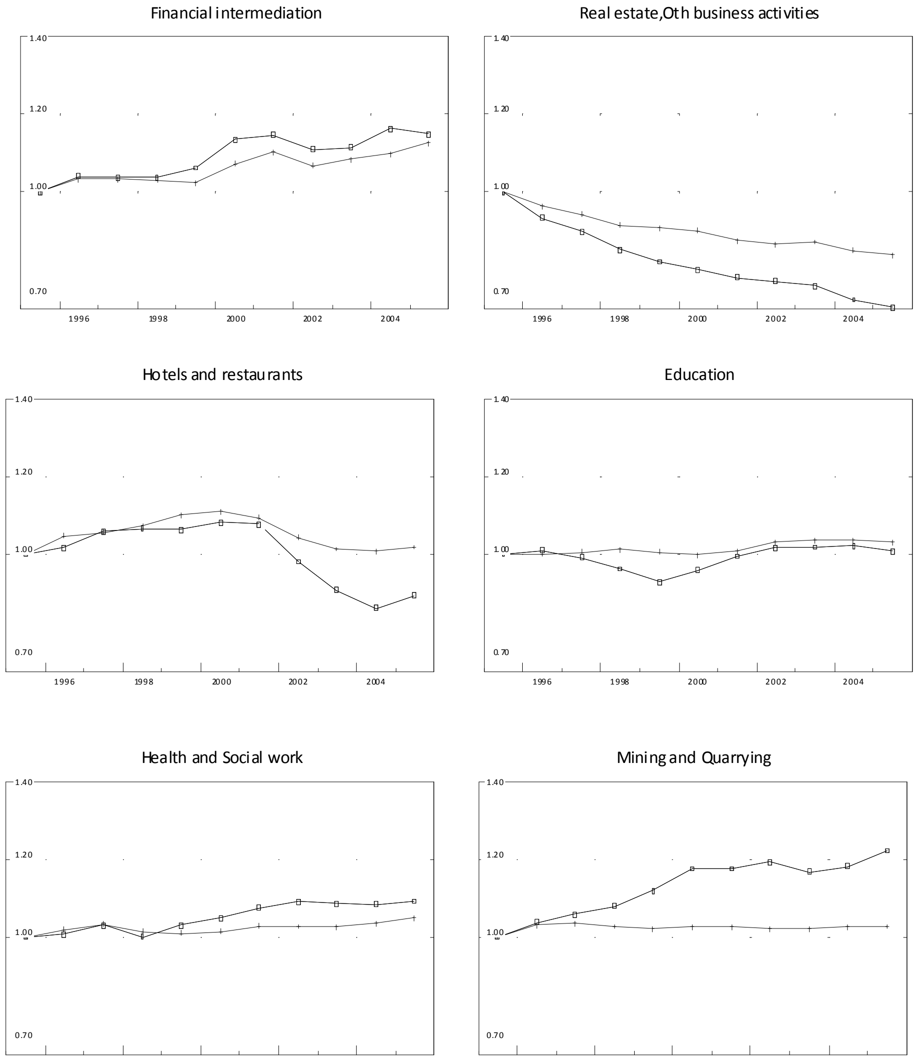


Figure 4: Labour productivity indexes (1995=1)

Notes: lines with plus signs, I-O indexes; lines with squares, EUKLEMS indexes.

Table 1: Sectoral shares of intermediate inputs over gross output

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	growth rates
AGRICULTURE, HUNTING, FORESTRY AND FISHING	36.8	36.1	35.5	35.4	35.8	37.3	38.2	38.3	38.1	38.6	40.6	10%
FOOD , BEVERAGES AND TOBACCO	77.1	76.3	76.1	75.9	76.2	76.6	77.0	76.0	76.8	76.6	77.6	1%
TEXTILES, LEATHER AND FOOTWEAR	68.6	68.1	69.0	69.7	70.5	71.2	70.9	71.3	71.4	71.4	72.6	6%
WOOD, PAPER AND PRINTING	63.2	62.6	64.0	64.9	66.1	66.6	63.5	64.6	67.0	67.0	67.7	7%
BASIC AND FABRICATED METALS, MACHINERY	67.9	65.4	66.7	66.8	66.6	68.0	68.0	68.2	68.1	69.8	70.3	3%
ELECTRICAL AND OPTICAL EQUIPMENT	66.6	65.7	66.2	66.7	67.4	67.6	67.6	67.2	66.7	66.2	66.9	0%
CHEMICAL, RUBBER, PLASTICS	71.9	72.0	72.9	71.8	73.8	76.6	76.7	76.9	77.3	78.2	79.4	10%
TRANSPORT EQUIPMENT	75.7	75.7	74.3	74.6	76.0	77.4	78.6	79.8	79.8	79.4	81.0	7%
ELECTRICITY, GAS AND WATER SUPPLY	51.0	51.1	53.5	51.3	52.9	61.7	62.0	59.9	61.7	61.0	64.2	26%
CONSTRUCTION	60.5	59.9	60.5	61.2	61.7	61.7	60.1	59.8	58.6	58.0	57.7	-5%
WHOLESALE AND RETAIL TRADE	50.3	50.8	52.1	53.1	54.7	56.0	56.2	57.1	57.6	58.1	59.2	18%
TRANSPORT AND STORAGE	56.3	56.2	57.1	56.9	58.8	60.3	60.3	58.5	59.5	59.2	60.8	8%
FINANCING INTERMEDIATION	28.4	29.1	30.5	31.3	32.1	32.2	33.5	33.6	32.8	33.4	33.5	18%
REAL ESTATE, RENTING AND BUSINESS ACTIVITIES	27.0	27.2	27.4	28.2	29.2	29.2	31.0	31.0	30.3	30.7	30.4	13%
HOTELS AND RESTAURANTS	51.0	49.8	50.8	51.3	50.8	51.3	50.8	51.9	52.9	52.6	53.2	4%
EDUCATION	15.5	15.2	14.9	15.7	15.7	16.5	16.2	15.4	15.3	16.1	15.5	0%
HEALTH AND SOCIAL WORK	33.0	32.5	31.2	32.7	32.9	32.2	32.7	33.5	34.2	34.4	35.1	6%
MINING AND QUARRYING	31.9	32.8	33.2	37.6	37.9	39.7	41.2	40.4	43.0	44.0	42.9	34%

Table 2: Difference of output and intermediate price growth rates by industry

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AGRICULTURE, HUNTING, FORESTRY AND FISHING	-0.42	0.81	-0.25	-1.49	-4.47	-2.36	-1.17	1.12	3.10	-7.02	-3.17
FOOD , BEVERAGES AND TOBACCO	-0.96	1.24	1.05	1.06	0.57	-0.58	0.51	1.42	-0.49	2.11	-0.54
TEXTILES, LEATHER AND FOOTWEAR	-1.57	1.08	0.19	0.95	0.03	-0.96	1.36	0.20	0.32	0.74	-0.75
WOOD, PAPER AND PRINTING	-1.14	1.14	-1.16	-0.17	-1.04	-0.83	3.63	-0.62	-1.94	-0.44	-0.41
BASIC AND FABRICATED METALS, MACHINERY	-1.45	2.41	-0.82	0.30	1.10	-1.91	0.11	-0.08	0.39	-2.08	-1.37
ELECTRICAL AND OPTICAL EQUIPMENT	-1.17	1.41	0.23	0.81	0.05	-0.43	0.68	1.03	0.60	0.47	-0.84
CHEMICAL, RUBBER, PLASTICS	-0.49	1.13	-0.03	2.60	-2.70	-3.16	0.23	-0.16	0.17	0.00	-0.02
TRANSPORT EQUIPMENT	-0.03	0.55	2.28	0.88	0.26	-0.84	-0.37	-0.31	0.45	1.39	-1.21
ELECTRICITY, GAS AND WATER SUPPLY	-4.86	1.51	-1.09	6.22	-4.25	-13.50	-1.51	3.19	-2.05	-0.17	-6.61
CONSTRUCTION	-1.02	1.22	-0.09	-0.05	0.43	0.24	0.50	0.31	1.38	1.42	0.48
WHOLESALE AND RETAIL TRADE	-2.38	0.88	-0.98	-0.16	-0.91	-1.50	0.69	0.11	0.85	-1.14	-1.63
TRANSPORT AND STORAGE	-3.05	0.68	-0.65	1.34	-2.25	-1.38	1.36	2.08	-0.04	-0.70	-0.81
FINANCING INTERMEDIATION	0.30	0.40	-0.96	-0.32	0.03	1.85	0.24	1.52	3.10	0.47	0.30
REAL ESTATE, RENTING AND BUSINESS ACTIVITIES	0.67	2.45	2.03	-0.11	0.60	2.31	-1.28	2.91	2.92	0.23	0.54
HOTELS AND RESTAURANTS	0.29	3.59	-0.57	0.29	2.10	-0.50	1.59	-0.11	-0.03	1.45	-0.29
EDUCATION	-4.32	-0.08	-0.35	-4.64	-2.11	-5.16	3.02	1.91	0.25	-12.35	-0.56
HEALTH AND SOCIAL WORK	3.28	0.89	3.29	-3.47	-1.97	-0.08	-1.06	-1.22	0.01	0.89	-0.03
MINING AND QUARRYING	-2.45	-1.42	0.89	-6.09	3.04	-5.60	1.62	-0.80	-2.48	-0.23	-0.08

REFERENCES

ALMON C. (2006). *The Craft of Economic Modelling*, Vol.3.
ALMON C. (2009). Double Trouble: The problem with Double Deflation of Value Added, and an Input-Output Alternative with an Application to Russia, in Bardazzi R. and M. Grassini, Editors(s), Energy Policy and International Competitiveness, *Firenze University Press.*
DE JUAN O., FEBRERO E. (2000). Measuring productivity from Vertically Integrated Sectors, *Economic Systems Research,* vol.12, 1, 65-82.
DIEWERT W. E., NAKAMURA A. O. (2007). The Measurement of Productivity for Nations, in James J. Heckman and Edward E. Leamer, Editor(s), *Handbook of Econometrics*, Elsevier, Volume 6, Part 1, 4501-4586.
JORGENSON D.W., GALLOP F.M., FRAUMENI B.M. (1987). Productivity and U.S. Economic Growth, *Harvard University Press,* Cambridge.
MEADE D.S. (2007). Is Real Value Added Real?, in Mariusz Plich and Michal Przybylinski, Editor(s), *Recent Developments in INFORUM-type Modeling, Lodz University.*
OECD (2001). Measuring Productivity, Measurement of Aggregate and Industry-level Productivity Growth, *OECD Manual,* Paris.
O'MAHONY M. AND TIMMER M.P. (2009). Output, Input And Productivity Measures At The Industry Level: The Eu Klems Database, *The Economic Journal,* 119, June, 374-403.
PASINETTI, L. L. (1973). The Notion of Vertical Integration In Economic Analysis, *Metroeconomica*, vol.25, 1, 1–29.
SCHREYER P. (2001). The OECD Productivity Manual: A Guide to the Measurement of Industry-Level and Aggregate Productivity, *International Productivity Monitor*, Number 2, Spring 2001.
TIMMER M.P., VAN MOERGASTEL T., STUIVENWOLD E., G. YPMA, O'MAHONY M., KANGASNIEMI M. (2007). *EU KLEMS Growth and Productivity Accounts, Part I Methodology*, March 2007.

THE INFLUENCE OF INTERSECTORAL COMPETITION LIMITATIONS IN RUSSIA

VADIM GILMUNDINOV[31], TATYANA TAGAEVA

Abstract
Russia is the fourth most pollutive country in the world. The rapid Russian economic development over the last decade has brought substantial environmental degradation. But environmental pollution development should contradict ecological limitations for economic growth. The paper is devoted to the analysis of the ecological limitations' influence on the Russian economic structure.
JEL classification: C67, Q53, Q51
Keywords: Environmental competitive restrictions; economic structural changes; direct and full pollution coefficients; and ecology-economic forecast of Russia

1. INTRODUCTION

The global processes have a strong influence on the Russian economy. The rapid Russian economic growth in 1999-2008 mainly depended on favourable external factors: the substantial increase of average annual export oil prices and favourable real exchange rate.

The last events of modern world economic crises made more evident the understanding of the scantiness and frailty of the existing economic model. The ignoring of social and ecological aspects of development, stereotypes of maximum of consumption standards, the building up of traditional economic indices and other factors have led to crisis phenomena, which have a global character and negative consequences. The modern type of economic development can be called technological. It has such distinctive features: exhaustion and extra-

31 Institute of Economics IE SB RAS, Novosibirsk StateUniversity.
gilmundinov@mail.ru, tagaeva@ieie.nsc.ru

exploitation of natural resources, enormous pollution and waste products, and economic damage because of environmental degradation. Thus, the analysis and forecast of economic development have to be conducted taking into account ecological aspects.

2. ENVIRONMENT ASPECTS OF HUMAN HEALTH IN RUSSIA

The ecological problems have serious actuality for Russia. Russia is one of the most pollutive countries in the world. Its contribution to the total world emission of major hazardous substances (solid substances, sulphurous oxide, nitrous oxide and carbonic gas) accounts for 13%.

There is a strong relation between environmental pollution and GDP (Fig.1), which shows that there is no improvement of production and environmental protection technologies, from the point of view of their influence on the quality of the ecology.

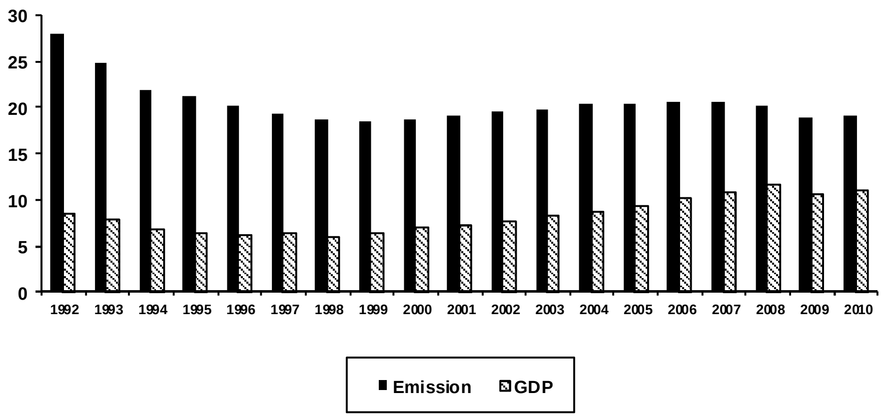


Figure 1: Stationary emission (mln. tons) and GDP (bln. Rbl. before 1998 and trln. Rbl. prices in 2000) in 1992-2010.

In spite of some decrease in yearly pollution, in crisis periods nature does not have time to neutralise accumulated pollution and as a result there is an increase in the general level of pollution. Maximum concentration levels of harmful substances are 5-10 times higher, and even more, in the atmosphere of 210 Russian cities. According to the Russian State Committee on Statistics, only 15% of urban population lives on the territories where air pollution does not exceed hygienic regulations. With regard to the cities where environmental health control is organised, 20% of urban population lives in ecologically harmful conditions. As a result of river and underground water pollution, a problematic situation emerges with regard to water supply to the population. Clean water supply in Russia covers only 50% of the requirements. Furthermore, motor transport is a considerable source of contamination of the air (Fig. 2).

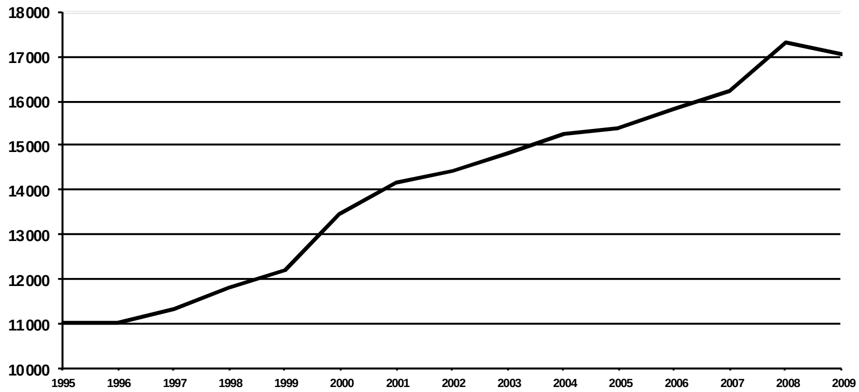


Figure 2: Motor transport emission of polluting substances into atmosphere in 1995-2009 (thousand tons)

The ecological factor is the main one among other risk factors (economic, cultural etc.) that have had a negative influence on the health of the Russian population during recent years. Children's health rates have the most sensitive response to changes in environmental quality. Numerous data prove that a high children sickness rate is registered in ecologically unfavourable areas and infant and children mortality rates are higher (25% higher in comparison with environmentally safe areas). The level of unusual diseases, a typical clinical cause of well-known diseases among children and rejuvenation of some diseases (ulcer diseases, pancreatic diabetes, essential hypertension, coronary heart disease, myocardial infarction and even cerebral stroke among children) also define ecological pathology.

The period of transition from command economy to market economy is characterised by serious ill health aggravation of Russian citizens. The number of yearly registered people who fell ill with cancer for the first time increased by 90% during 1990 - 2009, the number of those who fell ill with diseases of the digestive system increased by 22% and the number of those who fell ill with diseases of the circulatory system nearly doubled. Figure 3 illustrates the common morbidity.

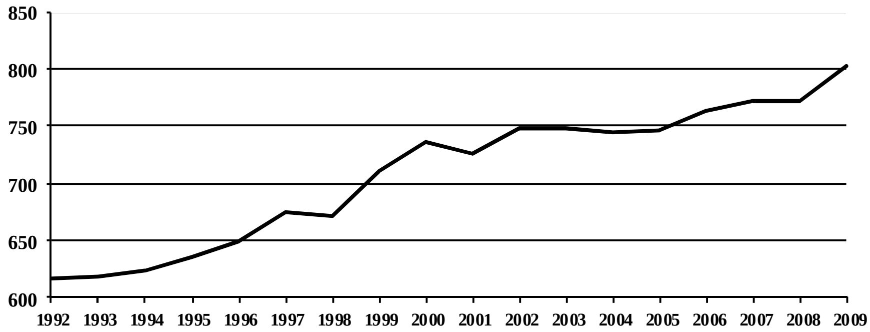


Figure 3: Morbidity in Russia in 1992-2009 (amount of registered patients with the first diagnosed disease for every thousand people)

So, it can be seen that the Russian economy has very serious ecological problems. The increasing environmental loading allows consideration of it as a competition limitation for branch development, which has to influence an economic structure for the benefit of more ecological industries. An ecological competitive limitation is formed by several factors (for example, enterprises of pollutive industries have to use ineffective equipment and sick workers in unfavourable ecological situations and pay pollution taxes). So, industries with high environmental pressure have to have more difficult conditions for development. If ecological competitive limitations are "strict" some changes in the sectoral structure may be expected towards more eco friendly production. If such restrictions are insignificant no change is to be expected. The seriousness of Russian environmental problems makes it possible to set a task of estimating a degree of severity of ecological competitive limitations. Such approach allows indirect conclusions concerning efficiency or in-efficiency of ecological governmental policy in Russia.

3. INFLUENCE OF ENVIRONMENTAL RESTRICTIONS ON RUSSIAN ECONOMIC STRUCTURE

For analysis of the Russian environmental impact on economic structures, the pollution coefficients (direct and full) of main branches of the Russian Economy have been estimated.

The direct pollution coefficient of branch i (dp_i) shows an amount of pollution produced per unit of branch i total output. Let's take n as amount of branches, $V^{P}{}_{i}$ as total annual pollution of branch i, and x_i as total annual output of branch i, then a direct pollution coefficient of branch i is calculated as follows:

$$dp_i = V^{P}{}_{i} / x_i, i = 1,...,n.$$

The estimation of full pollution coefficients is based on the full-costs I-O approach. The full pollutant coefficient of branch j (fp_j) shows an amount of pollution produced per unit of branch j final output. Calculation of the full pollution coefficient of branch i is defined by the following equation:

$$fp_j = \Sigma(i = 1,...,n) dp_i . b_{ij},$$

where b_{ij} is the specific coefficient of full costs I-O matrix (inverse matrix to the difference between unit matrix and input-output matrix).

In order to estimate the pressure on the Russian environment, the following indicators are used: amount of waste water discharge (cubic metres) and amount of emission polluting the atmosphere (kg). Results of the calculation are presented in Table 1.

Table 1: Pollution coefficients of main branches of Russian Economy in year 2003, price of 2003

The industries	Waste water discharge coefficients, cubic m per 1 thou Rbl of output		Atmospheric pollutant emissions coefficient, kilo per 1 thou Rbl of output		Average annual growth rates of output in 2003-2007, %
	direct	full	direct	Full	
Power engineering	0,837	1,332	3,597	4,942	1,5
Fuel industry	0,127	0,579	1,302	2,413	3,3
Ferrous metallurgy	0,689	1,434	2,414	4,668	4,7
Non- ferrous metallurgy	0,453	1,140	3,562	6,514	4,4
Chemical and petrochemical industry	1,636	2,855	0,525	2,343	7,4
Machine-building and metal-working industry	0,244	1,118	0,214	2,107	8,7
Logging, wood-working, pulp and paper industry	2,518	3,868	0,556	1,853	5,1
Building materials industry	0,312	0,958	0,990	2,633	9,0
Light industry	0,277	1,114	0,195	1,258	1,6
Food industry	0,037	0,852	0,107	0,855	5,4
Other industries	0,603	1,650	0,356	2,377	6,8
Construction	0,008	0,553	0,185	1,314	14,2
Agriculture	0,988	1,553	0,095	0,644	3,0
Transport and communication services	0,104	0,538	1,452	2,279	2,9
Trade	0,001	0,260	0,019	0,475	13,9
Other branches of material production	0,014	0,535	0,082	0,704	7,2
Non-material service	2,754	3,361	0,262	0,935	7,3
Average in Russia Economy	0,813	1,32	0,850	1,379	

Date of State Statistic Committee of the Russian Federation: Input-Output Tables of 2003 / Moscow, 2006.
Statistical Handbook Russia. 2009 / State Statistic Committee of RF, Moscow, 2009.

Analysis of the direct and full pollution coefficients shows that the full pollution level is considerably variable in the branches. The largest full waste water discharge coefficient is in logging, wood-working, and pulp and paper industry (3,9 cubic metres per 1000 rubles of final output), the lowest being in Trade (0,26 cubic metres per 1000 rubles of final output).

The largest full atmospheric pollutant emissions coefficient is in Non-ferrous metallurgy (6,5 kg per 1000 rubles of final output), the lowest being in Trade (0,475 kg per 1000 rubles of final output).

Accounting for the indirect costs for a number of branches of Russian Economy significantly increases the assessment of their negative impact on the environment. For example, for Trade the direct coefficient of discharges of polluted wastewater is only 0,001 cubic metres per 1000 rubles of total output, while the full coefficient is 246 times more (0.26 cubic metres per 1000 rubles of final output).

To verify the hardness of environmental restrictions in the Russian economy linear coefficients of pair correlation is estimated between the average annual growth rates of total output in 2003-2007 and the pollutant coefficients in 2003 (Table 2). All correlation coefficients are negative, but the statistical significance of Students' criteria, at a significance level of 5%, is not taken into account.

Table 2: Linear coefficients of pair correlation between the average annual growth rates of gross output in 2003-2007 and the pollutant coefficients in 2003

	Correlation	Significant level
Direct waste water discharge coefficient, cubic m per 1 thou Rbl of total output	-0,147	0,573
Full waste water discharge coefficient, cubic m per 1 thou Rbl of final output	-0,159	0,542
Direct atmospheric pollutant emissions coefficient, kg per 1 thou Rbl of total output	-0,457	0,065
Full atmospheric pollutant emissions coefficient, kg per 1 thou Rbl of final output	-0,363	0,152

Negative correlation coefficients signify that industries, which significantly influence the environment, have on average lower growth rates. So, the results allow comment on the possible influence of ecological competitive limitations on the development of the economic sectors of Russia. However, this possible influence is not significant. This may be caused first of all by very soft Russian environmental legislation, in particular on water resources protection.

To investigate correlation between industrial environmental pressure and industrial development, the industrial pollution structure transformation in 2010-2012 was forecasted. If the Russian economy meets toughening of ecological limitations it will be reasonable to expect a decrease of shares of most polluting industries in the industrial structure.

4. ECOLOGY-ECONOMICAL FORECAST OF RUSSIA IN 2009-2012

All the above-mentioned processes show that it is very important to take into account ecological aspects in analysing and forecasting the Russian economic development. The purpose of the investigations is to explore the moving forces and trends of social development, development dynamics of the branches of national economy, economic structural exchanges and conditions of competitiveness in the industries, taking into consideration not only production characteristics, but estimates of industry pollution loads. For these purposes CAIIN[32] is used (a System of Dynamic I-O Models of Russia), which has been created in the Intersectoral Research Department of the Institute of Economy and Industrial Organisation (IEIE SB RAS) in Novosibirsk. Figure 4 presents a brief scheme of one of the variants of the CAIIN system functioning with the environmental protection block (EP block).

In addition to the n traditional sectors of the economy, l elements, which represent natural resources, are allocated and one-to-one correspondence is expected between each of these elements and the areas of environmental protection (air protection, water conservation, etc.). At this stage, two natural resources are studied, namely atmospheric air and water. For water and air environmental protection activities, the reproduction processes of the main environmental funds and the formation of environmental costs are modelled into the DIOM

32 CAIIN - System of Comprehensive Analysis of Intersectoral Information.

(Dynamic Input-Output Model). The EP block describes the tangible indicators of ecological processes. Depending on the volume of manufactured goods in the traditional sectors of the economy (Xj), the volume of pollutants directly generated during the production process is determined. Thus, this model allows the forecasting of the level of pollution formation in the sphere of production, depending on the economic development of Russia, using coefficients of atmosphere polluting substances formation per unit of gross production output. With using estimates of the expenditures on the reduction of water and air pollution, the model complex allows the determination of volumes of pollution trapping. The difference between the formation and trapping of pollution gives the volumes of emissions.

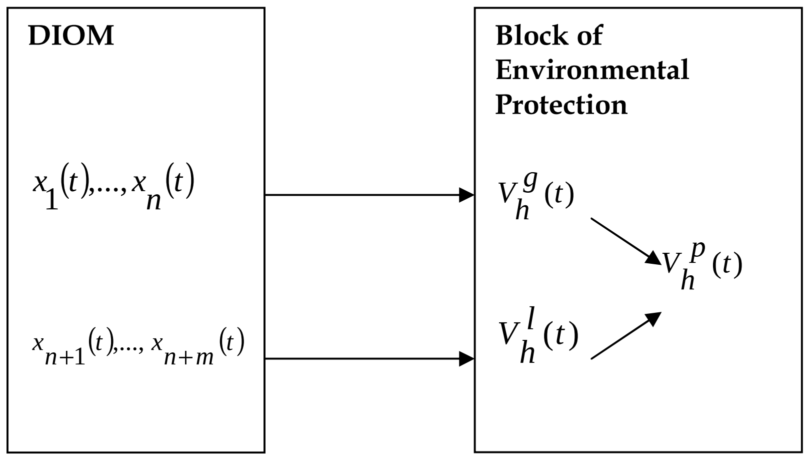


Figure 4: A brief outline of the CAIIN system with an EP block.

This is a description of the EP block[33]:

33 A more detailed description of the economic and ecological units of the model complex and the method of forming initial information, is given in BARANOV A., PAVLOV V., TAGAEVA T. (1997). *Analysis and Forecast of the State of Environmental Protection in Russia // Environmental and Resource Economics*. N 9: p.21-42. Kluwer Academic Publishers. ISSN 0924-6460.

$x(t)=(x_1(t),\ldots,x_n(t),x_{n+1}(t),\ldots,x_{n+m}(t))$ – a vector of gross outputs, where

$x_i(t), i=1,\ldots,n$ - gross output of industry i in year t, $x_{n+h}(t)$, $h=1,\ldots,m$ - current environmental protection cost for natural resource h;

$V_h^g(t)=\sum_{i=1}^{n} w_{ih}(t)x_i(t)+D_h(t)$ - volume of pollutants directly generated during the production process,

where wih – coefficient of pollutant h generation (volume of polluted natural resource h, referred to manufacturing of a unit of production of industry i); Dh (t) - output of pollutant h (volume of pollution or destruction of a natural resource) in household;

$$x_{n+h}(t)=\sum_{i=1}^{n} v_{ih}(t)V_{ih}^l(t) \qquad V_h^l(t)=\sum_{i=1}^{n} V_{ih}^l(t),$$

where vih (t) – current cost to recover unit of natural resource h (to destroy or to trap unit of pollutant h) in industry i; Vhl(t) - volume of a recovered natural resource (liquidated or trapped pollutant) of type h;

$V_h^p(t)=V_h^g(t)-V_h^l(t)$ volume of pollutant h (a polluted natural resource) that gets into the natural environment without purification (or by volume of destroyed but not reproduced natural resource).

Tables 3 and 4 represent indexes of two scenarios of Russian development in 2009-2012, which were calculated for forecast calculations: basic and optimistic.

Table 3: Dynamics of branch outputs of Russian economy in 2009-2012 according to the basic scenario
(%, 2008 year = 100%)

	2009	2010	2011	2012
GDP	93,3	95,2	100,3	108,7
Extractive industry	91,2	92,9	95,7	98,8
Manufacturing industry				
including Machine-building	80,6	82,2	85,3	91,0
industry	85,2	88,1	101,4	120,1
Power engineering	94,2	90,1	91,5	94,9
Agriculture	101,5	104,2	103,8	105,9
Construction	83,1	82,1	88,2	99,9
Transport	84,7	87,3	88,1	91,5
Trade	99,9	102,9	111,9	126,9
Other branches of material production	98,6	85,5	87,9	93,6
Non-material service	91,2	89,2	94,6	103,6

Both scenarios of the forecast proceed from the assumption that there will be no explosive industrial recovery after world economic crises. But an optimistic scenario assumes more rapid and early recovery [34].

---

34 These forecast scenarios have been created in the Intersectoral Research Department of IEIE SB RAS with participation of professors A. Baranov and V. Pavlov.

Table 4: Dynamics of branch outputs of Russian economy in 2009-2012 according to the second scenario (%, 2008 year = 100%)

	2009	2010	2011	2012
GDP	95,3	99,4	107,5	116,6
Extractive industry	95,6	97,0	99,2	102,0
Manufacturing industry	92,4	93,8	99,6	105,5
including Machine-building industry	85,7	93,6	112,7	134,0
Power engineering	96,0	97,2	99,2	99,7
Agriculture	101,5	102,6	106,8	110,8
Construction	82,7	85,6	96,2	108,7
Transport	87,5	88,1	91,5	95,1
Trade	94,6	102,4	116,7	135,4
Other branches of material production	88,4	89,9	95,2	101,0
Non-material service	101,5	109,0	120,5	132,8

The results of forecasting estimates of gross output volumes in the economic sectors (branches) make it possible to assess the amount of emission of polluting substances into the atmosphere and the amounts of discharge of polluted waste waters into water reservoirs (see Figs. 5 and 6). The ecological block estimates were based on the hypothesis that unit rates of pollution, as well as indices of sewage treatment and recovery of main pollutants of the atmosphere will stay at the level of 2008.

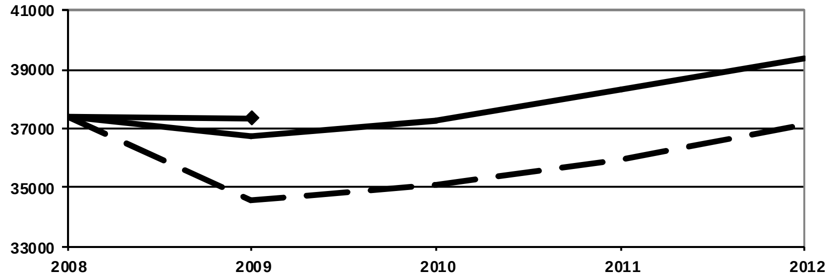


Figure 5: Amount of emission polluting the atmosphere (thousand tons) according to results of forecasting estimates in 2008-2012

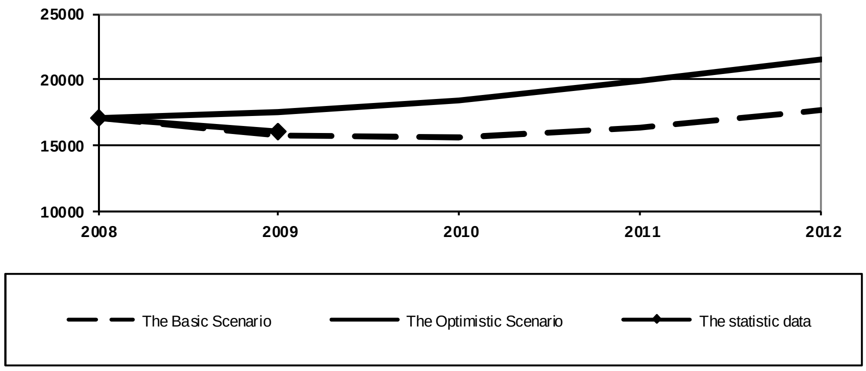


Figure 6: Amount of waste water discharge (mln. cubic metres) according to results of forecasting estimates in 2008-2012

We can see that the second scenario, which is more optimistic from the economic development point of view, is more pessimistic from the ecological point of view, because of the most environmental pressure. According to the basic scenario, the amount of waste water discharge will increase by 3,4% and stationary sources emission doesn't increase in 2008-2012. According to the optimistic scenario, the amount of waste water discharge will increase by 26% and emission by 5,2% in the same period. The transformation of the pollution industry structure because of economic structure changes according to the optimistic scenario (there is the same dynamic according to the basic scenario), is performed in Table 5.

Table 5: The transformation of pollution industry structure in 2008-2012 in Russia according the optimistic scenario (change in share, in %)

The industries	The atmospheric emission	The dumping of the polluted sewage
Power engineering	+0.2	-0.8
Fuel industry	+0.5	-0.4
Ferrous metallurgy	-0.8	-1.0
Non- ferrous metallurgy	-0.6	-0.7
Chemical and petrochemical industry	-0.2	-1.1
Machine-building and metal-working industry	+0.1	+0.1
Logging, wood-working, pulp and paper industry	0	-1.1
Building materials industry	-0.1	-0.3
Light industry	0	-0.1
Food industry	+0.1	0
Other industries	0	-0.3
Construction	+0.1	0
Agriculture	+0.1	-0.5
Transport and communication services	-0.4	-0.1
Other branches of material production	+0.1	0
Non-material service	+0.9	+6.3
Russian Economy	0	0

The analysis of results demonstrates that a share of industries having high direct and full pollution coefficient would statistically be slightly dropping in the total amount of emissions (ratios of linear pair correlation of direct and full emissions of industries, with changing shares in the total pollution amount, are -0,45 and -0,57 respectively). In the case of discharge of polluted water such correlation is not observed. One of the possible explanations is that Russia has an inefficient system of monitoring volumes of discharged polluted water.

Thus, the results of forecast calculations don't permit conclusions about substantial influence of ecological competitive limitations on the sectoral structure of national economy. So, ecological limitation is very soft in Russia because of imperfection of Russian ecological legislation and the low level of pollution taxes. The sizes of the pollution taxes don't provide the necessary volumes of investment and current expenditures for the purpose of pollution abatement. In addition, pollution taxes are depreciated quickly because of inflation. For instance, the price index increased in 2007 (compared to the level of 1991 year) 19,7 thou times, but index of pollution taxes was only 150,9 times. Thus, the difference is about 131 times. In such conditions Russian enterprises prefer to do emissions than to make pollution abatement.

Therefore the results of the investigations illustrate the necessity of toughening Russian ecological legislation.

5. CONCLUSIONS

Favourable external factors led to rapid economic growth in Russia, but it appeared to be unsustainable. The Russian economic structure has become more raw-oriented because of a high competitiveness of the primary sector.

The health and demographic situation in Russia strongly depends on the state of the environment. Significant deterioration of the environment results in high morbidity and mortality in Russia. For example, the maximum concentration level of harmful substances is 5-10 times higher and more in the atmosphere of Russian cities in 2010. The number of yearly registered patients with the first diagnosed disease per every thousand people has increased by 30% in the period 1992–2009.

A proposed approach based on direct and full pollution coefficients allows taking into consideration environmental competitive restrictions between branches of the economy, for analysis of a structural transformation of the national economy. The results show a possible impact of environment restrictions on development of Russian branches of the economy, but this possible impact is very negligible, especially with regard to waste water discharging.

The results of forecasting by using the Dynamic Input-Output Model show the growth of environmental pressure in the period 2009-2012 in Russia. The most optimistic result from an economic development scenario is the most pessimistic result from an ecological point of view, because of the most pressure on the environment. Thus, the results of this study suggest a need for tightening of the Russian environmental legislation.

ENERGY SCENARIOS FOR GERMANY: SIMULATIONS WITH THE MODEL PANTA RHEI

CHRISTIAN LUTZ[35]

Abstract
The German government decided in 2009 to develop a new energy concept on the basis of model scenarios. The model PANTA RHEI has been applied to evaluate economic impacts of a long-term shift towards a low-carbon economy until 2050. According to this a deep cut of national greenhouse gas emissions of more than 80% against 1990 levels until 2050 is economically feasible. Lower energy imports and higher energy efficiency are major drivers for even positive effects on GDP and employment in the long term. Depending on assumptions for additional security costs longer lifetimes of nuclear power plants will have some positive economic impacts in the medium term. The German government adopted a long term energy concept in late 2010 with a focus on renewable energy. However, it withdrew the decision of longer lifetimes of nuclear power plants in the light of the disaster in Japan in summer 2011.
JEL classification: C54, C67, Q43
Keywords: Macroeconomic modelling, energy policy, economic impacts, Germany

35 Gesellschaft für Wirtschaftliche Strukturforschung mbH, Osnabrück, Germany. Corresponding author. Tel: +4954140933120, Fax: +4954140933110, E-mail: lutz@gws-os.com

1. INTRODUCTION

Energy policy has been in the focus of the political agenda in Germany since the first oil price crisis in the 1970s. The fierce debate about nuclear power plants in the second half of that decade was a main reason for the foundation of the green party, which entered German parliament in 1983 for the first time. The nuclear disaster in Chernobyl in the former Soviet Union in 1986 brought the expansion of nuclear power to an end. In the 1990s Germany started to foster renewable energy sources. With the debate about global warming, and the Kyoto protocol, negotiated by Angela Merkel, minister of the environment at that time, the government decided to cut greenhouse gas emissions substantially against 1990 levels. When the green party joined the government in 1998, nuclear phase out until 2022 has been negotiated with the utility companies owning the nuclear power plants in 2002. Beginning in 2000 the introduction of the feed-in-tariff started to increase the share of renewable energy sources from around 5% to about 20% in electricity production in 2011. The European Union (EU) energy and climate package from 2008, to cut emissions by 20% until 1990 and increase the share of renewable energy to 20% in 2020, brought back the discussion about nuclear as a low carbon technology. At the eve of the Copenhagen climate summit in December 2009 (COP15) the German government decided to fundamentally change the energy system towards renewable and low carbon energy sources. The role of nuclear power as a bridging technology was to be evaluated in policy scenarios.

As policy evaluation is complex, three different models have been applied for the analysis. An EU electricity market optimisation model has been used for the electricity sector (Nagl et al. 2011). The European perspective is necessary due to the European Union Emissions Trading System (EU-ETS) and the planned further integration of EU electricity markets. A significant change in German CO_2 emissions will for example have impacts on EU-ETS carbon prices and therefore influence all EU economies. For final energy consumption a set of bottom-up technology models have been applied. PANTA RHEI (an econometric model for calculation of the GDP and employment effects of a given policy,) has been soft linked to these models. Results from the models as differences in electricity prices and volumes, investments in new installations and net electricity exports as well as savings in final energy demand and related investment differences have been used as inputs in PANTA RHEI. These primary impulses induce so-called second round impacts on economic variables. Main results are presented for Gross Domestic Product (GDP) and employment.

This paper starts with a description of the model PANTA RHEI which has been used for the macroeconomic evaluation as part of the scenario work in section 2. Section 3 presents the scenarios. The main economic impacts are described in section 4. Some conclusions and a brief discussion of the consequences of the nuclear disaster in Japan in March 2011 for German energy policy conclude the paper in section 5.

2. MODEL PANTA RHEI

PANTA RHEI is an environmentally extended version (Lehr et al. 2008, Meyer et al. 2007a, 2012, Lutz et al. 2007, 2005) of the macro-econometric simulation and forecasting model INFORGE of the German economy. It is based on official statistics. INFORGE consistently describes the annual inter-industry flows between the 59 sectors, their contributions to personal consumption, government, equipment investment, construction, inventory investment, exports as well as prices, wages, output, imports, employment, labour compensation, profits, taxes, etc. for each sector, as well as for the macro economy (Meyer et al. 2007b, Ahlert et al. 2009, Maier et al. 2012).

An overview of the model structure can be seen in Figure 1. Besides the comprehensive economic modelling energy and related air emissions, transport, dwelling, material and land use are depicted in detail. All parts are consistently linked via volumes and prices. The transport module for example delivers the gasoline (petrol and diesel) consumption in liter, which - multiplied with the gasoline price - is part of the intermediate demand of industries and the final demand of households in monetary terms. Changes in tax rates or international oil prices will induce various economic impacts on tax revenues, gasoline consumption and related economic behaviour.

The behavioural equations reflect bounded rationality rather than optimising behaviour of agents. All parameters are estimated econometrically from time series data (1991 – 2008). Producer prices are the result of mark-up calculations of firms. Output decisions follow observable historic developments, including observed inefficiencies rather than optimal choices. The model is solved by the Gauss-Seidel algorithm (iterative) model year on year.

Structural equations are usually modelled on the 59 sector level (2 digits Classification of Economic Activities in the European Community [NACE]) of the input-output accounting framework of the official System of National Accounts (SNA) and the corresponding macro variables are then endogenously calculated by explicit aggregation. In that sense the model has a bottom-up structure. The input-output part is consistently integrated into the SNA accounts, which fully reflect the circular flow of generation, distribution, redistribution and use of income.

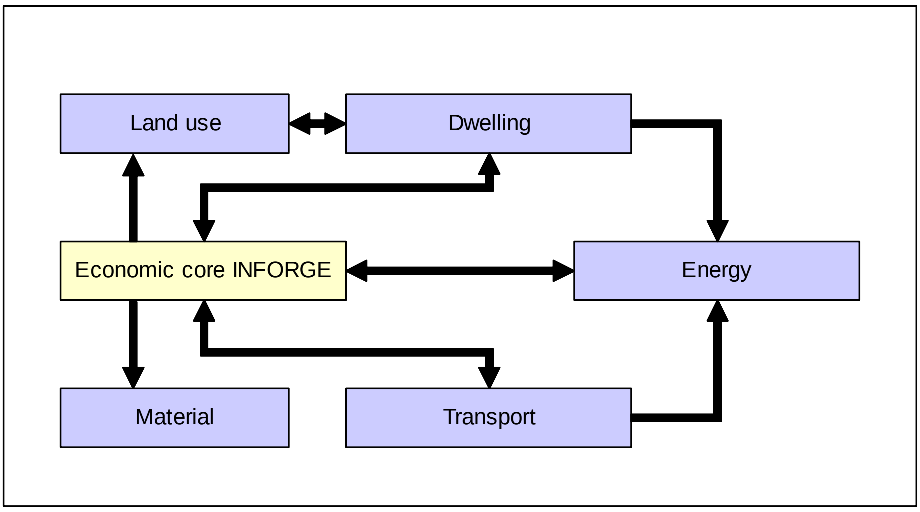


Figure 1: Structure of PANTA RHEI

2.1 Economic Core INFORGE

The core of PANTA RHEI is the economic module INFORGE, which belongs to the Interindustry Forecasting Project (INFORUM) modelling family (Almon 1991), that rests on two basic fundamentals: bottom-up construction and total integration. The former indicates that each industrial sector is modelled individually and that macroeconomic variables are calculated through explicit aggregation. This approach ensures that each individual sector is embedded within the economic context and that intersectoral dependencies are explicitly incorporated and used to explain economic interaction. The latter describes a complex and simultaneous solution which takes into consideration inter-industrial dependence as well as the distribution of income, the redistribution effects of the state and the usage of income for goods. Thus, the input-output tables are fully implemented in the system of national accounts (Ahlert et al. 2009). Both datasets are specified for improving the identification of gross fixed capital formation, private consumption, public consumption and foreign trade. Labour market specifics are consistently embedded in the macroeconomic context through output and unit costs. Macroeconomic indicators are determined by aggregation of 59 industries. For a detailed description of the economic part see Maier et al. (2012).

An integral element of input-output modelling is the determination of intermediate demand between industries. Input coefficients represent the relation of intermediate demand to total production. In INFORGE technological change is identified by applying variable input coefficients. They are endogenously determined with relative prices and time trend. The Leontief-inverse $(I-A)^{-1}$ – with A as input coefficient matrix and I as identity matrix – multiplied with final demand fd gives gross production y by 59 industries. In the following equations the notations are as follows: lower case letters are vectors, upper case letters are either time series or matrices. The dimension of vectors and matrices are indicated with subscripts. The subscript t indicates time dependency.

$$y_t = (I - A_t)^{-1} \cdot fd_t \qquad [1]$$

In many macroeconomic models, private consumption is based on the almost ideal demand system (AIDS) approach (e.g. Kratena & Wüger 2006), which allows the estimation of consumption structures according to utility maximisation behaviour and consequently does build upon the assumption of a representative individual (Deaton & Muelbauer 1980). Different to this approach, INFORGE estimates consumption patterns by 41 purposes of use c as a function of real disposable income Y/P and relative prices p/P. For some consumption purposes, trends t as proxy for long-term change in consumption behaviour or the number of private households HH is used as explanatory variable.

$$c_{l,t} = c_{i,t}\left(\frac{Y_t}{P_t}, \frac{p_{l,t}}{P_t}, t, HH_t\right) \qquad [2] \qquad l \in [1,\ldots,41]$$

INFORGE differentiates between ten classifications of the functions of governments for modelling public expenditures g. 80% of them are related to four government functions: (i) public administration, (ii) education, (iii) health and (iv) social welfare. Driving forces for state consumption are disposable income of the government YG, employment E as well as demographic change B.

$$g_{k,t} = g_{k,t}(YG_t, E_t, B_t) \qquad [3] \qquad k \in [1,\ldots,10]$$

Gross fixed capital formation is separately modelled for equipment and construction investment. Equipment investments by 59 industries are determined by estimating capital stock k which again is a function of production y of the previous year, costs of production factor labour l, autonomic technological change t and real interest rates IR.

$$k_{i,t} = k_{i,t}(y_{i,t-1}, l_{i,t}, t, IR_t) \qquad [4] \qquad i \in [1,\ldots,59]$$

Export demand in PANTA RHEI can be linked to the Global Inter-industry Forecasting System (GINFORS) (Lutz et al. 2010). But in this application, exports are kept constant in current prices, as similar energy and climate policy developments are assumed for the main competitors.

Prices are estimated econometrically. Basic prices p, which is decisive for entrepreneurs, are the result of unit costs uc and mark-up pricing. The extent to which mark-up pricing can be realised depends on the market form prevailing in specific industrial sectors. In industries with monopolistic structures, mark-up pricing is easier to realise than in competitive industrial structures. Industries will also consider import prices pim, if they are exposed to foreign competitors as well.

$$p_{i,t} = p_{i,t}(uc_{i,t}, pim_{i,t}) \qquad [5] \qquad i \in [1,...,59]$$

The labour demand functions depend on the number of hours employees work (volume of work). This approach builds on two important observations: first, a volume-based approach to labour demand considers the growing importance of part-time employees; second, labour policy instruments such as short-time work, for example, can be explicitly addressed. Working hours h are determined by sector-specific production y. In some industries real wages ae/p are also influential.

$$h_{i,t} = h_{i,t}\left(\frac{ae_{i,t}}{p_{i,t}}, y_{i,t}\right) \qquad [6] \qquad i \in [1,...,59]$$

Average earnings are determined by using a Phillips curve approach (a graphic description of the inverse relationship between wages and unemployment levels). Accordingly, average earnings by industry ae depend on the one hand on tariff wages AE (e.g. in machinery) and on the other hand on sector-specific productivity y/h.

$$ae_{i,t} = ae_{i,t}\left(AE_t, \frac{y_{i,t}}{h_t}\right) \qquad [7] \qquad i \in [1,...,59]$$

The number of employees e is derived by definition, dividing the number of working hours h by working time per year and head hy. The latter is preset exogenously.

$$e_{i,t} = \frac{h_{i,t}}{hy_{i,t}} \cdot 1000 \qquad [8] \qquad i \in [1,...,59]$$

2.2 Energy module

The energy module describes the interrelations between economic developments, energy consumption and related emissions. The relations are interdependent. Economic activity such as gross production of industries or final consumer demand influence respective energy demand. Vice versa, the expenditure for energy consumption has a direct influence on economic variables.

The energy module contains the full energy balance with primary energy input, transformation and final energy consumption for 20 energy consumption sectors, 27 fossil energy carriers and the satellite balance for renewable energy (AGEB 2011). All together, the energy balances divide energy consumption into 30 energy carriers. Prices, also in Euro per energy unit, are modelled for different energy users such as industry, services and private households for all energy carriers. CO2 emissions are related to energy consumption via emission factors of the Federal Environmental Agency (UBA 2011). The energy module is fully integrated into the economic part of the model.

Final energy consumption of industries fe is explained by sector output y, the relation of the aggregate energy price pe – an average of the different carrier prices weighted with their shares in the energy consumption of that sector – and the sector price p and time trends, which mirror exogenous technological progress.

$$fe_{i,t} = fe_{i,t}\left(y_{i,t}, \frac{pe_{i,t}}{p_{i,t}}, t\right) \qquad [9] \qquad i \in [1,\ldots,59]$$

For services, the number of employees turned out to be a better proxy for economic activity than gross output. Average temperatures also play a role for the energy consumption of the service sector. For private households, consumption by purpose as heating or fuels is already calculated in the economic model INFORGE in monetary terms. Additional information can be taken from stock models for transport and heating from the specific modules, as only new investments in cars or houses, or expensive insulation measures will gradually change average technical parameters over time.

Final demand fed of energy carrier k for industries can be calculated by definition, multiplying the share of the carrier sfe with overall final energy demand of the sector. For the shares, the influence of relative prices, the price of energy carrier k in relation to the weighted price of all energy inputs of the sector, and of time trends are econometrically tested.

$$sfe_{k,t} = sfe_{k,t}\left(\frac{pe_{k,t}}{p_{k,t}}, t\right) \qquad [10] \qquad i \in [1,\ldots,59]$$

$$fed_{k,t} = sfe_{k,t} \cdot fe_{k,t} \qquad [11] \qquad k \in [1,\ldots,30]$$

Energy carrier prices pe depend on exogenous world market prices pw for coal, oil and gas and specific other price components such as tax rates tr and margins mr. For electricity different cost components such as the apportionment of the feed-in-tariff for electricity are explicitly modelled.

$$pe_{k,t} = pe_{k,t}\left(pw_t, tr_{k,t,}, mr_{k,t}\right) \qquad [12] \qquad k \in [1,\ldots,30]$$

For services, households and transport specific prices are calculated, as for example tax rates partly differ between end users.

For energy-related carbon emissions ce, fix carbon emission factors cef from the German reporting (UBA 2011) to the United Nations Framework Convention on Climate Change (UNFCCC) are applied. Multiplication with final energy demand fe gives sector and energy carrier specific emissions.

$$ce_{i,k,t} = cef_{i,k,t} \cdot fe_{i,k,t} \qquad [13] \qquad i \in [1,\ldots,59];\ k \in [1,\ldots,30]$$

All detailed information in the energy balance for 30 energy carriers is consistently aggregated and linked to the corresponding four industries of the I-O table (Figure 2). For renewable energy sources additional cost structure detail is used (see Lehr et al. 2008, 2012). This ensures that changes of international energy prices or tax rate changes and associated changes in energy volumes are fully accounted for in the economic part of the model.

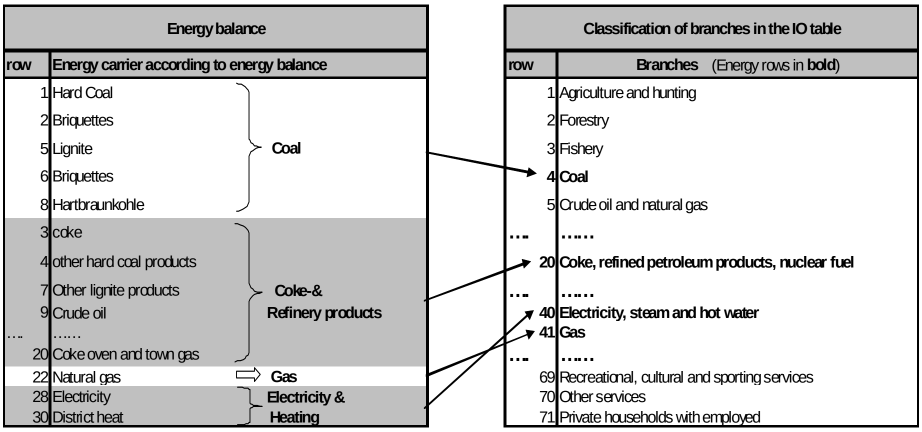


Figure 2: Linkage of energy balance to I-O sectors

The future development of renewable energy sources is strongly influenced by policy design. Assumptions on future developments are therefore often based on detailed sector studies such as the semi-official lead scenario (Nitsch et al. 2010) for the Ministry of Environment. For results presented below, an EU electricity optimisation model has been applied (Nagl et al. 2011).

3. SCENARIOS

After general elections in autumn 2009, the German government decided in late 2009 to develop a new energy concept on the basis of model scenarios within one year. Main objectives are climate mitigation targets for 2020 and 2050, shaping the way towards a renewable energy future and to clarify the role of different energy carriers in this process. Focus has been on nuclear energy (see Table 1). As around two thirds of the population has been skeptical about nuclear power, the building of new nuclear power stations had already been viewed before as a no-go policy option. Nuclear power is perceived as a bridging technology, until renewable energy carriers are fully competitive.

The reference scenario mainly continues past trends in the future. Additional assumptions include long-term GDP growth with a bit below 1% p.a., international energy price developments in line with

IEA (2009) assumptions, an international climate agreement that will come in force no later than 2020, CO_2 prices in the EU-ETS to reach the 30% EU reduction target and a carbon tax for the non-ETS sectors of the economy, which will reach the EU-ETS price in 2020. For the necessary investment in security measures to prolong the lifetime of nuclear power plants, two different sets of assumptions have been used, the A scenarios describing lower security standards and costs, whereas the B scenarios imply much higher security standards.

Table 1: Central milestones of the scenarios

	I	**II**	**III**	**IV**	**Reference**
Green House Gases emission reduction against 1990 until (year)	- 40 % (2020) - 85 % (2050)	- 40 % (2020) - 85 % (2050)	- 40 % (2020) - 85 % (2050)	- 40 % (2020) - 85 % (2050)	Proposal of consultants
Additional lifetime of nuclear power plants in years	4	12	20	28	0
Increase of energy efficiency p.a. in %	Endo-genous	2.3 – 2.5	2.3 – 2.5	Endo-genous	Business as usual (1.7 – 1.9)
Renewable energy					
share of gross final energy demand in 2020	≥ 18 %	≥ 18 %	≥ 18 %	≥ 18 %	≥ 16 %
Share of primary energy supply in 2050	≥ 50 %	≥ 50 %	≥ 50 %	≥ 50 %	Proposal of consultants

Source: Prognos, EWI, GWS 2010

4. RESULTS

The nine scenarios have been implemented in bottom-up models for the electricity sector in an EU electricity market optimisation model (Nagl et al. 2011) and for final energy demand in sector specific models (Prognos, EWI, GWS 2010). They calculated energy volumes and prices and related cost respectively, and investment differences between the scenarios and the reference on a microeconomic basis (Lindenberger et al. 2010). For final energy demand, additional investment needs reach around 15 billion Euro p.a., about half of it used for housing insulation. Electricity prices are up to 1 Cent/kWh lower due to longer lifetime of nuclear power plants. At the same time net electricity imports decrease in the scenarios in comparison to the reference (see Nagl et al. 2011 for a detailed description of effects on the electricity markets). These primary impulses are introduced into PANTA RHEI, in which they induce different second-round effects and reactions.

In the reference annual GDP growth will be slightly below 1% p.a. until 2050. This might be perceived to be low. But due to an expected decrease of the population GDP per capita is supposed to grow with rates of the last two decades. Scenario results show positive impacts of the German energy program with only two exceptions in 2030, for scenarios with 4 years extension of nuclear power plants lifetime. In 2050, GDP will be between 0.46 % and 0.72 % higher in the scenarios than in the reference. The main reason for this positive effect is the reduced use of energy and therefore need of energy imports without additional costs of electricity production and energy demand in the long term. This result has to be related to the scenario assumptions. After all, the analysis assumes the implementation of a cost-optimised energy concept in a favourable international climate policy regime without competitiveness problems for German companies and the danger of carbon leakage. Barriers for economically feasible energy savings (International Energy Agency [IEA] 2010) as the landlord-tenant problem will be reduced by the government. The development of the European electricity grid will be much faster than in the past.

Comparison of the scenarios shows differences which are mainly caused by different lifetimes of nuclear power plants. In the A scenarios with lower security standards for nuclear power, especially scenarios III and IV with additional 20 to 28 years for nuclear power plants, higher

GDP is achieved than in scenario I with only 4 years lifetime expansion. The main reason is lower electricity prices, particularly for electricity intensive users such as metal industries. In the B scenarios with higher retrofit costs, the picture does not give a clear order of the scenarios.

For the components of GDP, the scenarios deliver a quite heterogeneous picture, as can be seen in the comparison of scenario A I with the reference in Table 2. Investment in equipment and construction are higher than in the reference, whereas private consumption is lower throughout the simulation period. This is partly due to the statistical classification of expenditures for building insulation as investment of a specific industry, even if private households simply perceive it as another form of consumption. The increase in construction and the decrease in private consumption are partly due to this rededication of private spending. Foreign trade changes are small, as terms of trade do not change significantly. German exports could even increase in relation to the reference, if other countries will follow similar concepts and rely on German goods. Import costs are reduced due to lower energy imports.

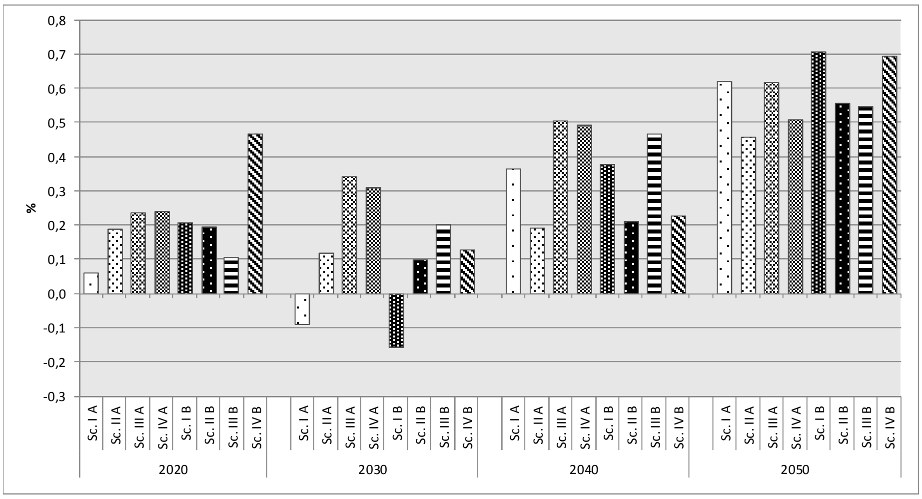


Figure 3: GDP in constant prices – percentage deviations from the reference

Impacts on GDP components are linked to changes in price relations. The reduction of expensive energy imports reduces domestic price increases, which are induced by higher investment for energy savings. Consumer and producer prices are therefore higher in scenario I A in 2020 and 2030 compared to the reference. After 2030, lower fossil energy imports dampen the price increase.

Table 2: Macroeconomic impacts of scenario I A: absolute and percentage deviations against the reference from 2020 to 2050

Scenario I A in comparison to reference	absolute values				deviations in %			
	2020	2030	2040	2050	2020	2030	2040	2050
Components of GDP in constant prices	deviations in bill. Euro							
GDP	1.4	-2.5	10.4	19.5	0.1	-0.1	0.4	0.6
Private consumption	-7.3	-13.4	-8.3	-3.8	-0.6	-1.0	-0.6	-0.3
Public consumption	-0.4	-0.7	-0.4	-0.4	-0.1	-0.1	-0.1	-0.1
Equipment investment	3.3	-0.4	4.9	3.8	1.3	-0.1	1.5	0.9
Construction	9.2	9.7	9.8	9.0	4.7	5.7	5.9	5.4
Exports	-0.2	-1.2	1.0	3.0	0.0	-0.1	0.0	0.1
Imports	3.1	-3.6	-2.9	-7.2	0.3	-0.3	-0.2	-0.3
Price indices	dev. in percentage points							
Private consumption	0.2	0.6	-0.1	-0.8	0.2	0.4	-0.1	-0.5
Output	0.2	0.5	0.0	-0.2	0.1	0.4	0.0	-0.1
Imports	-0.2	-0.7	-1.7	-2.4	-0.2	-0.6	-1.4	-2.0

The investment ratio, i.e. the relation of investments to GDP, will not reach more than 19 %, (the 2008 value). In all scenarios the ratio is only slightly above the reference. Crowding out and problems of financing the additional investment are not to be expected.

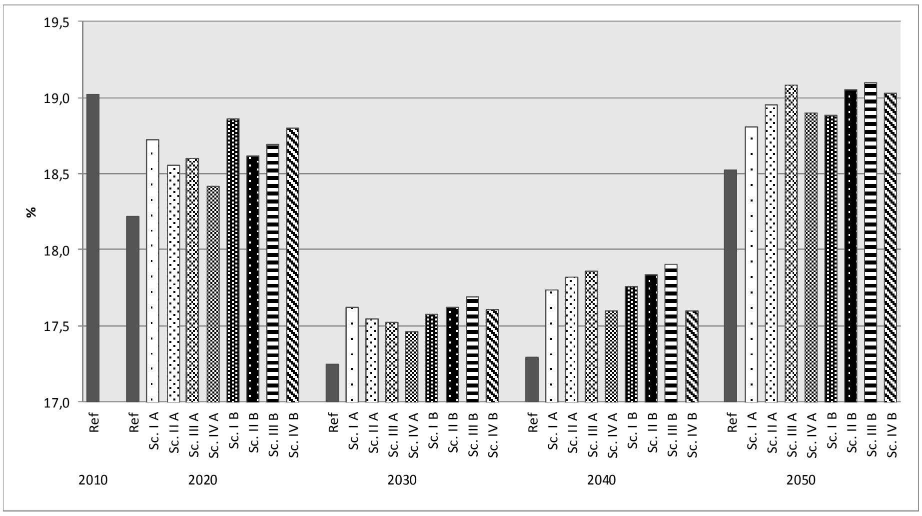


Figure 4: Investment ratio in the scenarios in per cent

On the labour market, effects are low in most scenarios until 2030. Scenarios A I and B I, however, show substantial job losses of 63 000 to 76 000 people for 2030. In 2040 all scenarios give slightly positive employment impacts. In 2050, the number of additional jobs is around 100 000.

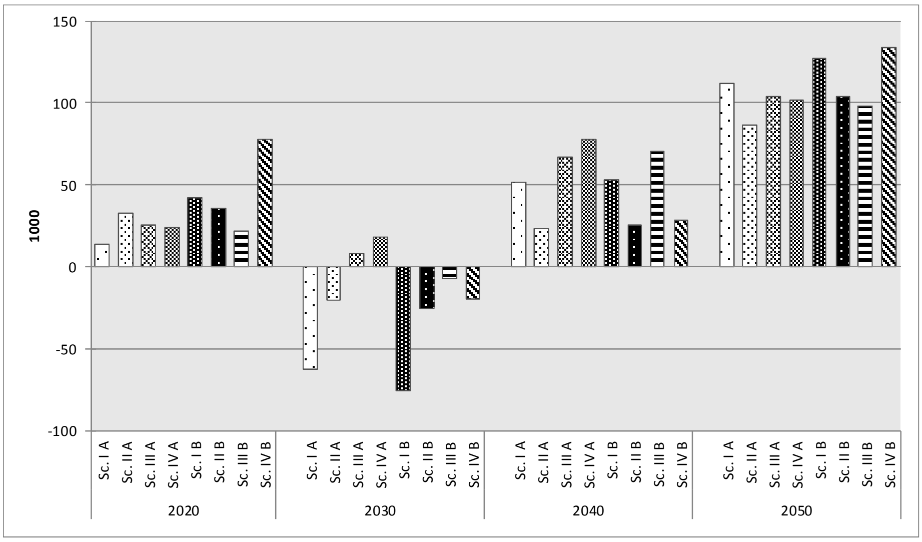


Figure 5: Employment impacts of the scenarios against the reference in 1000

The largest job impacts for scenario I A are reported for construction due to higher investment in housing insulation throughout the simulation period. Changes in manufacturing and trade are low. For mining and energy changes between providers of renewable energy and of fossil fuel and nuclear will be much higher than the low numbers suggest. Intra-industry changes are expected to be substantial. Larger employment impacts for services in absolute numbers have to be related to their overall importance. The total impacts are more positive for scenario III A.

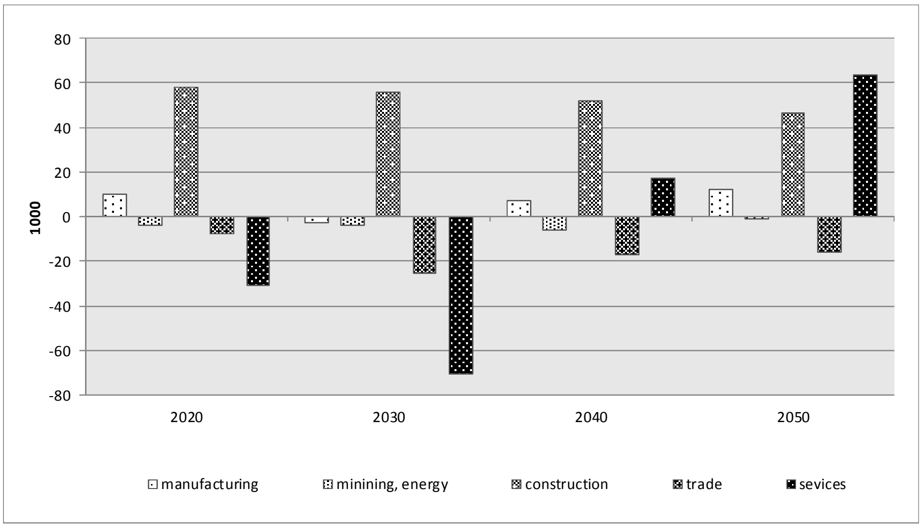


Figure 6: Employment impacts by sector of scenario I A against the reference in 1000

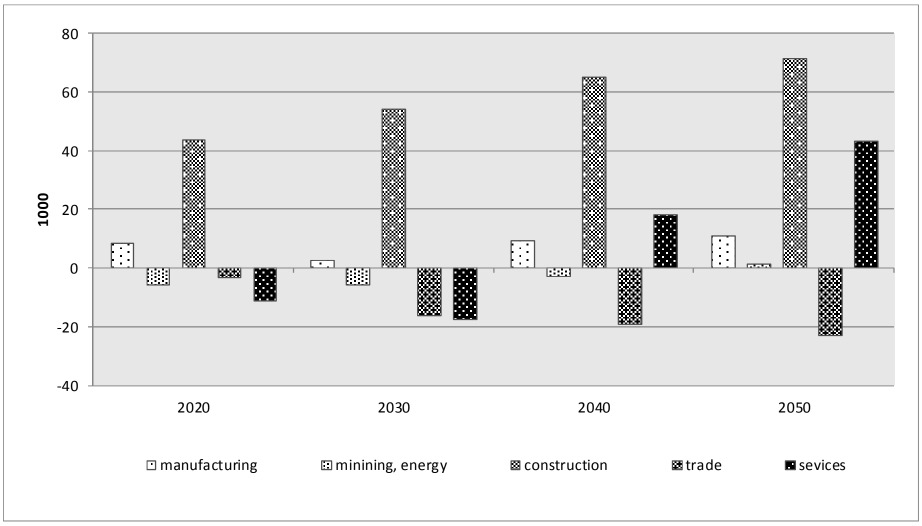


Figure 7: Employment impacts by sector of scenario III A against the reference in 1000

Labour market effects in the scenarios compared to the reference are a bit lower than GDP effects. This is caused by a structural shift of employment towards sectors with higher labour productivity and higher compensation per employee.

5. CONCLUSIONS

The macroeconomic results have to be related to the scenario assumptions and the bottom-up models that delivered the primary impulses. Three main conclusions can be drawn:

International developments can influence the national results substantially, but are difficult to foresee and largely independent of German policy action. If a global climate agreement will be reached and maintained until 2020, it will offer German industries additional possibilities to increase exports and to further improve the economic impacts without endangering energy intensive production on global markets. This also holds for the development of low carbon emission technologies. Even without an international agreement, strong market development in countries like China or India can bring down costs of these new technologies to or below costs of fossil fuel-based technologies within the next decade.

GDP is a measure for economic activity in a certain time span. Recent activities like the Stiglitz commission report (Stiglitz, Sen, Fitoussi 2009) for the French president and green growth Organisation for Economic Co-operation and Development (OECD [2011]) or green economy United Nations Environment Programme (UNEP [2011]) initiatives go beyond GDP to measure welfare and human well being. However, GDP and employment are still regarded to be the best available indicators for policy evaluation and currently without alternative. But interpretation should take external costs and benefits into account that are not (yet) monetarised. The long term problem (and costs) of nuclear waste and the benefit of avoided damages of global warming due to reduced green house gases (GHG) emissions, are not part of GDP. The long term welfare gains in the scenarios will be even higher, if these externalities are taken into account.

A considerable cut in national GHG emissions of more than 80% against 1990 levels until 2050, which is in line with reaching the global warming target of 2° Celsius, is economically viable. Depending on assumptions for additional security costs, longer lifetimes of nuclear power plants will have positive economic impacts in the medium term.

The German government decided in autumn 2010 on its new energy concept (BMU, BMWi 2010). Key components have been 8 to 14 years lifetime expansion for nuclear power plants and the need for further measures to foster renewable energy and energy efficiency. On the demand side, insulation of buildings is the most important of a number of measures. For the electricity sector, the continued expansion of partly fluctuating renewable energy sources, such as wind and photovoltaic generation, calls for new market design. Feed-in-tariffs for renewable energy sources will remain at least until 2020, but have to be adjusted to enforce the market entry of renewables.

The central targets of the new energy concept are to reduce greenhouse gas emissions by 40% by 2020, 55% by 2030, 70% by 2040 and 80-95% by 2050 (compared with 1990 levels). By 2020, the share of renewables in final energy consumption is to reach 18%, and then gradually increase further to 30% by 2030 and 60% by 2050. The share in electricity production is to reach 80% by 2050. Concerning energy efficiency, the new energy concept aims to reduce primary energy consumption by 20% by 2020 and 50% by 2050 compared to 2008. The building renovation rate is to be doubled from currently 1% to 2%. It is planned to cut energy consumption in the transport sector by around 10% by 2020 and around 40% by 2050 (BMU 2010).

In the light of the nuclear disaster in Japan in March 2011, the German government defined higher security standards for nuclear power plants. As eight older reactors could not be retrofitted to meet these higher standards, they have been shut down in the spring of 2011. The remaining nine reactors will be closed step by step until 2022. The time schedule is quite close to the plans before 2010, which means in reverse of the presented results in section 4, that economic impacts of the new German energy concept will be less favourable in the medium term than reported above. Additional measures for renewable generation and energy efficiency will have to fill the gap.

But the changes made in 2011 are marginal in the long-term and overall economic perspective of the new German energy concept. The major decisions have been made in 2010. Germany is heading for the age of renewable energy and model results indicate that this decision will pay off.

REFERENCES

AHLERT, G., DISTELKAMP, M., LUTZ, C., MEYER, B., MÖNNIG, A., WOLTER, M.I. (2009): Das IAB/INFORGE-Modell, in: Schnur, P., Zika, G. (Eds.), Das IAB/INFORGE-Modell. Ein sektorales makroökonometrisches Projektions- und Simulationsmodell zur Vorausschätzung des längerfristigen Arbeitskräftebedarfs. *IAB-Bibliothek 318,* Nürnberg, 15-175.

ALMON, C. (1991): The INFORUM Approach to Interindustry Modelling. In: *Economic Systems Research* 3, 1-7.

AGEB (2011): *Energy balances for Germany, Arbeitsgemeinschaft Energiebilanzen e.V.,* Berlin.

BMU, BMWi (2010): *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Federal Ministry of Economics and Technology (BMWi). Energy Concept,* Berlin.

BMU (2010): *Energy concept 2050. Milestones and assessments. http://www.bmu.de/english/energy_efficiency/doc/46721.php*

Deaton, A., Muelbauer, J. (1980): An almost ideal demand system. *American Economic Review.* 70 (3), 312-326.

IEA (2009): International Energy Agency. *World Energy Outlook 2009,* Paris.

IEA (2010): *International Energy Agency. Energy Efficiency Governance,* Paris.

KRATENA, K., WÜGER, M. (2006): PROMETEUS: Ein multisektorales makroökonomisches Modell der österreichischen Wirtschaft, *WIFO-Monatsbericht* 3/2006, 187-205.

KREWITT, W., TESKE, S., PREGGER, T., NAEGLER, T., SIMON, S., GRAUS, W., BLOMEN, E. et al. (2008): "Energy (R)evolution – a Sustainable World Energy Outlook." Study commissioned by *Greenpeace Int. and the European Renewable Energy Council (EREC),* Stuttgart, Utrecht, 2nd edition 2008.

LEHR, U., LUTZ, C., EDLER, D. (2012): *Green jobs? Economic impacts of renewable energy in Germany. Energy Policy 40, forthcoming.*

LEHR, U., NITSCH, J., KRATZAT, M., LUTZ, C., EDLER, D. (2008): Renewable Energy and Employment in Germany. *Energy Policy* 36, 108-117.

LINDENBERGER, D., LUTZ, C., SCHLESINGER, M. (2010): Szenarien für ein Energiekonzept der Bundesregierung. *Energiewirtschaftliche Tagesfragen,* 60, 32-35.

LUTZ, C., MEYER, B., WOLTER, M.I. (2010): The Global Multisector/Multicountry 3E-Model GINFORS. A Description of the Model and a Baseline Forecast for Global Energy Demand and CO2 Emissions. *International Journal of Global Environmental Issues,* 10(1-2), 25-45.

LUTZ, C., MEYER, B., NATHANI, C., SCHLEICH, J. (2005): Endogenous technological change and emissions: The case of the German steel industry. *Energy Policy* 33, 1143-1154.

LUTZ, C., MEYER, B., NATHANI, C., SCHLEICH, J. (2007): Endogenous innovation, economy and environment: impacts of a technology based modelling approach for energy-intensive industries in Germany. *Energy Studies Review* 15(1), 2-18.

MAIER, T., MÖNNIG, A., ZIKA, G. (2012): Labour Demand by Industrial Sector, Occupational Field and Qualification until 2025 – Model Calculations using the IAB/INFORGE Model. *Economic Systems Research, forthcoming.*

MEYER, B., LUTZ, C., SCHNUR, P., ZIKA, G. (2007): Economic Policy Simulations with Global Interdependencies: A sensitivity analysis for Germany. *Economic Systems Research* 19, 37-55.

MEYER, B., MEYER, M., DISTELKAMP, M. (2012): Modelling Green Growth and Resource Efficiency: New Results, *Mineral Economics, forthcoming.*

NAGL, S., FÜRSCH, M., PAULUS, M., RICHTER, J., TRÜBY, J., LINDENBERGER, D. (2011): Energy Policy Scenarios to Reach Challenging Climate Protection Targets in the German Electricity Sector until 2050. *Utilities Policy* 19, 185-192.

NITSCH, J., PREGGER, T., SCHOLZ, Y., NAEGLER, T., STERNER, M., VON OEHSEN, A., PAPE, C., SAINT-DRENAN, Y., WENZEL, B. (2010): Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global. *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Stuttgart, Berlin.*

OECD (2011): *Towards Green Growth,* Paris. http://dx.doi.org/10.1787/9789264111318-en
PROGNOS, EWI, GWS (2010): Energieszenarien für ein Energiekonzept der Bundesregierung. Study commissioned by *the Federal Ministry of Economics and Technology (BMWi),* Basel, Köln, Osnabrück.
STIGLITZ, J.E., SEN, A., FITOUSSI, J.-P. (2009): *Report by the Commission on the Measurement of Economic Performance and Social Progress,* Paris.
UMWELTBUNDESAMT [UBA] (2011): *National Inventory Report for the German Greenhouse Gas Inventory* 1990 – 2009, Dessau.
UNEP (2011): Towards a Green Economy. *Pathways to Sustainable Development and Poverty Eradication.* www.unep.org/greeneconomy

FORECAST AND ANALYSIS OF SOUTH AFRICA'S ELECTRICITY SECTOR

DAVID MULLINS[36], JEAUNÉS VILJOEN AND HERMAN LEEUWNER

Abstract
Since 2007, South Africa has experienced a severe lack of capacity in the generation of sufficient electricity. A key aspect of the electricity dilemma is the large discrepancy which exists between the current average Eskom selling price of electricity and the average marginal cost of providing new electricity generating capacity. The South African Inter-Industry Macro-Econometric Model (SAFRIM) was used as the main “driver” of the modelling system, in a study to analyse and forecast the electricity sector in South Africa. The projection of electricity demand is dependent on the expected growth of the various economic sectors, as well as the price elasticity existing in various economic sectors and private households. The study modelled various electricity generation technologies such as wind turbines; concentrated solar power; residential solar water heating; nuclear power; and coal fired power. The model calculates the impact on electricity tariffs, funding (including the impact of various funding options), South Africa’s foreign debt situation, inflation, economic growth and employment.
JEL Classification: C32, C53, E31, Q43, Q47
Keywords: SAFRIM; electricity demand; electricity tariffs; electricity generation sources; funding options

---

36 Conningarth Consulting Economists, Pretoria, South Africa

1. INTRODUCTION

This paper is based on the research conducted by Conningarth Economists in two projects financed by the Development Bank of Southern Africa (DBSA)[37] and the National Energy Regulator of South Africa (NERSA)[38]. Although, in these projects the objective was to a large extent a strategy to put the electricity sector in South Africa back on a sound technical and financial footing and identify the main policy guidelines, in this paper the focus is mainly on the analysis and forecasting of the electricity sector by making use of the INFORUM modelling system, supported by other econometric instruments.

2. THE ELECTRICITY POWER DILEMMA IN SOUTH AFRICA

Since 2007, South Africa has experienced a severe lack of capacity for the generation of sufficient electricity. As a result, electricity shortages and load shedding have been experienced during the last two to three years. The objective of this section is to explain the difficult position that South Africa's electricity sector is heading for, unless important strategic decisions are taken timeously. On the one hand, electricity supply capacity has to be expanded in order to ensure that the economy will realise its (long-term) development potential. On the other hand, the electricity supply expansion will create a large demand for capital funding, which could necessitate significant increases in electricity prices. This in turn could also lead to large increases in local and foreign loans, which could in turn lead to a negative impact on South Africa's debt position and credit rating.

A key aspect of the electricity dilemma is also that, in South Africa's electricity utility, Eskom, a large discrepancy exists between the average current selling price of electricity and the average marginal cost of providing new electricity generating capacity. If one were to assume

---

37 Guidelines/Principles for the Optimal Provision of Electricity in South Africa – an Economic Growth and Development Perspective (2010): Development Bank of Southern Africa.

38 Development and Implementation of a Model to be used for economic impact assessment of regulatory decisions taken by NERSA (2011): National Energy Regulator of South Africa (NERSA).

that increasing electricity prices is the only solution to the dilemma, then this would mean that the current tariff would have to be more than double in order for it to cover the marginal cost of new power stations.

Due to the importance of electricity as an input for production in the South African economy and the knock on effect of electricity prices on the prices of other goods and services, the sharp increase in electricity prices described above would have a substantial negative effect on inflation. Firstly, it would drive the inflation rate far beyond the inflation target that has been set by the South African Reserve Bank, which is between 3% to 6%; and secondly, it would have substantial negative effects on South Africa's international competitiveness, which in turn will have a decreasing effect on export demand and an increasing effect on import demand, with a high net negative effect on the current account of the balance of payments.

3. CURRENT SUPPLY AND DEMAND OF ELECTRICITY IN SOUTH AFRICA

3.1 Current Supply of Electricity in South Africa

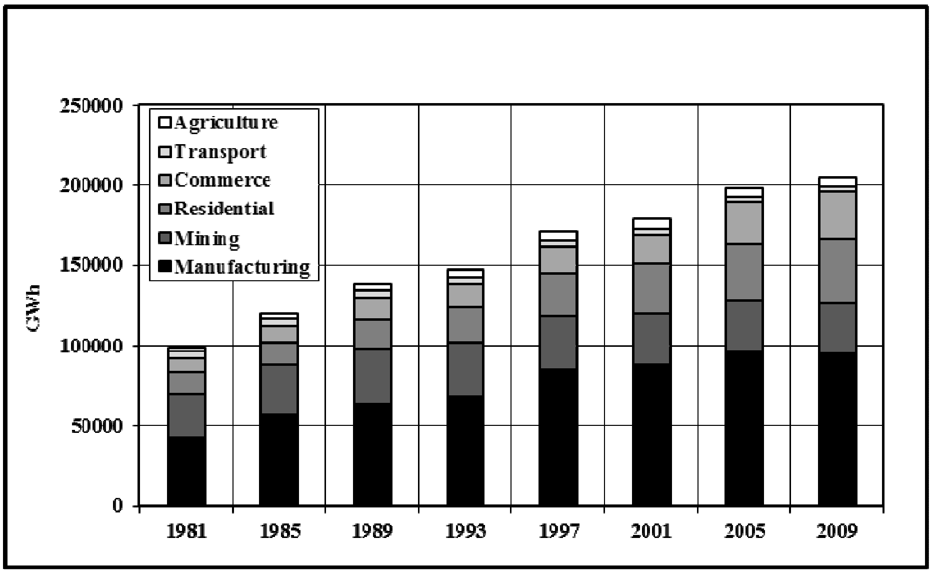
It is important that the supply and demand for electricity be balanced as closely as possible for both technical and economic reasons. Excess supply capacity will leave expensive assets unutilised, with a resultant negative impact on economic growth. On the other hand, a shortage of supply will constrain economic growth. Table 1 below shows the supply mix of Eskom's total net maximum generation capacity in MW, in the 2008/9 financial year.

Table 1: Power Stations by Production Source

Power stations by production source	Total net maximum capacity (MW)
Coal-fired stations	34 294
Gas/liquid fuel turbine stations (Acacia, Ankerlig, Gourikwa and Port Rex)	2 409
Hydro-electric stations	600
Pumped storage schemes (Drakensberg and Palmietrivier)	1 400
Wind energy (Klipheuwel)	0
Nuclear power (Koeberg)	1 800
Total	**40 503**

3.2 Current Demand for Electricity in South Africa

During 2000 to 2007, South Africa experienced high economic growth, and this, together with the concomitant commodities boom, resulted in an average electricity demand growth of 3.5% during this period. The mining and manufacturing industries are the two largest consumers of electricity in South Africa. However, their share is decreasing, which is typical of an economy slowly moving towards becoming more services based. Demand by the mining sector has actually remained reasonably constant over the period under review, despite the declining gold mining industry. Figure 1 below shows an estimate of the historical electricity demand of all the different sectors of the economy.



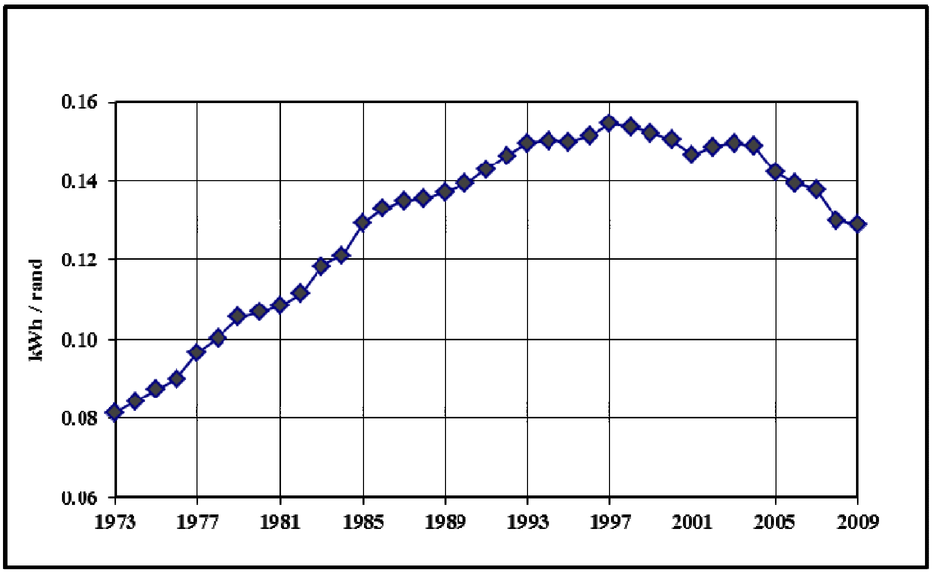
Source: Estimates based on NERSA data up to 2005

Figure 1: SA Electricity Demand by Sector-Sales

3.3 South Africa's Electricity Intensity

Electricity intensity is defined as the amount of electricity consumed for one Rand of GDP produced in real terms. Although growth in output of the economy *per se* is a major driver of electricity consumption, the electricity intensity of the economy has a major bearing on current and future electricity demand. If, for example electricity intensity is on the increase, it will add to the demand for electricity over the period.

Figure 2 below shows the course or trend of the historical electricity intensity of the South African economy over time. The decline in intensity since 1997 is due to the fact that South Africa's economic structure had been changing towards becoming more secondary and tertiary industry sector based.



Source: StatsSA

Figure 2: South Africa's Total Electricity Intensity (GDP 2005 = 100)

4. LINKING THE ELECTRICITY SECTOR TO THE INTER-INDUSTRY MACRO-ECONOMETRIC MODEL

The Inter-Industry Macro-Econometric Model (IM) was used as the main "driver" for the modelling system, which must incorporate the electricity sector. After selecting the INFORUM based macro-econometric model (re-named as SAFRIM – the South African Inter-Industry Macro-Econometric Model) as the main "driver" of the modelling system, the electricity sector and its inter-relationships with the rest of the economy were modelled and linked to a macro model, named the Electricity Growth model.

The SAFRIM Model was developed by Conningarth Economists, and assisted by Clopper Almon of the University of Maryland in 2006. It is based on a standard INFORUM framework approach (Almon, C., 2004). By making use of Excel Spreadsheet analysis, the electricity sector and its inter-relationships with the rest of the economy were modelled. With SAFRIM as the main driver of the Electricity Growth model and its linkages to the Excel Spreadsheet modelling system, a workable South African system is arrived at (see Figure 3 below):

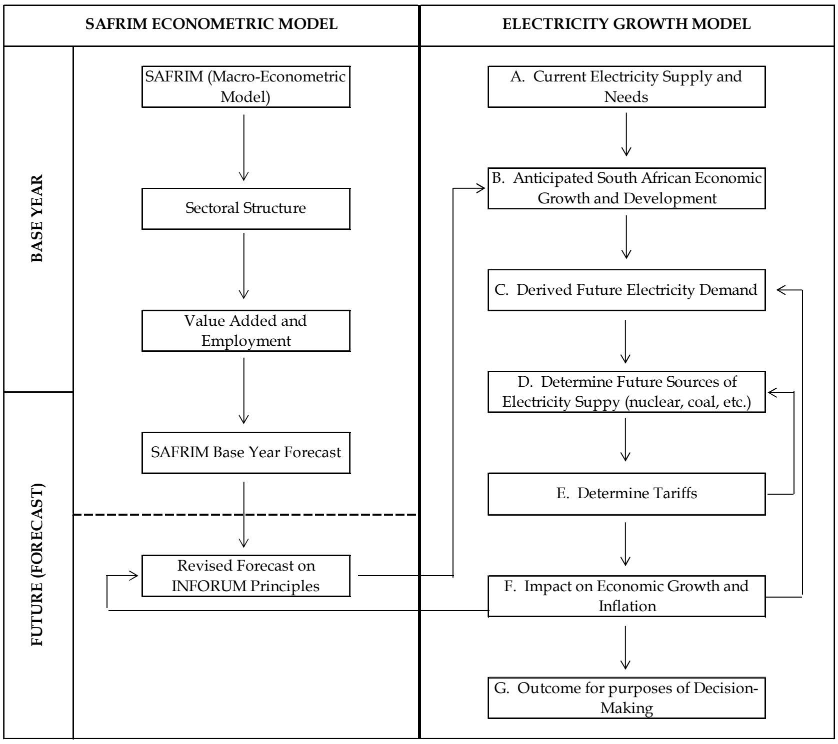


Figure 3: SAFRIM Model linked to the Electricity Growth Model

From this figure it can be deduced that the Electricity Growth Model is driven by the outcome of the SAFRIM model and in particular the values of sectoral production.

4.1 Framework of the Electricity Growth Model

The components (A to F), as per the Framework of the Electricity Growth Model in Figure 3 above, are discussed below

A. Current Electricity Supply and Demand

The 2010 supply of and demand for electricity constitutes the base year of the forecast of the supply and demand for electricity. The global demand and supply figures were directly derived from the Eskom Annual Report (2010). In order to apportion the global demand and supply figures, on an industry level, electricity/production coefficients were used, developed by Conningarth Economists for Eskom (Guidelines/Principles for the Optimal Provision of Electricity in South Africa – an Economic Growth and Development Perspective [2010]).

B. Anticipated South African Sustainable Economic Growth and Development

The point of departure of the economic impact assessment model, to optimise electricity supply and demand, is the current long-term forecast of the South African economy on a 46 sector basis. The forecast is done by SAFRIM, combining the main features of key macroeconomic models, i.e. they are macroeconomic since they depict the behaviour of the economy as a whole, and produce projections for aggregated GDP and its components. They are multi-sectoral as they include Input-Output (I-O) accounting that shows intermediate consumption, and they integrate intermediate input prices with sectoral price formation, reflecting the actual economy in a bottom-up approach.

C. Derived Future Electricity Demand

The projection of electricity demand is dependent on the expected growth of the various economic sectors, as well as the course that the real price of electricity is expected to follow. The model makes use of detail long-term average sectoral electricity price elasticities for South Africa.

The model also forecasts the electricity demand for household consumption based on the growth in the number of households, as well as the growth in intensity of usage per household. The growth in intensity of usage, per definition, takes into account the substitution effect between various electricity sources.

Provision is also made in the model for additional electricity capacity required. The demand for electricity at a given moment is not *per se* equal to the generating capacity installed by the electricity industry. The reason being that, for example, technical/engineering allowances have to be made for energy efficiency imperatives, such as the necessary reserve margin and decommissioning of existing generation plants, to be able to calculate what a reasonably safe and workable capacity is.

D. Determine Future Sources of Electricity Supply (Nuclear, Coal, etc.)

The model makes provision for various sources of electricity supply, such as nuclear power, different renewable energy sources and coal firing. The model allows the analyst to make a choice of the electricity supply magnitude of nuclear power and the different renewable energy sources. However, the model uses coal as the residual source of electricity supply. The renewable energy sources that were modelled are Wind Turbines and Concentrated Solar Power (CSP). The potential of Residential Solar Water Heating (SWH) is also taken into account in the model.

E. Derived Tariffs

The future electricity tariffs are a derivative of the demand and supply factors. The electricity tariff is thus a derivative rather than a price which the market can necessarily bear. The model calculates various aspects of the future electricity tariff, namely the marginal tariff of new generation capacity, the marginal tariff of the different electricity sources, as well as the average tariff (combination of old capacity and new capacity sources) at any given point in time in the future.

F. Impact on Economic Growth and Inflation

The model serves as a complete dynamic inter-linked system. Changes in electricity tariffs lead directly and indirectly to inflationary impacts by making use of the Leontief Price Model, which in turn has an effect on economic growth and development. Furthermore, a change in tariff leads to a change in direct demand for electricity through the price elasticity of electricity demand. The Electricity Growth Model caters for these interactions by means of a process of convergence through iterations.

The model provides results on the impact of various scenarios regarding electricity supply, demand and funding options and are depicted in terms of macroeconomic indicators. For instance, the financial indicators constitute aspects such as an increase in electricity tariffs; and macroeconomic indicators in terms of economic growth; employment opportunities; inflation; etc.

4.2 Additional Modelling

The functioning of the electricity sector in all its facets and the impact thereof on the South African economy were described and analysed through a set of physical (technical), financial and economic modules, linked into a comprehensive interactive user friendly modelling system. It is important to note that the various modelling aspects are linked. The model system can, for example, show that if more funds are invested in the electricity sector the electricity tariff has to increase to service the additional financing cost. If the electricity tariff increases inflation is impacted negatively. This in turn will have a negative effect on economic growth and employment, with subsequent effects on the need and demand for electricity, which will then again have a bearing on the need to invest in electricity in the first place.

4.3 Computer Software

The INFORUM model uses very sophisticated programming software, where some hand-coding in C++ is necessary. To render this system more user-friendly, the entire INFORUM based modelling system was translated into a user-friendly system based on Excel Spreadsheets. The main purpose was to link the Electricity Satellite Model with the macro model. This user-friendly model is menu-driven and has various result tables to depict the impact of electricity policy scenarios on financial, economic and social indicators.

5. FUTURE ELECTRICITY DEMAND AND REQUIRED ELECTRICITY EXPANSION IN SOUTH AFRICA

5.1 Economic Growth Projections

The SAFRIM model captures the integrated nature of the South African economy in terms of the linkages that occur between economic sectors and households throughout the national economy. Furthermore, the model also captures the linkages that exist between the South African national economy and its international trading partners by incorporating imports and exports into the model. As such, the forecasts produced by the SAFRIM model are based on macroeconomic data that provides a broad and high level of perspective on the national economy.

The results of the projection by the Macroeconomic Forecasting Model (MFM) indicate that the most likely long-term GDP growth rate from 2010 to 2025 will be in the order of 3.7% per annum. This growth rate is very much in line with a growth of 3.6% p.a. which was obtained over the last decade. The main final demand "drivers" of this outcome are shown in the Table 2 below.

Table 2: Estimated Long-Term Economic Growth for Final Demand Components and Gross Domestic Product

	GDP Growth rate per annum		
	2010-2025	**2010-2015**	**2016-2025**
Final Consumption Expenditure by Households	3.70%	4.40%	3.80%
Final Consumption Expenditure by Government	3.20%	3.70%	3.20%
Gross Capital Formation	4.60%	6.50%	4.80%
Exports of Goods and Services	3.80%	3.90%	4.00%
Imports of Goods and Services	4.20%	5.20%	4.70%
Total Real Gross Domestic Product	**3.70%**	**3.80%**	**3.70%**

Note: Growth in 2010 is included in the above projections.

The exports are mostly derived from a bottom up research approach where government expenditure was based on an assumption. The other components form an integrated/endogenous part of the modelling system. Key economic "drivers" such as population growth, government expenditure, global economic trends and international trade, were also applied (South Africa being regarded as the Gateway to Africa).

Regarding assumptions on these drivers, cognisance was taken of the Harvard report[39], especially the recommendations. Key issues include high unemployment levels consisting of mainly unskilled labour and the serious shortage of skilled labour, the limited ability of South Africa to increase its exports in line with its main trading partners, and the limitations in existing infrastructure placed on economic growth.

---

39 South Africa: Macroeconomic Challenges after a Decade of Success: September 2006: Harvard Report

5.2 Estimation of Future Electricity Demand

5.2.1 Electricity Price Elasticity

Price elasticities, as well as the growth of the various sectors, have been incorporated into statistical functions for electricity demand estimation in order to forecast electricity demand. It is important to note that an iterative process was adopted in modelling electricity demand. This is due to the fact that the assumed increase in the required electricity tariff will have an effect on the demand for electricity, which in turn has an effect on the amount of funding needed to finance new electricity generation capacity, which in turn will affect the electricity tariff, which again affects demand and thus sets off the iterative process until an equilibrium is reached.

5.2.2 Forecast of Electricity Demand

As explained above, the projection of electricity demand is dependent on the expected growth of the various economic sectors, as well as the course that the real price of electricity is expected to follow. Furthermore, it is important to note that the model used was constructed in such a way that price changes will have an effect on demand, and demand in turn has an effect on prices. If the average calculated increase in real electricity prices over the period 2010 to 2025 is 3.7% per annum, it implies that the electricity price in real terms will be 97% higher in 2025, than the current price.

In Table 3 below, the forecasted average growth of electricity demand from 2010 to 2025, before and after tariff adjustments, is depicted. According to this table, it is projected that the most likely long-term growth in the South African economy will, as mentioned before, be 3.7% per annum on average. This growth rate will be accompanied by a growth rate of 3.4% in the demand for electricity. This is, however, without consideration of any real price changes, which implies that the electricity price will only increase in accordance with the general inflation rate. If it is assumed that the price of electricity will increase in real terms by an average of 3.7% per annum, over and above the projected inflation rate (baseline scenario), the electricity demand growth will decline to 2%. This outcome is reflected in the lower growth of 3.5% per annum for the economy in general.

Table 3: Average Growth Rate from 2010 to 2025, Before and After the Real Electricity Price Adjustment of 3.7% per annum

	Average Growth Rate (2010 - 2025)	
	Before Price Adjustment	**After Price Adjustment**
South African Economy	3.7%	3.5%
Electricity Demand (GWh)	3.4%	2.0%

6. ELECTRICITY GENERATION SOURCES AND COSTS OF THE ELECTRICITY DEVELOPMENT PROGRAMME IN SOUTH AFRICA

In this section the estimated capital and operational costs of the electricity development programme, intended to meet the future demand for electricity, are shown. The section describes the methodology used for quantifying new electricity generation capacity requirements from each of the various electricity generation technologies.

6.1 Generation Technologies

In addressing the question of programme costs, the following electricity generation technologies were modelled:

- Wind Turbines;
- Concentrated Solar Power (CSP), incorporating Power Tower technology;
- Residential Solar Water Heating (SWH);
- Pressure Water Reactor (PWR) Nuclear; and
- Supercritical Coal Firing with Flue-Gas Desulpherisation (FGD) technology.

In the case of Wind, CSP, SWH, and Nuclear, a 'pragmatic' approach was adopted to determine the volume of electricity that could be supplied from these technologies over the course of the next 25 years.

As stated earlier, coal has been treated as a 'residual' technology, used to balance electricity demand and supply once the other technologies have been taken into account. In determining the aggregate MW output for each technology modelled, the approach was adopted of utilising a standard generation plant size for each technology, i.e.:

- Wind Farms: 100 MW
- CSP Plants: 100 MW
- Nuclear: 4 000 MW
- Supercritical Coal: 4 800 MW

In the case of residential Solar Water Heating, households were divided into three categories: High Income Households, Middle Income Households, and Low Income Households. An appropriate SWH system, that delivers a standard MW saving for each household category, was then used for each category of household.

In modelling the above technologies, it was assumed that individual plants will be built over a number of years, and that these plants will, during the construction phase, be able to supply at least a portion of its maximum potential electricity generation. Within this context, it was assumed that wind farms and CSP plants will have a construction lead time of three years; whilst new supercritical coal-fired power stations and nuclear power stations will have a construction lead time of six years. These lead times are in line with those used in other local and international studies.

6.2 Determining the Capital Cost of Building New Electricity Generation Capacity

In order to determine the capital cost of the new electricity generation capacity described above, construction costs per MW for each of the technologies modelled, were used and derived from the various published sources described above i.e. the Long Term Mitigation Strategies Input Report 1[40] and the Costing a 2020 Target study[41]. In

40Long Term Mitigation Strategies Input Report 1: Energy Research Centre, University of Cape Town (October 2010).

41 Costing a 2020 Target study of 15% Renewable Electricity for South Africa: Energy Research Centre, University of Cape Town (October 2008).

addition, an amount was incorporated into these capital costs for connecting individual plants to the National Grid. A comparison of the cost of the various energy sources, as per kWh is depicted in Figure 4 below:

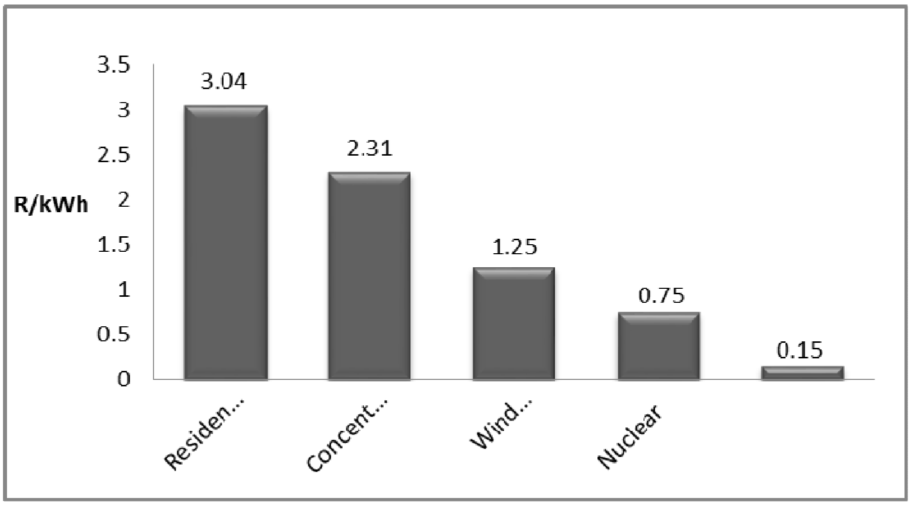


Figure 4: Comparison of Energy sources' Cost per kWh, 2009 prices.

The investment costs for new electricity generation infrastructure are massive in absolute and relative terms and cost overruns would have major opportunity costs and implications. Development of electricity generation capacity holds major financial implications for both Eskom and the economy.

In the baseline scenario, the total cost of the programme over the programming period is R 780 billion. In terms of scale comparatives this is equivalent to:

- About 9% of South Africa's gross savings over the period.
- Or 89% of South Africa's net savings over the period.

Figure 5 below shows the current (2010) and incremental future (2025) electricity supply source mix - percentage of total and new capacity.

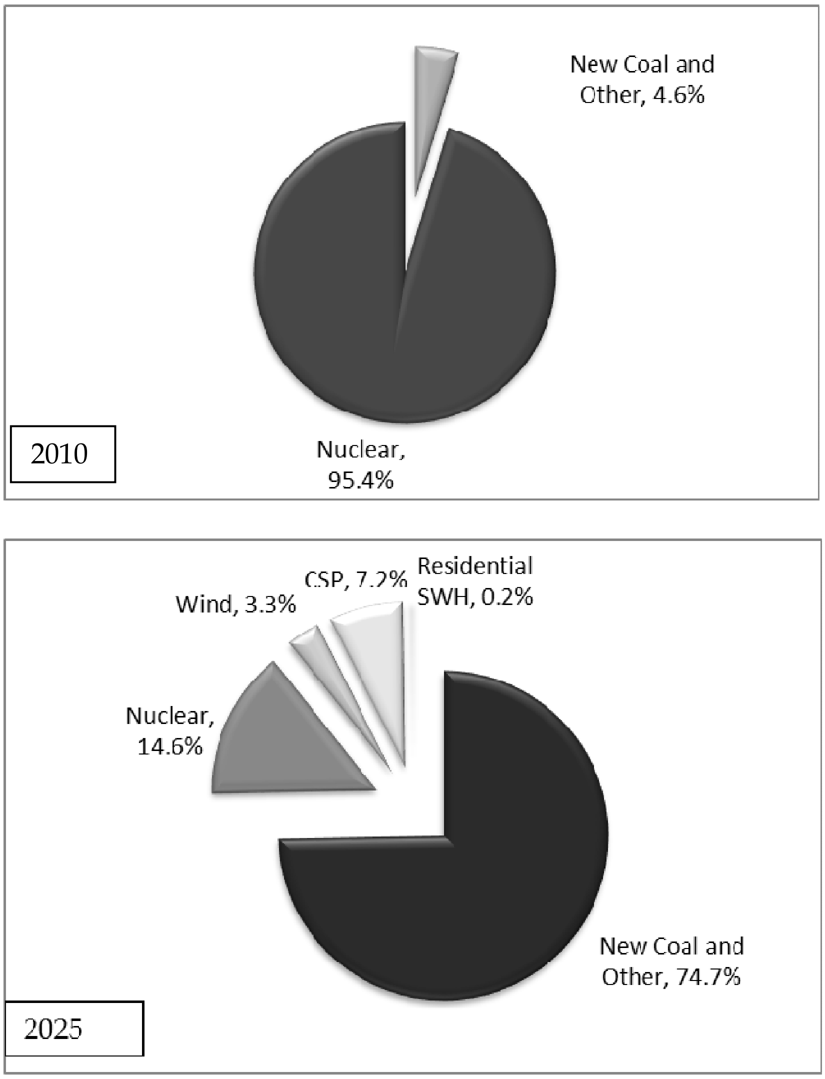


Figure 5: Current and Incremental Future Electricity Supply Source Mix for 2010 and 2025 - Percentage of Total and New Capacity

7. FUNDING OF THE ELECTRICITY GENERATION INVESTMENT PROGRAMME - IMPLICATIONS OF ELECTRICITY INFRASTRUCTURE FINANCING OPTIONS

7.1 Financing New Capacity

The provision of additional electricity generation capacity to the South African economy and the financing thereof holds implications for both the economy and Eskom. Apart from the infrastructural capital formation, with its positive impact on the economy, the financing options chosen for funding the investment could have far reaching repercussions for economic growth and inflation. The price of electricity (tariffs) will to a large extent be derived from the amount of capital needed for the investments as well as the options decided upon for financing that capital. The amount and the method of financing new generation capacity, and the technology combinations that can be utilised, have an important bearing on the electricity tariff and the performance of the economy - with varying impacts on different sectors. There are essentially four broad ways of financing capital formation of electricity infrastructure.

7.2 Loans

Loans could vary from short- to long-term loans. For purposes of financing capital formation (fixed investment), the conventional asset life / loans match was assumed to be the most appropriate tenor. These loans are redeemed over the life-span of the investment, while depreciation (consumption of capital) of the asset is written off accordingly over the asset life. The real cost of the loans is accepted as the prevailing social discount rate of 8% per year for South Africa. The real social discount rate is determined by the expected real return on investment given the scarcity of capital in a region/country.

Financing through long-term loans implies that the cost of expanding the supply capacity is spread over the lifespan of the capital asset, and that tariff implications should therefore also be distributed over the lifespan of the asset created.

7.3 Financing from Current Income

The investment in new capacity could be financed from the current income of Eskom by increasing tariffs sufficiently to create an annual surplus to finance the incurred capital expenditure. In this case, tariff increases will be much higher in the initial years, but will taper off markedly over the lifespan of the asset.

7.4 Equity Increase

Non-financial corporations are legal entities that are created for the purpose of producing goods or services for the market. They may be a source of profit or other financial gain to their owners. Government should consider increasing its equity holding in Eskom, a public sector entity, thereby strengthening its balance sheet over the short to medium term. By increasing the equity holding, the balance sheet could be strengthened in order to acquire more and cheaper loan finance in future. Equity provision by the state would also have to be seen as an annual capital grant and an integral part of the financing options. It was assumed that government (sole owner of Eskom) will increase its equity at a lower than market rate.

7.5 State Grants for Social Development and Responsibility

Eskom's main responsibility is to provide electricity at the lowest cost to a growing economy. Through Government's burdening of Eskom with a social responsibility, it was forced to either recover the cost of electricity provision to the socially deprived households from other electricity users, or to accumulate losses. It is quite apparent that Eskom, and other electricity users, are in no position to accept a financial burden at the peril of its sole mandate to generate electricity. The statutory obligations of Eskom should be revisited if necessary. As can be seen from the above four options for financing capital formation in the electricity sector, each alternative has unique implications for tariffs. By combining these types of finance into a financing package, the tariffs component can be adjusted such that the most optimal results for Eskom and sustainable economic growth are achieved in the longer term.

8. IMPACT ON SOUTH AFRICA'S FOREIGN AND PUBLIC DEBT SITUATION

It is necessary to take a holistic view of the effect, which changes in Eskom's debt situation will have on South Africa's foreign debt situation, especially with regard to the public sector. The public sector includes the general Government and a range of Government business enterprises (including public corporations). Graph 5 below provides information on likely trends in foreign debt resulting from various criteria such as foreign liability as percentage of GDP; total loans as percentage of GDP; public sector loans and debt securities as percentage of GDP and public sector debt as percentage of GDP. The most important of these are the public sector foreign debt and the public sector debt. Public sector debt consists of domestic and foreign debt in the form of direct loans outstanding, and securities issued in the primary capital markets. In 2009, the total domestically sourced public sector debt amounted to 33% of GDP, with foreign liabilities amounting to 10.4% of GDP. Total debt of the public sector in relation to GDP therefore stood at 43.4% in 2009. This ratio is set to increase to 45.4% in 2010 and to some 72% in 2025. It is assumed that Eskom will have to obtain the bulk of its long-term financing needs through loans and other forms of securities from abroad. The financing option according to the baseline scenario will see foreign debt of the public sector increase from 12.4% of GDP in 2010 to about 39% of GDP in 2025.

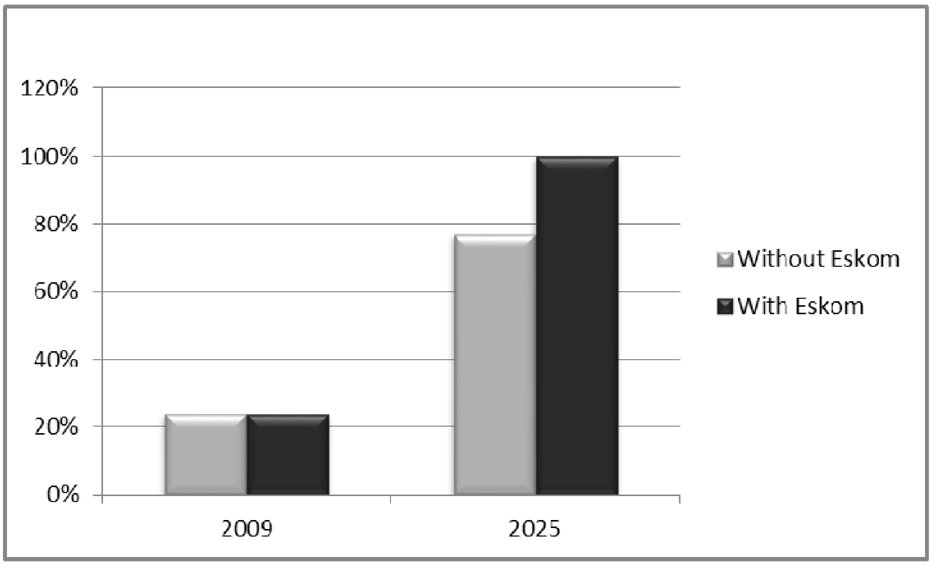


Figure 6: Total South African Foreign Debt as a Percentage of GDP

Foreign liabilities (total loans as a % of GDP) for 2010 stood at 28% of GDP. According to forecasts using the SAFRIM model and based on an assumption that South Africa (private and public sector) should invest at least 25% of GDP each year up to 2025 in order to sustain the predicted growth rate in the economy. The South African foreign debt as percentage of GDP can increase to about 78% without taking into account Eskom debt and 100% with taking it into account respectively.

9. MACROECONOMIC IMPACT OF FUTURE DEVELOPMENT OF THE ELECTRICITY INDUSTRY

A baseline scenario was constructed which was compared with a number of alternative scenarios. The baseline scenario is configured to reflect preferred strategic options within a number of dimensions namely, generation technology mix, financing options mix and likely economic growth rate and associated derived demand for electricity. The main outcome of the baseline scenario can be summarised as follows:

- In order to fund the considerable investment required to create the necessary electricity infrastructure, an increase in the electricity tariff in real terms is required. According to the baseline scenario, it is foreseen that the real electricity tariff will increase by 3.5% p.a. which will lead to an increase in the general inflation rate of 0.5 percentage points, on average p.a., over the period 2009 to 2025. This means that the projected inflation rate will increase to 6.5% p.a. over the programming period compared to 6.0% if the effect of the real electricity tariff increases on inflation is not taken into account.
- The ultimate impact of electricity tariff increases on inflation and the impact of inflation on economic growth are to a large extent dependent on the policy measures that fiscal and monetary authorities take to curb its effects. For instance, to counter the negative effects on the country's international trade competitiveness, the Rand exchange rate could be allowed to weaken. This will, however, lead to further inflationary impacts and thus could prompt the monetary authorities to increase

interest rates to defend inflation targets. In terms of the specifications of the modelling used (Input-Output analysis and the INFORUM Macroeconomic Model), it was decided to "close the model" by allowing international competitiveness to deteriorate in line with the additional inflation. However, it is important to note that it does not really matter which policy measures are used to curb the impact of inflation, as each of such measures has consequences. South African production costs will increase relative to those of its international trading partners, thus weakening the country's international trade competitiveness. This is true for both increases in interest rates and a weakening of the Rand.

- In the baseline scenario, economic growth rates will be constrained by an increase in real electricity tariffs. The projected economic growth rate (measured in terms of the gross domestic product before taking into account the increase in real electricity tariffs), is projected at 3.7% p.a. over the programming period. If the assumed real electricity tariff increases are taken into account, GDP growth is reduced to 3.5% p.a. It is important to note that, under some alternative funding options to finance the required investment, for example, 100% loans, or 100% from current income, real electricity tariffs will need to be even higher than in the baseline scenario. The negative effects on economic growth and employment would be even more pronounced.
- Employment creation suffers when the economic growth rate decreases. In the baseline scenario, if generation capacity is expanded without recourse to real electricity tariff increases, some 492 774 more employment opportunities would be created than if the envisaged real tariff increases, with its constraining effect on economic growth, were implemented. It is also estimated that the negative impact, of no new investment in electricity generation capacity, will result in the forfeiting of about 2 million potential employment opportunities by 2025.

In order to assess various decision options for the expansion of generating capacity and the method of financing, four alternative scenarios, other than the baseline scenario, were developed and are listed below:

- Scenario 1: No Electricity Generation Expansion
- Scenario 2: High Electricity Demand
- Scenario 3: High Loan Funding
- Scenario 4: High Current Income Funding

The above scenarios do not necessarily represent an exhaustive list of possibilities. Rather they serve to demonstrate the sensitivity in terms of financial and economic consequences of the development of electricity generation capacity to variations in key assumptions and decision parameters. Table 4 below (Scenario 3 section) reflects the results of the baseline scenario as well as the results of the four alternative scenarios. The results of the analysis of each alternative scenario are discussed below with particular reference to its main findings, drivers and implications.

Scenario 1: No Electricity Expansion

The first alternative scenario estimates the impact on the South African economy if there is no further increase in electricity supply. In this scenario the economic growth rate in terms of GDP will decrease from the baseline scenario growth of 3.5% p.a. to a maximum of 2.5% p.a. It should be kept in mind, however, that a 1.0 percentage point drop of average growth to 2.5 percent p.a. would imply significant energy utilisation adjustments in the economy, as the outputs in the economy will still be 44.8 % higher after 15 years of 2.5% growth p.a.

However, in terms of employment, the opportunities foregone will accumulate to almost 2 million by the year 2025, compared to employment creation in the baseline scenario.

Scenario 2: High Electricity Demand and Supply

This scenario considers the impact on the South African economy of meeting a high demand for electricity. The scenario could materialise if the price elasticity of demand for electricity is lower than estimated and the demand for electricity thus grows faster despite an increase in real tariffs. For purposes of this scenario a 5.6% growth p.a. in electricity supply capacity was assumed, for the required increase. In this regard it is important to note that it is not the level of economic activity that will increase relative to the baseline scenario, but the assumption on the required increase in electricity supply. In comparison the baseline scenario estimates the required increase in electricity supply capacity at 2.7% p.a.

If the impact of price elasticity on electricity demand is overestimated and electricity demand grows faster than anticipated in the baseline scenario, Scenario 2 indicates an additional required electricity capacity of 58 518 MW by 2025. This is more than double that of the baseline scenario. The impact of this eventuality is that the capital required to fund this expansion (R1 644 billion) is over 50% more than needed for the baseline scenario (R779 billion). This high electricity demand and supply scenario will increase South Africa's foreign liabilities (total loans as a percentage of GDP) to almost 119%, which is 20 percentage points higher than the baseline. This result will place South Africa's international credit rating under further pressure.

However, an important point to note is that from the model specification and assumptions, the real tariff by 2025 will only be slightly lower in this scenario than in the baseline scenario. The reason is that in the model, the additional supply capacity is assumed to come from new coal-fired power stations. Coal-fired power stations are a relatively cheaper source of electricity compared with nuclear and renewable energy. In this scenario, coal represents a larger portion of the electricity resource mix, and the envisaged tariff decreases.

Scenario 3: High Loan Funding

This scenario investigates the impact of a change in the composition of the funding package, where loan funding plays a more significant role than in the baseline scenario. In this scenario, it is still accepted that the Government participates in funding the expansion via social grants, but that the remainder will be financed via loans. Current income will only be used to meet operating costs (including depreciation), and not to finance capital costs at the required level of investment. The financing structure of the high-loan-funding-scenario compared to the baseline scenario, is as follows:

Table 4: Financing structure of the high-loan-funding-scenario compared to the baseline scenario

Financing Structure	Baseline Scenario	High Loan Funding Scenario
Loans	60.6%	90.6%
Direct Finance from Current Income (excl. the impact of 2010 tariff increase on capital financing)	0.0%	0.0%
Government Equity	30.0%	0.0%
Social Recurrent Grant	9.4%	9.4%
Total	**100.0%**	**100.0%**

The main difference between the baseline scenario and the high-loan-funding-scenario is the fact that Government does not take up any equity, and that loan funding constitutes a high portion of this scenario's funding package. The impact of increasing the loan proportion of the funding package manifests predominantly on the real electricity tariff. In this case the real tariff will have to increase by about 4.5% p.a. over the programming period. By 2025 this would push Eskom's electricity tariff from 59c/kWh, as calculated in the baseline scenario, to 68c/kWh.

The macroeconomic impact of this scenario relative to the baseline scenario is that it will have a more pronounced negative impact on South Africa's Balance of Payments than the baseline scenario. The substantially higher real tariff increases necessary in this scenario, will impact on the country's international competitiveness and thus impact negatively on the export performance. A substantial decrease in exports would be anticipated and imports would be expected to rise. This will lead to a dampening of the long term economic growth performance relative to the baseline scenario, leading to a further possible forfeiting of nearly 175 000 potential employment opportunities by 2025.

A high loan funding scenario could have negative implications for Eskom's financial situation and credit rating as well as inflate aggregated public sector debt. If the financial obligations were transferred to the Government, there is the option of funding from the Fiscus. However, if the Fiscus were to borrow the funds in the capital markets, public debt ratios would increase and impact negatively on the Government's credit rating. Loan funding raised abroad, or guaranteed by the Government could mean pressure on the country's sovereign credit rating. On the other hand the Fiscus has the ability to increase taxes or reduce expenditure on other goods and services in the economy, in order to make the relevant funds available for funding electricity generation expansion and is, therefore, not forced to raise such funds in the capital markets.

Scenario 4: High Current Income Funding

The fourth scenario provides an indication of the nature of the impact on the economy if capital costs are funded from current income raised via tariffs. In analysing this scenario, it was assumed that 50% of the funds required will be directly financed by current income. This compares to no recourse to direct finance from current income in the baseline scenario. A comparison between the baseline scenario funding package and the high-current-income-funding-scenario package is depicted in Table 5 below:

Table 5: Comparison between the baseline scenario funding package and the high-current-income-funding-scenario package

Financing Structure	Baseline Scenario	High Current Income Funding Scenario
Loans	60.6%	50.0%
Direct Finance from Current Income (excl. the impact of 2010 tariff increase on capital financing)	0.0%	50.0%
Government Equity	30.0%	0.0%
Social Recurrent Grant	9.4%	0.0%
Total	**100.0%**	**100.0%**

It is important to note that the social recurrent grant and the Government equity portions of the funding package fall away when compared with the baseline scenario.

Financing the electricity capacity expansion from current income has an even higher negative impact on the economy than the high loan funding scenario. The real electricity tariff will need to increase to 75c/kWh by 2025. Under this scenario, potential employment creation foregone will be even greater if investments are mainly financed by loans. When compared to the baseline scenario, nearly 308 000 more potential employment opportunities could be foregone.

Any increase in electricity tariffs will have inflationary impacts. In the baseline scenario modelled, inflation will increase over the programming period of 15 years, by 0.5 % per annum. Thus, arithmetically, if the annual inflation rate before electricity tariff increases is already 6% over the 15 year period, when the tariff increase is taken into account, the inflation rate per annum will rise to 6.53%.

10. CONCLUSION

In retrospect it seems that the broader modelling system used in the electricity application, including the South African Forecasting Inter-Industry Model (SAFRIM), as well as the additional modelling that was done outside SAFRIM, performed satisfactory and the results were on par with economic theory. It performed well in terms of the forecasting of the South African Economy and responded in an acceptable manner in accordance with changes in exogenous variables. It was not as rigid such that big changes in exogenous variables obtain small changes in results, which is sometimes the case with standard econometric models being dependent on lagged variables. It could, therefore, be deduced that it can be used for forecasting purposes as well as macroeconomic impact analysis. It also proved that it could be used in combination with other input-output applications.

However, it is important to note that the whole electricity application could undertake an INFORUM approach. This refers to the INFORUM theoretical approach as well as the INFORUM software. Currently the analysis was done through the INFORUM software in conjunction with the Excel Spreadsheet programme. To make the modelling system more dynamic as well as user friendly, it is probably necessary to include the whole programming system as part of SAFRIM, supported by the INFORUM software.

REFERENCES

Conningarth Economists: Guidelines/Principles for the Optimal Provision of Electricity in South Africa – an Economic Growth and Development Perspective (2010), for the *Development Bank of Southern Africa.*

Conningarth Economists: Development and Implementation of a Model to be used for economic impact assessment of regulatory decisions taken by NERSA (2011), for the *National Energy Regulator of South Africa (NERSA).*

Hughes, A., Haw, M., Winkler, H., Marquard, A., and Merven, B. (2007). Long Term Mitigation Strategies Input Report 1. *Energy Research Centre, University of Cape Town.*

Marquard, A., Merven, B., and Tyler, E. (2008). Costing a 2020 Target study of 15% Renewable Electricity for South Africa. *Energy Research Centre, University of Cape Town.*

THE SIMULATION OF HOUSEHOLD CONSUMPTION OF TURINA --TURKEY'S INTERINDUSTRY ANALYSIS MODEL

GAZI ÖZHAN[42]; WANG YINCHU[43] AND MERAL ÖZHAN[44]

Abstract
Two basic input-output (I-O) vector equations, one for prices and one for production, based on 58-sector classification are the pillars of the analysis. Nonlinear regression results for 10-category household consumption functions, in the form of a simplified PADS, are converted into the 58-sector I-O system for 2002. Due to the lack of required data, income elasticity for two categories (food and clothing) is estimated slightly above their expected magnitudes. However, historical simulation of the model over 1998-2008 shows a high degree of accuracy: About 72.65% of the 1740 results showed less than 3% error, and only 1.55% showed more than 10% error.
JEL Classification: C53, C67, E21, E27
Keywords: Turkey`s interindustry model, household consumption (PADS), policy simulation

42 European University of Lefke.
43 China Economic Information Network of the State Information Center.
44 European University of Lefke.

1. INTRODUCTION

TURINA had its basic data base ready in the summer of 2010, after a one month workshop in the European University of Lefke located in North Cyprus, and the progress was presented in the 18th INFORUM world conference held in Japan in September 2010. The prepared data base has input-output tables for each year between 1998 and 2008 and their value added and final demand sides are consistent with the national account data and also subject to the price vector equation,

$$A'p + va/out = p \quad (1)$$

On the basis of the prepared data, simulation and analysis for household consumption of TURINA, including the output, value added and price vectors' changes, were carried out during the 2011 workshop of May 27 to June 26.

In this paper, the current state of modelling with TURINA will be presented in five sections. The next section presents the framework of the modelling, which is about basic modelling logic and some related considerations. Section 3 explains the estimations of household consumption equations by category, in which a simplified PADS system, according to the real situation of household consumption category classification, was used for Turkey. Also the regression results of the value added vector, by 58 sectors, are described in this section. Section 4 is devoted to the simulations of the household consumption vector, the output vector, value added vector and price vector, in the framework of the Input-Output concept. Finally, section 5 concludes the work.

2. THE FRAMEWORK OF THE MODELLING

It was decided that to have household consumption as the first simulation and application of the model TURINA, would be a good start. The rationale for this is the fact that the share of household consumption in GDP by expenditure in Turkey is more than two thirds, as shown in Table 1 below.

Table 1: The share of household consumption in GDP by expenditure (%)

1998	2000	2002	2004	2006	2008	2009
66.5	70.5	68.0	71.3	70.5	69.8	71.5

The initial framework of the model TURINA was designed by the calculation approach summarised in the following steps:

Step 1: Give an assumed per capita disposable income in constant prices for the year when the model runs.

Step 2: Use the per capita disposable income to calculate the per capita household consumption in constant prices by 10 categories according to the equations resulting from the regression in the sample period 1998-2008.

Step 3: Convert 10 categories of household consumption per capita into 58 sectors' household consumption per capita, by using a bridge matrix and then get total household consumption by 58 sectors through multiplying the population number in that year.

Step 4: Get the final demand vector " fd " if all the other component vectors such as government consumption, fixed capital formation, inventory changes, export and import are exogenously given.

Step 5: Calculate the gross output vector out, in constant prices, according to the equation

$$out = (I - A)^{-1} * fd \quad (2)$$

Step 6: Calculate the value added vector " va" in current prices, according to the regression analysis between output in constant prices by last year's price index and value added in current prices from the sample period 1998-2008.

Step 7: For new unit value added (value added in current prices of per unit output in constant prices), va/out calculate the price index vector, p according to the equation
$A'p + va/out = p$.

Step 8: Have GDP in current prices and in constant prices, which is the sum of value added vector va and final demand vector fd , respectively.

Step 9: Have GDP per capita in constant prices and in current prices, and the GDP deflator.

Step 10: Estimate the disposable income per capita in current prices and in constant prices according to the regression analysis from the sample period 1998 and 2008.

Step 11: If the resulted disposable income per capita is very close to the one used in step 2, the model finishes the run for that year and goes to the next year. Otherwise, use this new disposable income per capita and go to step 2 for the next iteration of the model.

Obviously, the logical structure of the model is not very complicated and its key point is the relationship analysis between the value added vector in current prices and the gross output vector in constant prices, as in other countries' INFORUM models.

Further development of TURINA can be done to make the other final demand component vectors endogenous. Or it can be extended to have value added by cost component vectors, plus employment and productivity. It is also possible to develop the accounting block to include total taxes, government revenue, and so on.

However, the modelling practice got trouble from the very beginning, caused by the most simple time series data "personal disposable income". Official reporting directly about the variable "personal disposable income" could not be found in the Turkish statistics for 2010. This year, still it is not possible to find any new data directly reporting this variable.

Finally, it was given up to use the personal disposable income in the model and the consumption per capita in constant prices is directly explained by GDP per capita in constant prices. Fortunately, this treatment has no negative influence on the household consumption demand system to be used.

To simulate the household consumption, a good way is to use PADS (Perhaps Adequate Demand System). The basic formula of PADS is:

$$x_i(t) = \left(a_i(t) + b_i(y/P)\right).\left(\frac{p_i}{P}\right)^{-\lambda_i} \prod_{k=1}^{n}\left(\frac{p_i}{p_k}\right)^{-\lambda_k s_k} . \left(\frac{p_i}{p_G}\right)^{-\mu_G}\left(\frac{p_i}{p_g}\right)^{-\nu_g} ; \quad (3)$$

where the left side is the consumption *per capita* of product i in period t and $a_i(t)$ is a function of time. The b_i is a positive constant. The y is nominal income *per capita*; p_k is the price index of product k; P is an overall price index defined by

$$P = \prod_{k=1}^{n} p_k^{s_k} ;$$

where, s_k is the budget share of product k in the period in which the price indexes are all 1, and λ_i is the relative (or real) price elasticity. All the notations with subscript G or g are related to a concept of "group" and "subgroup" which will not be used in this analysis because of the reason to be mentioned below.

In TURINA, the classification of household consumption categories is listed in Table 2.

Table 2: The household consumption categories in TURINA

	Category	Budget share %	
		1998	2008
1	Food, beverages, alcoholic drinks and tobacco	30.1	25.9
2	Clothing and footwear	12.0	5.7
3	Housing, water, electricity, and gas	10.8	20.3
4	Furnishing, household equipment and routine maintenance of the house	9.4	7.2
5	Health	2.6	4.1
6	Transport and communication	14.3	18.5
7	Recreation and culture	5.8	3.9
8	Education	0.6	1.3
9	Restaurants and hotels	6.6	6.0
10	Other goods and service	7.6	7.1

It is seen that in 2008 three big consumption categories are Food, beverage, alcoholic drinks and tobacco (25.9%), Housing, water, electricity, gas (20.3%), and Transportation and communication (18.5). They altogether account for almost two thirds of total household consumption. From the same table it can be seen that it is not necessary to do the group or subgroup classification because the household consumption categories in TURINA are very basic. Without the parameters μ and v, formula (3) becomes:

$$x_i(t) = \left(a_i(t) + b_i(y/P)\right).\left(\frac{p_i}{P}\right)^{-\lambda_i} \prod_{k=1}^{n}\left(\frac{p_i}{p_k}\right)^{-\lambda_k s_k} \quad (4)$$

Again, since the classification of household consumption categories is very basic, the price comparison between two different categories, or the cross price elasticity between two categories can be ignored. It means the term indicated by the product sign in (4) above can be omitted. Therefore, a simplified formula:

$$x_i(t) = \left(a_i(t) + b_i(y/P)\right) \cdot \left(\frac{p_i}{P}\right)^{-\lambda_i} \tag{5}$$

Just like the situation pointed out by Almon (1996b), "[some parts] …, could be omitted from the equation, with a great reduction in complexity in estimation".

On the other hand, the total household consumption expenditure per capita could be used as the income per capita, variable y, in the calculation practice of the PADS system. Therefore, it will not be a big problem that there is no personal disposable income in TURINA. A relationship between GDP per capita and the total household consumption per capita can directly be set up. In other words, the model's logic will be modified into the following steps:

Step 1: Give total household consumption expenditure per capita for the year when the model runs.

Step 2: Use the consumption value to calculate the per capita household consumption in constant prices by 10 categories according to the equations resulting from the regression in the sample period 1998-2008.

Step 3: Convert 10 categories of household consumption per capita into 58 sectors' household consumption per capita by using a bridge matrix and then get total household consumption by 58 sectors through multiplying the population number in that year.

Step 4: Get final demand vector " fd " if all the other component vectors such as government consumption, fixed capital formation, inventory changes, export and import are exogenously given.

Step 5: Calculate the gross output vector out, in constant prices, according to the equation:

$$out = (I - A)^{-1} * fd\ .$$

Step 6: Calculate the value added vector "va" in current prices, according to the regression analysis between output in constant prices by last year's price index and value added in current prices from the sample period 1998-2008.

Step 7: For the new unit value added (value added in current prices of per unit output in constant prices), va/out calculate the price index vector, p according to the equation:

$$A'p + va/out = p\ .$$

Step 8: Has GDP in current prices and in constant prices, which is the sum of value, added vector va and final demand vector fd , respectively.

Step 9: Has GDP per capita in constant and in current prices, and the GDP deflator.

Step 10: Estimate the total household consumption per capita according to the regression analysis from the sample period 1998 and 2008.

Step 11: If the resulting total household consumption per capita is very close to the one used in step 1, the model finishes the run for that year and goes to the next year. Otherwise, replace the household consumption per capita in step 1 with this new value and go to step 2 for the next iteration of the model.

The numerical relationships between the total household consumption per capita and GDP per capita, in constant and in current prices, are all very good. Table 3 show the regression result, in which phhconsR is total household consumption per capita in constant prices and pgdpR is GDP per capita in constant prices. Table 4 show the regression result, in which phhconsN is total household consumption per capita in current prices and pgdpN is GDP per capita in current prices. The simulation effects are shown in Figure 1 and Figure 2, respectively.

Comparing the two tables and the figures, the result in current prices could appear to be better than the one in constant prices: the fitness is better and the coefficient (0.71) of the GDP per capita is more close to the ratios listed in Table 1, than the coefficient (0.77) from the result in constant. Furthermore, the elasticity on GDP per capita, in the situation in current prices, is 1.01 (almost unity) and is more reasonable than the one (1.11) from the result in constant prices. The difference between these two regressions is just the GDP and household consumption in current prices deflated by GDP deflator. In fact, the GDP deflator in the period 1998-2008 is varied and raised very much in Turkey. Table 5 shows its values.

Table 3: Result of regression, in constant prices

SEE = 15.57 RSQ = 0.9809 RHO = 0.35 Obser = 11 from 1998.000
SEE+1 = 15.83 RBSQ = 0.9787 DW = 1.31 DoFree = 9 to 2008.000
MAPE = 1.55

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta	t-value	F-Stat
0 phhconsR	- - - - - -	- - - - - -	- - - - -		853.78	- - - - -	- - - - -	
1 intercept	-94.48297	22.5	-0.11	52.24	1.00		-2.125	
2 pgdpR	0.77641	622.8	1.11	1.00	1221.35	0.990	21.475	461.16

Table 4: Result of regression, in current prices

SEE = 72.79 RSQ = 0.9994 RHO = 0.08 Obser = 11 from 1998.000
SEE+1 = 73.38 RBSQ = 0.9993 DW = 1.83 DoFree = 9 to 2008.000
MAPE = 1.31

Variable name	Reg-Coef	Mexval	Elas	NorRes	Mean	Beta
0 phhconsN	- - - - - -	- - - - - -	- - - - -		4801.27	- - -
1 intercept	-45.30306	5.0	-0.01	1594.91	1.00	
2 pgdpN	0.70918	3893.6	1.01	1.00	6834.06	1.000

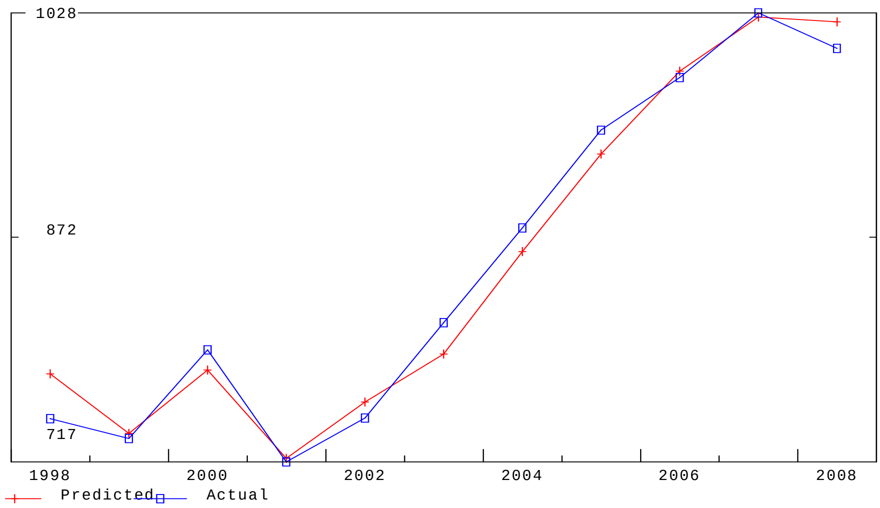


Figure 1: Simulation in constant prices

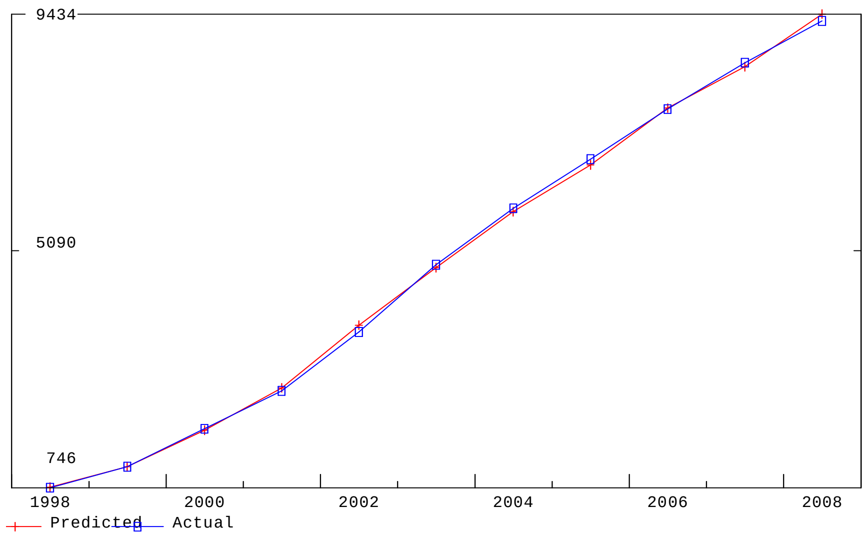


Figure 2: Simulation in current prices

Table 5: The GDP deflator from 1998 to 2008 (%)

1998	1999	2000	2001	2002	
100.00	154.18	230.08	351.67	483.28	
2003	2004	2005	2006	2007	2008
595.74	669.62	717.05	783.96	832.73	929.97

So it was decided to use the regression result in current prices in the model. The model's calculation logic can be shown in Figure 3.

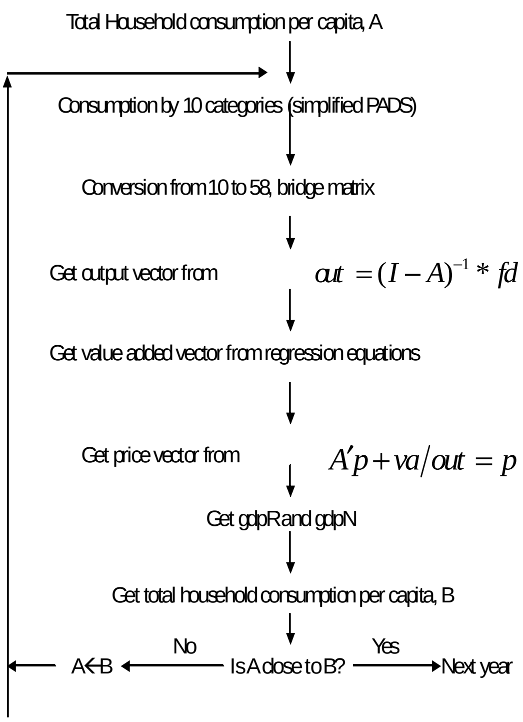


Figure 3: Flow chart of the model calculations

It should be pointed out that the last sector, sector 58 which is "Private households with employed persons" in TURINA, is a special one. It has neither intermediate output nor intermediate input. Its value added is its gross output. Its household consumption is its gross output. For this sector, there is a special treatment in the data preparation stage, especially in the process of creating the consumption bridge matrix. The consumption value of sector 58 was removed from total household consumption and the 10 categories' household consumption. The elements in the row 58 of the consumption bridge matrix are all zero. Therefore, the household consumption by 58 sectors resulted from using consumption bridge matrix will not include the sector 58. It is necessary to estimate the household consumption of sector 58 individually in a proper place of the model. Once it is estimated, its value is also the gross output and the value added of the sector 58, respectively.

The estimation result of the household consumption in sector 58 is shown in Table 6, in which the variable fcehhr58 is the household consumption in constant prices of sector 58 and its data directly from gross output vector, gdpR is GDP in constant prices and D58 is a dummy variable. The simulation situation of the regression is shown in Figure 4.

Table 6: Estimation Result of Household Consumption in Sector 58

SEE = 4438.48 RSQ = 0.9863 RHO = 0.35 Obser = 11 from 1998.000
SEE+1 = 4192.42 RBSQ = 0.9828 DW = 1.30 DoFree = 8 to 2008.000
MAPE = 3.26
Variable name Reg-Coef Mexval Elas NorRes Mean Beta
0 fcehhr58 - - - - - - - - - - - - - - - -------------------------- 116459.00 - - -
1 intercept -120022.79509 329.5 -1.03 72.73 1.00
2 gdpR 0.00285 725.5 2.01 2.49 81980884.36 0.967
3 d58 14125.08201 57.7 0.02 1.00 0.18 0.144

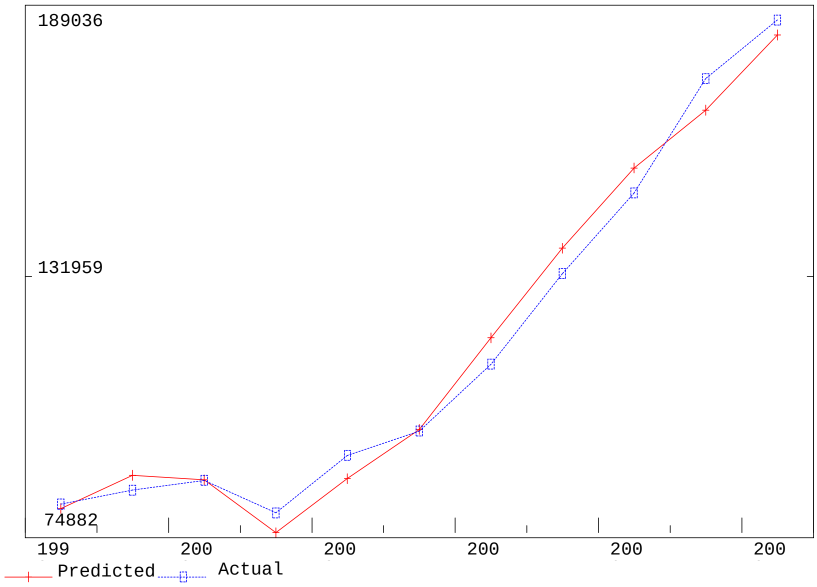


Figure 4: Household Consumption of sector 58

3. THE ESTIMATION OF BEHAVIOURAL VECTOR EQUATIONS

According to the model's framework mentioned in part 1, the estimation of behavioural vector equations includes two vectors. One is the per capita household consumption in constant prices by 10 categories. Another is the value added in current prices by 58 sectors.

As discussed in Part 2, the form of the household consumption by 10 categories is a simplified PADS with the formula (5). For a full formula of a PADS equation, there is a special program SYMCON.EXE, developed by INFORUM, which can solve the non-linear simultaneous equations and give results. To use SYMCON.exe, there are seven files, two control information files plus five input data files that need to be prepared. These two control files are related to groups and soft constraints. On the other hand, due to the fact that PADS to be used in the model is simplified and can easily be solved by the non-linear regression command in G7, which seems less complicated, it was decided not to use SYMCON.EXE.

The command line for the non-linear regression of the equation (5), say for the household consumption category 1, is:

```
nl x1 = (a0*time + a1*y/P)*@pow(p1/P,-a2)
3
1, .5, .25
.1  .1  .1
```

In case it is necessary to put a soft constraint on some parameter, for example a1 = 0.3, a term c*@sq(a1-0.3) can simply be added into the first line, which becomes:

```
nl x1= (a0*time + a1*y/P)*@pow(p1/P,-a2) + c*@sq(a1-.3).
```

The c in the formula above is number 1, or 10, or 100 and so on, which reflects how strong the soft constraint is.

As is known, there is so far no non-linear optimisation algorithm which can guarantee to reach global optimisation. The result from the non-linear regression will depend upon the initial values and the initial step sizes. To understand this, consider the following examination which is for the household consumption category 4 (Furnishing, household equipment, and routine maintenance of the house) in TURINA.

For parameter a0, 10 different values were tried: -0.9, -0.7, -0.5, -0.3, -0.1, 0.1, 0.3, 0.5, 0.7 and 0.9. For parameter a1, it is known that it should be less than 1.0 and positive. Therefore 5 values were tried: 0.1, 0.3, 0.5, 0.7 and 0.9. For parameter a2, the λ, an initial value is given: 0.25. For the step sizes, 0.1 0.05 and 0.1 are given respectively. Therefore, there are 50 different starting points for the same category 4. There are differences among the 50 different results. Following are two of them (Table 7A, 7B):

Table 7(A). Result A: initial start point: a0 = -0.7, a1=0.9, a2=0.25

SEE = 3.580546			
Param	Coef	T-value	StdDev
a0	-1.865426	-2.34	0.795748
a1	0.091674	22.02	0.004164
a2	0.484494	0.34	1.434325

The Variance-Covariance Matrix

6.3321e-01	-1.8202e-03	8.7364e-01
-1.8202e-03	1.7337e-05	3.6122e-04
8.7364e-01	3.6122e-04	2.0573e+00

Table 7(B). Result B: initial start point: a0=0.3, a1=0 .1, a2=0 .25

SEE = 3.152363			
Param	Coef	T-value	StdDev
a0	-0.974917	-1.18	0.826381
a1	0.091634	24.40	0.003756
a2	2.424041	1.79	1.352643

The Variance-Covariance Matrix

6.8291e-01	-1.7260e-03	9.1756e-01
-1.7260e-03	1.4109e-05	-1.9992e-04
9.1756e-01	-1.9992e-04	1.8296e+00

It can be seen that these two results (a0 = -1.865, a1 =0.0917, a2 = 0.4845, SEE = 3.5805) and (a0= -0.9749, a1 = 0.0916, a2 = 2.4240, SEE = 3.1524) are quite different (SEE has a difference of 13%, a0 and a2 from both results have big differences. These differences are just due to the different starting points (a0 = -0.7, a1=0.9, a2=0.25) and (a0=0.3, a1=0 .1, a2=0 .25). The only common value in the two results is the parameter a1 (both are 0.091) which is close to its budget share (varying from 0.071 to 0.094 during the sample period).

It is realised, through this examination, that it would be better to implement different regressions with different starting points for the same household consumption category.

Different combinations of the starting points are organised as follows. Initially, 50 different combinations are needed for one category: the parameter a1 having its values -.9, -.7, ..., 0.7, 0.9 respectively; parameter a2 having its values .1, .2, …,.9 respectively and parameter a2 = .25 However, from the examination above, it was learned that since the budget share of household consumption category 4 is from 0.094 to 0.071 during the sample period 1998-2008, to have a rough value as a1, which is close to its budget share, may be a good point and can save time, from using 50 combinations to just comparing 10 results.

Therefore, for each household consumption category, 10 initial starting points were tried for parameter a0, which is from -0.9, -0.7, ……, to 0.7 and 0.9. For a1, a value was used, which is closest to its budget share. For a2, 0.25 was used. Among the 10 results, the selected one has a minimal value of SEE if the parameters a1 and a2 are all positive. If at least one of these two parameters is negative, a soft constraint should be added into the expression.

As an example, Table 8 shows the 10 results for the household consumption of category 5. It can be seen that the minimal SEE among these 10 results is 1.409359 from starting values a0 = -0.3, a1 = 0.1 and a2 = 0.25. It can also be seen, from this table, that if the starting values a0 = -0.5, a1 = 0.1 and a2 = 0.25, are used the “minimal” value of the SEE will be 3.75846, which is 100% more than the one selected from running 10 different starting values.

Table 8: 10 Different results for category 5, from 10 different starting values

start:	a0=-0.9	a1=0.1	a2=0.25			start:	a0-0.7	a1=0.1	a20.25	
SEE	=	1.472188				SEE	=	1.443135		
	Param	Coef	T-value	StdDev			Param	Coef	T-value	StdDev
	a0	0.784159	4.06	0.193298			a0	1.677693	3.11	0.539531
	a1	0.027301	14.42	0.001893			a1	0.024933	11.12	0.002242
	a2	1.247082	105.87	0.011779			a2	0.921925	5.93	0.155454
start:	a0=-0.5	a1=0.1	a2=0.25			start:	a0=-0.3	a1=0.1	a2=0.25	
SEE	=	3.75846				SEE	=	1.409359		
	Param	Coef	T-value	StdDev			Param	Coef	T-value	StdDev
	a0	-0.37279	-0.74	0.505833			a0	0.983779	2.1	0.468211
	a1	0.037808	7.72	0.004896			a1	0.026595	13.35	0.001992
	a2	1.242744	53.78	0.023108			a2	1.180607	7.58	0.15572
start:	a0=-0.1	a1=0.1	a2=0.25			start:	a0=0.1	a1=0.1	a2=0.25	
SEE	=	2.40257				SEE	=	2.49591		
	Param	Coef	T-value	StdDev			Param	Coef	T-value	StdDev
	a0	-0.3922	-0.72	0.546313			a0	-0.48551	-0.86	0.562333
	a1	0.031536	11.83	0.002666			a1	0.032607	11.79	0.002765
	a2	1.670702	6.71	0.248908			a2	1.655141	6.5	0.254678
start:	a0=0.3	a1=0.1	a2=0.25			start:	a0=0.5	a1=0.1	a2=0.25	

SEE	=	2.111447				SEE	=	1.811162		
	Param	Coef	T-value	StdDev			Param	Coef	T-value	StdDev
	a0	0.25364	0.83	0.306352			a0	0.402165	1.53	0.262845
	a1	0.031929	11.3	0.002825			a1	0.030624	12.64	0.002423
	a2	1.250881	571.85	0.002187			a2	1.252908	644.79	0.001943
start:	a0=0.7	a1=0.1	a2=0.25			start:	a0=0.9	a1=0.1	a2=0.25	
SEE	=	1.627575				SEE	=	1.502015		
	Param	Coef	T-value	StdDev			Param	Coef	T-value	StdDev
	a0	0.589434	2.49	0.236359			a0	0.666604	3.37	0.197899
	a1	0.029282	13.44	0.002178			a1	0.028389	14.67	0.001935
	a2	1.253003	692.28	0.00181			a2	1.244468	106.79	0.011654

The disadvantage of using non-linear regression in G7 is the result displayed without the elasticity of the income term. However, it is not difficult to overcome this problem. The parameter λ (i.e. the a2) can be replaced with its estimated value in the formula (5) so that the non-linear term (p_i/P) disappears and the regression becomes linear, from which its result display includes the income elasticity term. For example, for the result selected from table 7, the value of λ =1.180607 (a2) is replaced into the formula (5) and the linear regression equation is:

$$x_5 = a_5(t)*(p_5/P)^{-1.180607} + b_5(y/P)*(p_5/P)^{-1.180607}$$

From its regression result display, the income elasticity term is 0.78. Table 9 to 18 show the non-linear regression results for the 10 household consumption categories and Figures 5—14 show the fitness situation of these regressions, respectively:

Table 9: Category 1

SEE = 5.934833			
Param	Coef	T-value	StdDev
a0	-2.503816	-2.62	0.956751
a1	0.306482	38.53	0.007953
a2	0.331077	1.12	0.296063

The Variance-Covariance Matrix

9.1537e-01	-3.0432e-03	-1.4540e-01
-3.0432e-03	6.3258e-05	-1.2615e-03
-1.4540e-01	-1.2615e-03	8.7653e-02

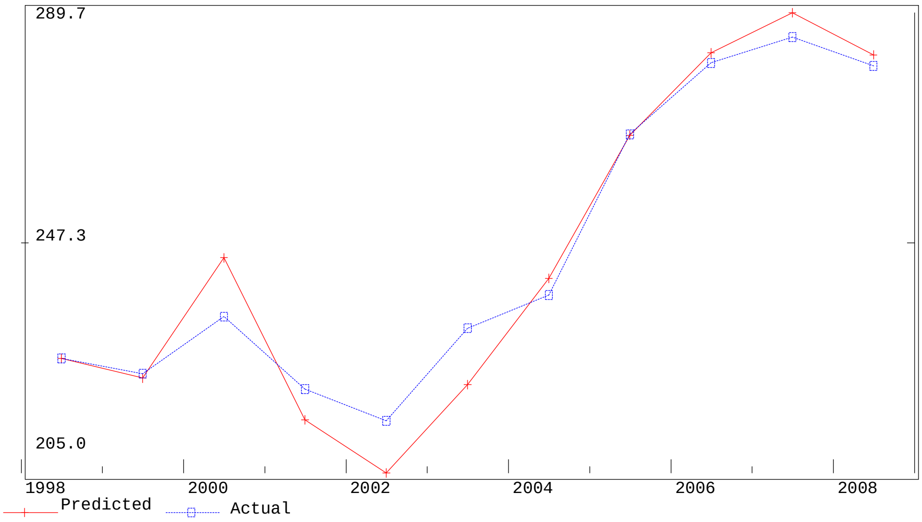


Figure 5: Food, beverage, tobacco

The income elasticity is 1.06

How are the coefficients estimated in the regression for Category 1 interpreted? First, the negative value of a0 shows that the budget share of the Food, beverages, tobacco, and alcoholic drinks in Turkish family budget should have been getting smaller over time. This is true as it can be seen in Table 2, (Part 2), the budget share of Food item has fallen from 30.1 in 1998 to 25.9% in 2008. Second, a positive a1 value (0.306) shows that income has a positive effect on consumption behaviour of households in this sector in general. In terms of economic theory this is normal for `normal goods`. Third, the broad category of food, tobacco, and all kinds of drinks has a price elasticity of less than one in absolute terms. It can be shown that a2 = λ, and $-\lambda$ = price elasticity. This result supports one piece of the basic economic theory that food is a necessity in general, so it is price inelastic, i.e. its price elasticity is less than 1 in absolute terms. However, this conclusion holds only for the broad category of food items but may not be true for all items in this category.

As for income elasticity the food category seems a superior good for the fact that its income elasticity is slightly greater than 1 (1.06). This conclusion does not deserve much credibility. For many items in this category income elasticity should be less than 1. To overcome this pitfall, a soft constraint on some parameters should be tried in the future, with more data and perhaps with `groups` and `subgroups`.

Table 10: Category 2

SEE = 6.577104			
Param	Coef	T-value	StdDev
a0	-3.804061	-2.18	1.741906
a1	0.096326	89.85	0.001072
a2	0.038585	0.02	2.327677

The Variance-Covariance Matrix

3.0342e+00	1.6932e-03	-3.7003e+00
1.6932e-03	1.1494e-06	-1.8001e-03
-3.7003e+00	-1.8001e-03	5.4181e+00

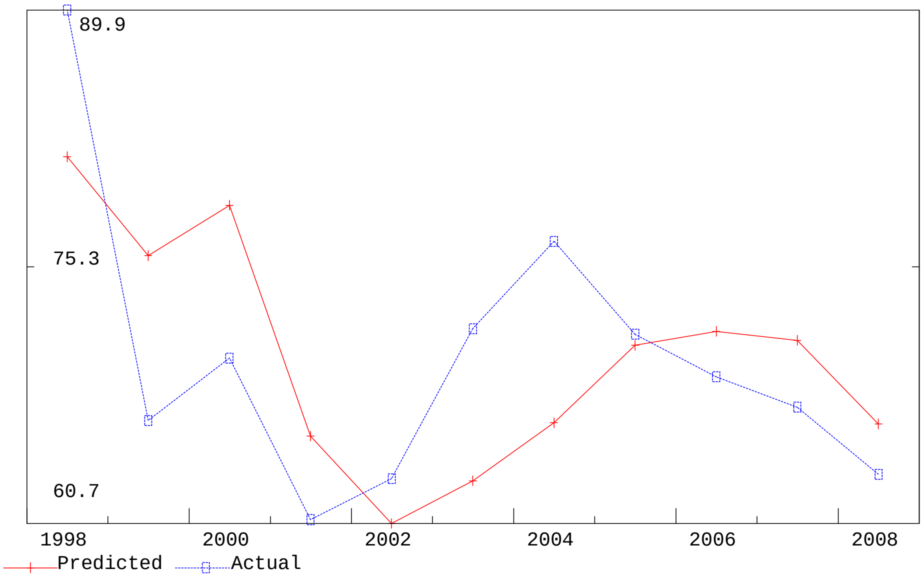


Figure 6: Clothes and footwear

The income elasticity is 1.14

For clothing and footwear (category 2) the time effect is negative therefore its budget share should be getting smaller. This conclusion is confirmed by the fact that the budget share of this category has fallen from 12% to 5.7% over 10 years, from 1998 to 2008. A relatively small income effect is found for this category. Price elasticity is close to zero in absolute terms (0.038). So in terms of price elasticity, clothing and footwear is a necessity for Turkish consumers. And, finally, income elasticity seems quite high, which puts this item in the range of luxurious (superior) goods. Again, as in the case of the first category, this disputable result requires further checking with data and an estimation method.

Table 11: Category 3

SEE = 7.109050			
Param	Coef	T-value	StdDev
a0	1.068673	0.37	2.898244
a1	0.152508	2.60	0.058655
a2	23.290649	2.84	8.188540
a3	0.382491	0.19	2.039955

The Variance-Covariance Matrix

8.3998e+00	-1.6702e-01	7.4781e+00	4.5084
-1.6702e-01	3.4404e-03	-8.4055e-02	-0.07591
7.4781e+00	-8.4055e-02	6.7052e+01	12.353
4.5084e+00	-7.5909e-02	1.2353e+01	4.1614

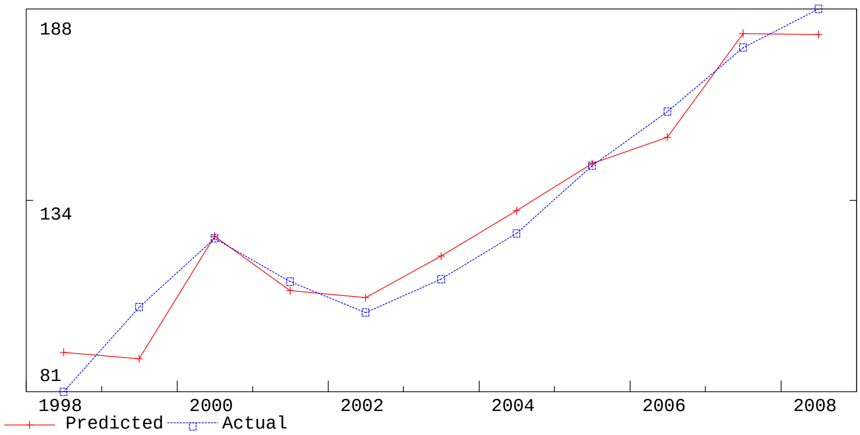


Figure7: Housing, water, electricity, gas

The income elasticity is 1.03.

Housing, water, electricity, gas and other services, category 3, is also a broad category. Its budget share has been almost doubled from 10.8% to 20.3% during the course of the estimation period. The consumption function for category 3 is a special one. Here there are four parameters. As for other categories a0 shows the effect of time, which is positive as it is expected for this category. The second coefficient a1 measures the effect of income, which is again positive. The fourth coefficient a3 shows the absolute value of price elasticity as usual. Since this value is less than 1, housing expenditure is price inelastic. As regards parameter a2, it is included in the equation for a dummy variable to eradicate the excessive jumps in the regression function. So en economic meaning cannot be added to it.

Table 12: Category 4

SEE = 3.152363			
Param	Coef	T-value	StdDev
a0	-0.974917	-1.18	0.826381
a1	0.091634	24.40	0.003756
a2	2.424041	1.79	1.352643

The Variance-Covariance Matrix

6.8291e-01	-1.7260e-03	9.1756e-01
-1.7260e-03	1.4109e-05	-1.9992e-04
9.1756e-01	-1.9992e-04	1.8296e+00

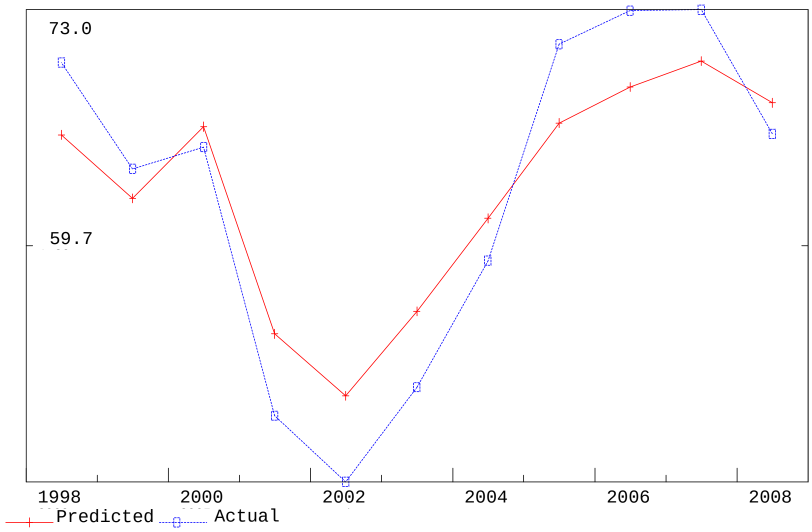


Figure 8: Furnishing, household equipment and maintenance

The income elasticity is 1.08

For Furnishing, household equipment and routine maintenance of the household, the time effect appears with a negative coefficient (a0 = -0.975). This sign is in line with a decreasing budget share from 9.4 to 7.2. The role of income is considerably low (0.092). The price elasticity of this category is the second highest. When the price of furniture goes up the Turkish households cut their expenditures, in percentage terms, a lot more than the increase in prices. On the other hand income elasticity is greater than 1 so that the furniture is to some extent a luxury for the Turkish consumers.

Table 13: Category 5

SEE = 1.409359			
Param	Coef	T-value	StdDev
a0	0.983779	2.10	0.468211
a1	0.026595	13.35	0.001992
a2	1.180607	7.58	0.155720

The Variance-Covariance Matrix

2.1922e-01	-8.0676e-04	-6.8096e-02
-8.0676e-04	3.9672e-06	1.9893e-04
-6.8096e-02	1.9893e-04	2.4249e-02

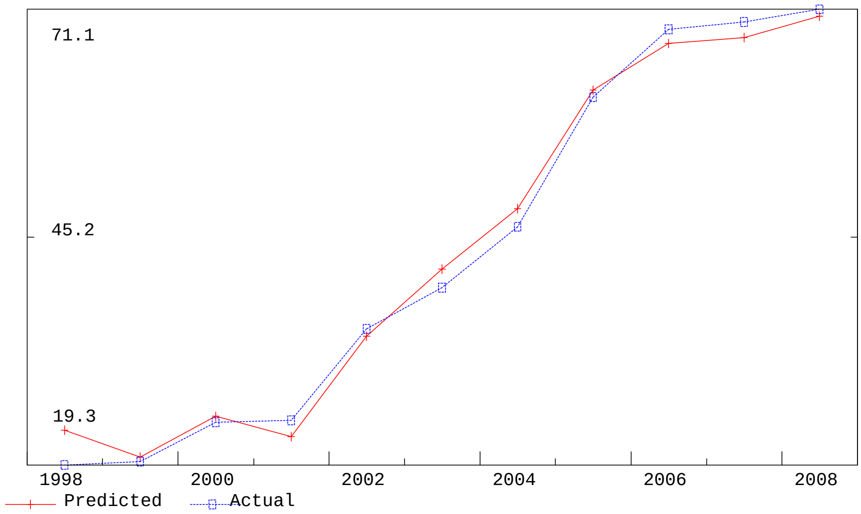


Figure 9: Health

The income elasticity is 0.78

Category 5 represents Health expenditures, the budget share of which has gone up from 2.6% to 4.1%. A positive time coefficient also supports this conclusion. The income coefficient is also positive as for all other categories, though with a relatively low value. Health expenditure has relatively strong price elasticity (-1.18). Income elasticity is less than 1 (0.78). This result indicates that the Turkish families substitute public health services with relatively low prices for private health services with relative high costs.

Table 14: Category 6

SEE = 3.955514			
Param	Coef	T-value	StdDev
a0	2.953342	3.88	0.761408
a1	0.141288	26.36	0.005360
a2	0.230426	0.53	0.433724

The Variance-Covariance Matrix

5.7974e-01	-1.0461e-03	2.2032e-01
-1.0461e-03	2.8732e-05	1.1818e-03
2.2032e-01	1.1818e-03	1.8812e-01

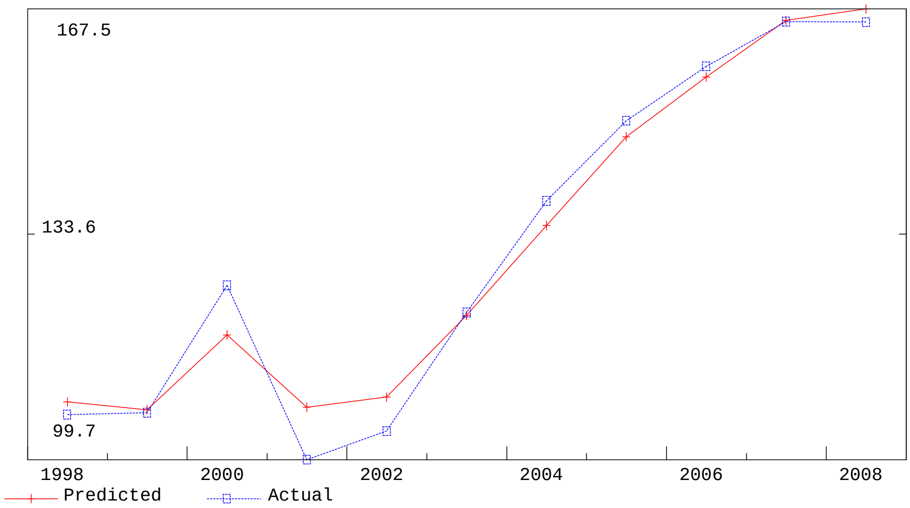


Figure 10: Transport and communication

The income elasticity is 0.87

Category 6 shows Transport and communication. Its budget share has increased from 14.3% to 18.5% so that the time effect (2.953) appears with the highest coefficient among the 10 categories. Its income coefficient is positive as for other categories. The price elasticity is relatively low so that it is generally a necessity. The income elasticity is relatively high, though still less than 1, i.e., it is a normal good.

Table 15: Category 7

SEE = 1.882960			
Param	Coef	T-value	StdDev
a0	-1.627992	-4.34	0.375494
a1	0.057759	25.98	0.002223
a2	0.048447	0.04	1.192981

The Variance-Covariance Matrix

1.4100e-01	-4.1287e-04	3.1555e-01
-4.1287e-04	4.9428e-06	5.6449e-04
3.1555e-01	5.6449e-04	1.4232e+00

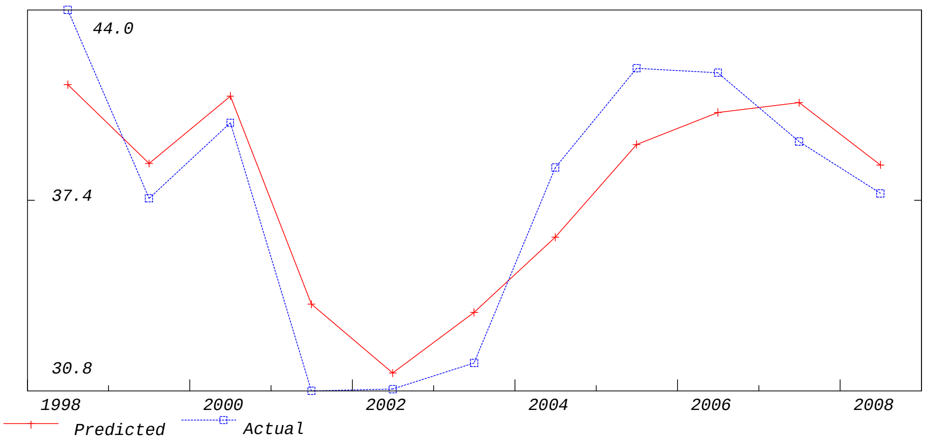


Figure 11: Recreation and culture

The income elasticity is 1.26

For recreation and culture, the time effect appears with a high negative coefficient (a0 = -1.628), which is consistent with a falling budget share from 5.8 to 3.9. The role of income seems relatively low (0.058). The price elasticity of this category is the second lowest (-0.048). When the price of recreational and cultural services goes up Turkish households do not cut their expenditure in this category much. On the other hand, income elasticity is greater than 1 so that recreation and culture is to some extent a luxury for the Turkish households.

Table 16: Category 8

SEE = 0.747344			
Param	Coef	T-value	StdDev
a0	0.711030	2.43	0.292238
a1	0.005023	5.49	0.000915
a2	1.105001	0.30	3.728090

The Variance-Covariance Matrix

8.5403e-02	-1.6010e-04	1.0117e+00
-1.6010e-04	8.3765e-07	-9.9321e-04
1.0117e+00	-9.9321e-04	1.3899e+01

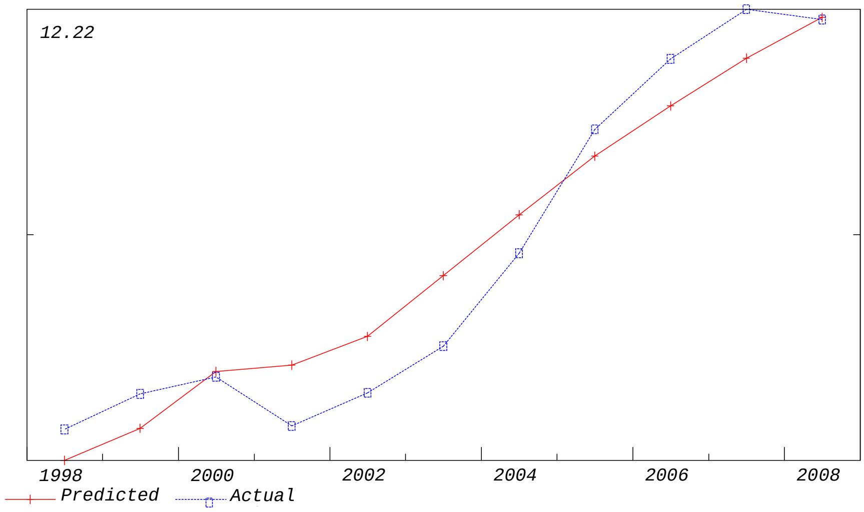


Figure 12: Education

The income elasticity is 0.50

Education had the lowest budget share in 1998 (0.6) but this share has more than doubled in ten years. This tendency is also confirmed with a positive time coefficient (0.711). Income does not have much effect on education expenditures. The reason is that to a large extent this service is provided almost freely by the public sector from the primary to the higher education. Price elasticity is greater than 1 in absolute terms (1.105), which imply strong price elasticity. It seems that when the fees in private schools get higher, the public tend to cut their expenditure on that service.

Income elasticity for educational services is the lowest (0.50) among 10 expenditure categories. Again, since education is generally a free public good at all level, a change in household income does not affect expenditure on education much. Again mostly for the same reason its share is still the lowest and negligible (1.3%) even in 2008.

Table 17: Category 9

SEE = 1.476018			
Param	Coef	T-value	StdDev
a0	-0.449828	-1.44	0.313460
a1	0.064085	33.78	0.001897
a2	0.927172	4.56	0.203487

The Variance-Covariance Matrix

9.8257e-02	-5.2068e-04	4.4842e-02
-5.2068e-04	3.5998e-06	-1.4771e-04
4.4842e-02	-1.4771e-04	4.1407e-02

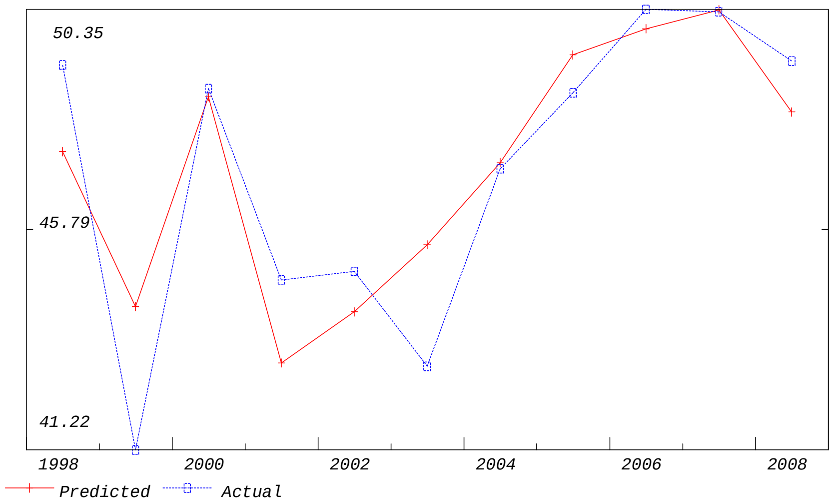


Figure 13: Restaurants and hotels

The income elasticity is 1.05.

The budget share of restaurants and hotels (category 9) has decreased slightly from 6.6% in 1998 to 6% in 2008. Accordingly, the time coefficient of the regression function has a negative sign, though small in absolute terms (-0.450). This expenditure category has a positive income coefficient. Its price elasticity is high but still less than 1 in absolute terms (0.927) so that for the Turkish consumers eating out is relatively price inelastic. Income elasticity is slightly higher than 1 so that eating out and having holidays mainly in summer time is a luxury for the consumers. These last two conclusions seem a little bit in conflict, so that further analysis may prove better results and understanding for this sector.

Table 18: Category 10

SEE = 2.882543			
Param	Coef	T-value	StdDev
a0	0.380770	0.24	1.563779
a1	0.077070	16.26	0.004739
a2	2.483072	1.92	1.295588

The Variance-Covariance Matrix

2.4454e+00	-6.2318e-03	1.9356e+00
-6.2318e-03	2.2457e-05	-4.1284e-03
1.9356e+00	-4.1284e-03	1.6785e+00

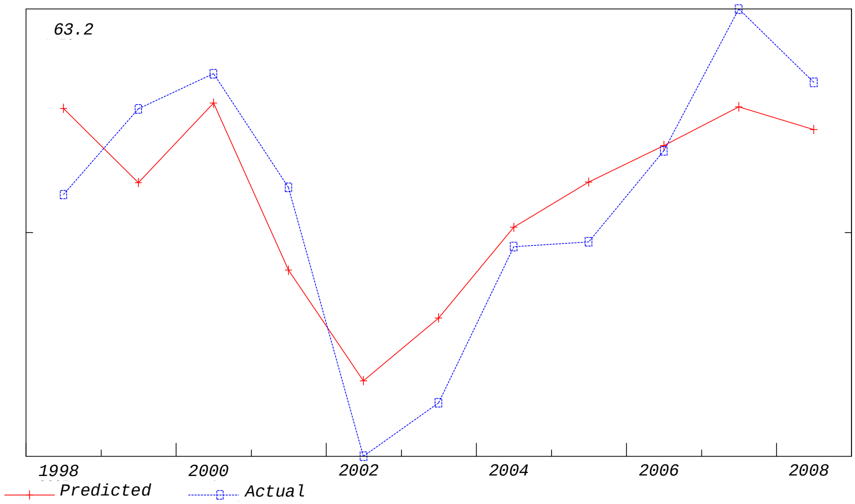


Figure 14: Other goods and services

The income elasticity is 0.97.

Finally, other goods and services (category 10) show a slightly declining budget share from 7.6% to 7.1%. However, for this sector the time coefficient appears with a positive sign. This is the only adverse result among 10 categories. It may be caused by the coverage of the data. That is to say that the data probably cover different expenditure categories in different years from 1998 to 2008. Income has a positive effect on the consumption of other goods and services. Price elasticity is the highest among all categories. People probably go for other goods and/or cut back their demand for this category drastically if there is a price increase. Finally, income elasticity is positive and slightly less than 1 implying that other goods and services is a normal good.

Excluding the behavioural vector equation for household consumption discussed above, another behavioural vector equation, in the model's framework, is the value added vector in current prices. It has 58 components or elements. Therefore, there are 58 behavioural equations for those 58 components, one for each. A simple but efficient way to explain the value added in current prices is to use the output in current prices as the main explanatory variable. In the model logic, the value added vector will be calculated after getting the output in constant prices by using the basic Input-output formula, Equation (2). Therefore, a natural idea is to use the product, between output in constant prices and corresponding prices, as the explanatory variable for value added in current prices, i.e., to have

$$va = f(out * p) \tag{6}$$

And after that, with the value added in current prices of per unit of output in constant prices, a new prices vector can be calculated by using Equation (1).

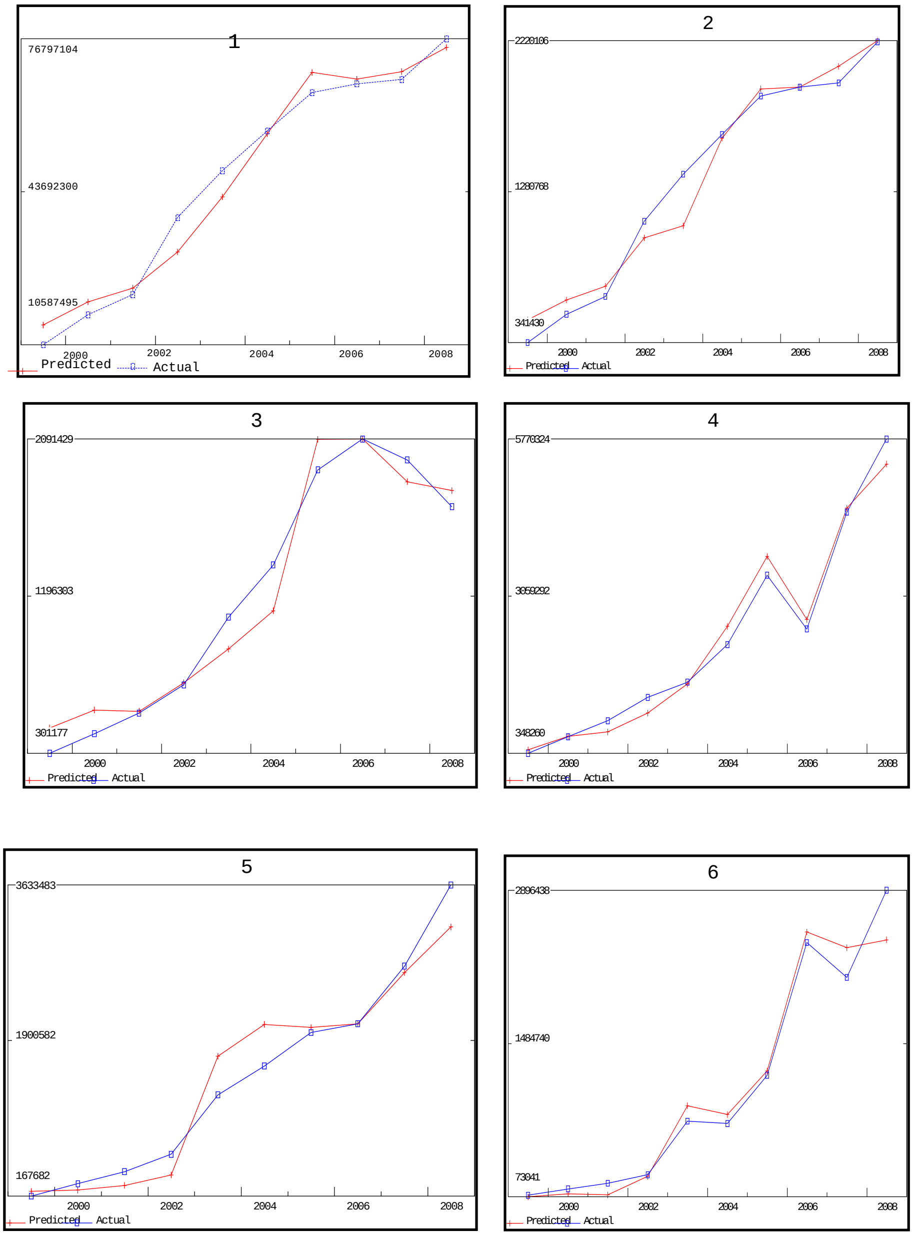
However, according to the experiences from past years, this kind of structure will cause problems in the model's convergence.

A possible way to solve this problem is to use the one year lag of the prices vector, i.e.,

$$va = f(out * p(-1)) \tag{7}$$

One of the disadvantages of doing so is that, the sample period will be 1 year less. The calculation practice of the model, which includes the behavioural Equation (7), shows that this treatment is quite satisfactory.

For the particular estimations of the 58 value added equations, to overcome the excessive ups and downs of some sector's value added in some year(s), dummy variables are used. The estimation results or the fitness situation of the value added in current prices are shown in Figure 15 below. To save space only the results for the first 10 sectors are depicted.


1
76797104
43692300
10587495
2000
2002
2004
2006
2008
Predicted
Actual
2
2220186
1280768
341430
2000
2002
2004
2006
2008
Predicted
Actual
3
2091429
1196303
301177
2000
2002
2004
2006
2008
Predicted
Actual
4
5770324
3059292
348260
2000
2002
2004
2006
2008
Predicted
Actual
5
3633483
1900582
167682
2000
2002
2004
2006
2008
Predicted
Actual
6
2896438
1484740
73041
2000
2002
2004
2006
2008
Predicted
Actual

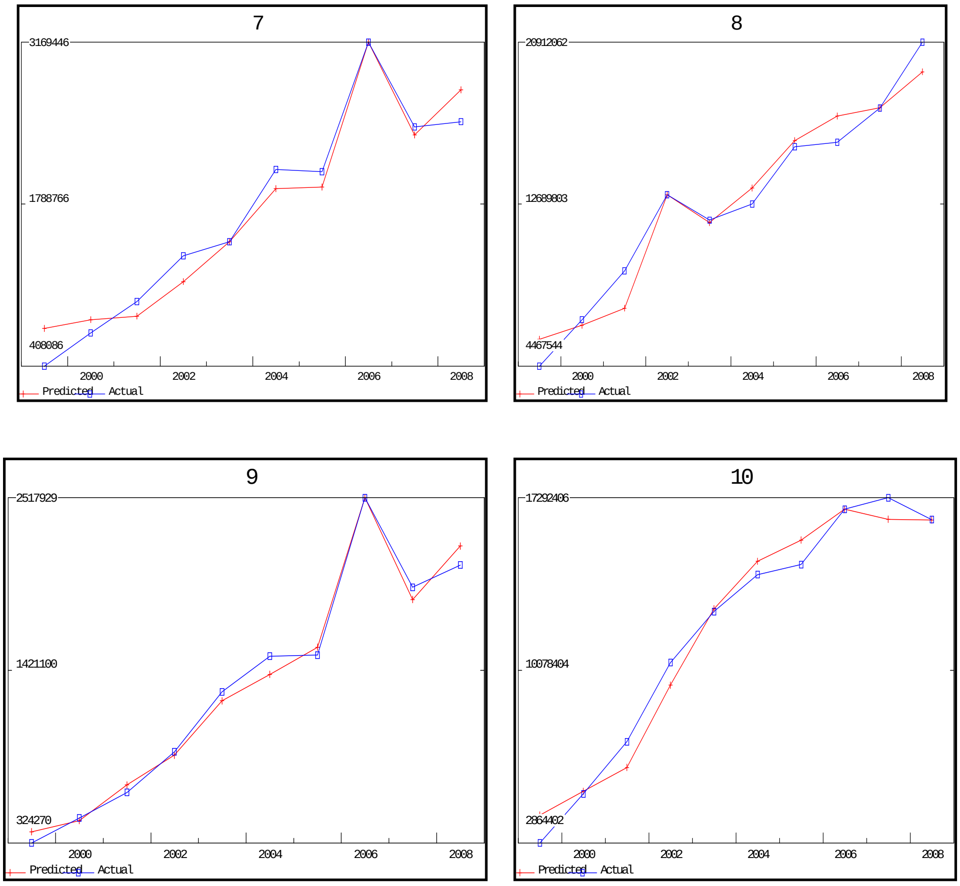


Figure 15: Estimation results of value added equations

4. THE SIMULATION OF THE MODEL

After getting ready the files such as model.cpp and so, it is not difficult to get a dyme.exe file whose content is the INFORUM model for Turkey. Simulation for the sample period is carried out. Some results of the simulation are listed in this section. Figures 16-19 below are the simulations of household consumption per capita in current prices, GDP in constant prices, GDP in current prices and the GDP deflator respectively. Subsequently Tables 19-21 show the percentage change comparison of three vectors: household consumption in constant prices, output in constant prices and the price vector.

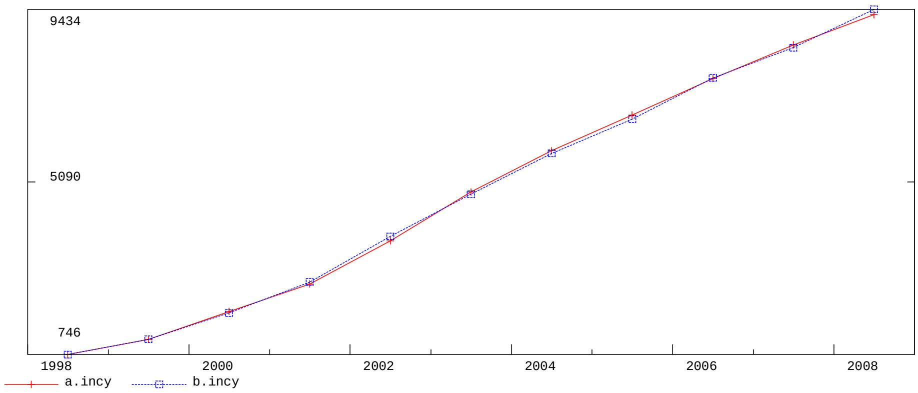


Figure 16: Total household consumption

Figure 17: gdpR

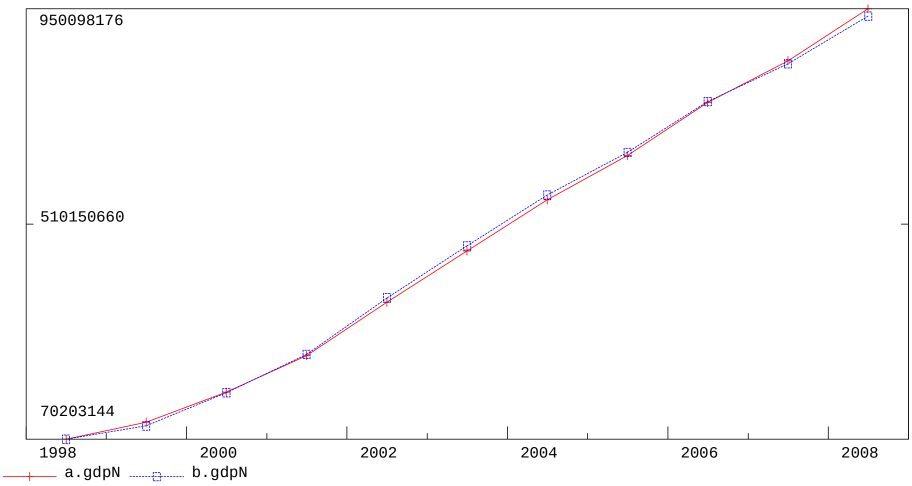


Figure 18: gdpN

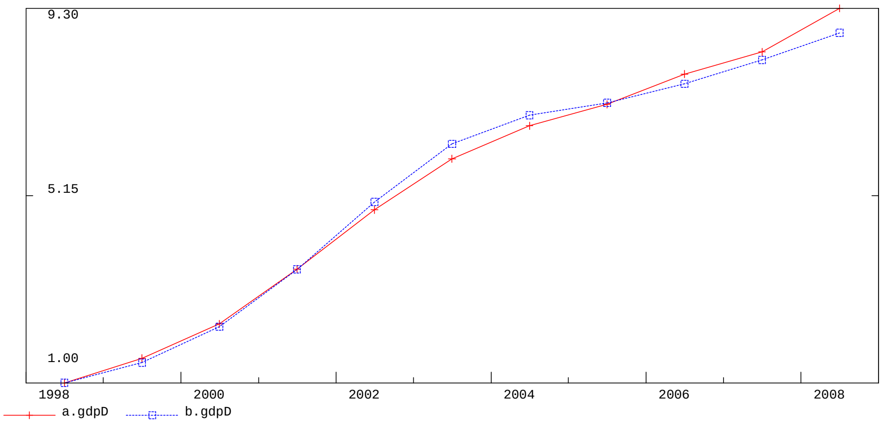


Figure 19: gdp deflator

In the following three tables (19-21) the first line shows the actual historical values of the variable and the second line shows the percentage deviation of the estimated value of the same variable by the model from its historical value. Again, to save space in these tables the results for only the first 20 sectors are shown.

Table 19: The Simulation of Household Consumption Vector

	2000	2002	2004	2006	2008
1Agriculture	7693.67	4646.41	4966.57	5865.95	6034.41
	0.30	-1.29	-0.17	1.20	3.23
2Forestry	114.65	106.85	88.91	110.76	120.59
	0.30	-1.29	-0.17	1.20	3.23
3Fish	404.82	166.09	142.25	208.02	273.64
	0.30	-1.29	-0.17	1.20	3.23
4CoalLignite	178.39	221.61	252.93	317.19	318.98
	-3.72	6.55	2.47	-4.22	-13.25
8FoodBeverage	5797.96	6162.71	7027.51	8575.49	8560.78
	0.30	-1.29	-0.17	1.20	3.23
9Tobacco	410.84	224.20	205.02	229.85	278.88
	0.03	-0.90	-0.63	0.98	3.38
10Textiles	503.82	1120.40	1434.88	1417.95	1401.38
	6.85	0.02	-13.47	2.81	6.36
11WearingApp.	452.05	1678.08	1907.31	1829.42	1790.19
	6.85	0.02	-13.47	2.81	6.36
12Leather	166.40	262.14	324.08	298.83	295.01
	6.85	0.02	-13.47	2.81	6.36
13Wood	8.21	105.07	118.66	155.85	175.73
	-2.36	6.38	1.29	-4.46	-6.25
14PulpePaper	195.69	173.86	254.76	344.93	427.33
	-2.60	6.95	3.27	-4.92	-7.43
15PrintedMedia	531.74	255.43	365.82	463.24	496.65
	-2.32	6.74	1.53	-4.57	-5.87
16Coke	497.83	333.62	416.05	346.54	322.81
	-4.60	6.90	0.44	-3.05	-3.71
17Chemicals	1720.24	1119.07	1620.76	2214.86	2380.68
	-4.02	7.00	-0.23	-3.11	-2.75
18RuuberPlast.	920.91	292.43	412.13	514.17	578.26
	-4.51	7.15	0.64	-3.18	-3.51
19NonMet.Mine.	254.52	108.54	142.39	166.99	188.17
	-2.32	6.74	1.53	-4.57	-5.87
20BasicMetal	0.00	1.54	1.49	1.65	1.60
	0.00	6.38	1.29	-4.46	-6.25

Table 20: The Simulation of Output Vector

1Agriculture	13778.82	13048.66	13006.98	14053.67	13523.35
	-0.04	-0.68	-0.53	0.88	2.70
2Forestry	301.03	303.30	235.35	268.22	269.07
	-1.08	1.41	-0.33	-0.59	0.39
3Fish	319.06	278.07	293.75	507.59	448.58
	-0.16	-0.54	-0.44	0.36	2.19
4CoalLignite	460.54	344.99	412.88	376.31	619.50
	-3.75	6.28	0.87	-4.76	-7.64
5PetroleumGas	63.14	68.21	389.94	155.68	328.77
	-29.65	48.07	-4.34	-15.44	-6.68
6MetalOres	78.66	92.10	216.11	513.53	385.03
	-5.03	4.50	-0.45	-2.01	-1.94
7OtherMining	647.12	691.64	904.38	1026.81	1158.10
	-1.72	3.56	-1.23	-1.57	-1.01
8FoodBeverage	9834.02	10080.79	10804.35	12938.24	13882.55
	-0.63	-0.77	-0.43	0.88	2.47
9Tobacco	455.75	330.00	247.89	241.94	293.21
	-0.02	-0.65	-0.56	0.99	3.39
10Textiles	6850.50	6892.27	6999.10	7010.03	6736.92
	0.24	0.36	-6.75	1.05	2.59
11WearingApp.	2456.75	3914.57	4112.65	4886.42	4719.41
	0.55	0.09	-6.71	1.09	2.55
12Leather	632.48	678.03	745.62	867.56	773.53
	1.90	0.23	-10.03	1.54	3.83
13Wood	733.17	725.87	835.93	1192.50	1445.37
	-1.75	2.94	-0.01	-1.64	-1.78
14PulpePaper	1400.54	1123.74	1268.79	1550.76	1741.96
	-3.37	3.64	-0.54	-2.42	-2.27
15PrintedMedia	1120.75	867.23	1434.27	1634.34	1731.46
	-2.28	3.80	-0.79	-2.05	-1.65
16Coke	2153.97	1074.83	1118.05	1181.43	1172.16
	-4.20	4.82	-1.74	-1.73	-0.59
17Chemicals	4322.58	3219.94	3994.17	5351.45	5911.47
	-4.45	5.41	-3.10	-2.51	-1.20
18RuuberPlast.	1864.33	1682.89	2203.56	2701.56	2919.77
	-3.77	3.43	-0.85	-1.55	-1.00
19NonMet.Mine.	2314.86	2094.06	2528.26	3421.47	3481.16

	-0.85	2.04	-0.10	-1.20	-1.11
20BasicMetal	4073.59	3050.08	3857.17	5090.99	5756.17
	-3.25	3.69	-0.31	-1.76	-1.73

Table21: The Simulation of Price Vector

1Agriculture	196.84	439.79	658.81	719.31	868.87
	5.46	0.25	1.05	0.18	-1.63
2Forestry	199.57	421.13	810.39	838.87	957.40
	3.28	-1.54	0.61	0.93	-0.17
3Fish	159.47	325.66	608.83	536.91	507.17
	4.28	0.08	0.89	0.37	-1.41
4CoalLignite	209.80	593.78	854.79	1006.22	1402.53
	7.57	-4.72	0.35	4.62	6.18
5PetroleumGas	593.74	1230.32	1668.29	2558.28	3856.33
	37.71	-25.35	2.99	11.39	3.43
6MetalOres	239.02	635.06	771.58	1084.32	1735.92
	7.77	-3.14	1.58	2.89	1.84
7OtherMining	187.01	452.69	655.74	729.75	809.85
	9.84	-3.24	2.06	2.84	1.42
8FoodBeverage	214.06	507.83	713.08	753.56	937.99
	7.64	0.00	1.44	0.93	-0.68
9Tobacco	324.04	820.77	1443.64	1658.34	1683.43
	10.12	0.24	1.49	0.08	-1.19
10Textiles	219.28	555.32	730.19	760.90	832.85
	6.67	-0.99	4.53	1.38	-0.25
11WearingApp.	223.53	575.56	852.74	915.52	1012.07
	3.54	-0.68	4.65	1.30	-0.24
12Leather	214.01	519.02	706.96	789.52	865.12
	5.79	-0.72	4.84	1.39	-1.01
13Wood	204.70	402.53	595.30	651.75	735.71
	9.12	-1.99	1.81	2.69	1.44
14PulpePaper	249.27	568.48	647.95	709.01	747.68
	13.28	-2.82	2.00	3.13	1.74
15PrintedMedia	188.32	404.84	474.65	542.21	643.51
	11.08	-2.58	1.80	2.56	1.44
16Coke	350.29	938.51	1286.39	2224.81	3045.85
	20.86	-15.82	2.72	8.74	2.50
17Chemicals	248.91	587.83	696.72	727.74	849.76

	10.68	-3.43	2.68	2.75	1.13
18RubberPlast.	262.10	571.27	695.23	806.23	913.94
	9.75	-2.85	1.89	2.34	1.12
19NonMet.Mine.	234.06	563.33	721.00	889.34	1004.24
	9.69	-3.04	1.20	2.31	1.47
20BasicMetal	234.80	570.82	984.00	1283.52	1681.93
	12.10	-3.26	1.30	2.59	1.65

From the Figures 16-19 above, it can be seen that the simulations for the 4 aggregated variables (total household consumption per capita, gdpR, gdpN and gdpD) are quite good. Similarly, from Tables 19-21, it can be concluded that most simulations have small relative error. In fact, a statistical calculation for the 1740 simulation results, 58(sector number)*3(vector number)*10(years), is done and listed in Table 22 below.

Table22: The Statistics of the Percentage Change of Simulation Results for 3 Vectors

Error	<=3%	>3% and <5%	>5% and <10%	>10%
%	72.65	16.55	9.25	1.55

It's regarded satisfactory that only 1.55% of total simulation results show more than 10% error from the actual historical values.

5. CONCLUSION

Throughout constructing a simplified non-linear behavioural equations system "PADS", the main part of the GDP by expenditure, i.e. the household consumption, is described by the model TURINA. The behavioural vectors, output and price vectors are calculated by the model, according to the two basic input-output equations of the INFORUM model. The next step should perhaps have more detailed data for consumption so that 'groups' and 'subgroups' can also be identified. Forecasting with alternative policy formulations, say up to 2023 (centennial of the modern Turkish Republic) or to 2050, will be the next main step forward. In its present form, the historical simulation results show that the "bird" "TURINA", or "Turna" for the Turkish speaking readers, is able to fly.

REFERENCES

CLOPPER ALMON (1979). "A System of Consumption Functions and its Estimation for Belgium", *Southern Economic Journal 26*.

CLOPPER ALMON (1996a). "A Perhaps Adequate Demand System". INFORUM Working Paper, *Department of Economics, University of* Maryland.

CLOPPER ALMON (2011). *The Craft of Economic Modelling*, Vols 1, 2, 3.

DOUGLAS S. MEADE (1995). *"An Overview of INTERDYME".* INFORUM Working Paper.

GAZI OZHAN, YINCHU WANG AND MERAL OZHAN (2010). "Data Preparation and Preliminary Trails with TURINA", *18th INFORUM international Conference,* Japan.

INFORUM (1996-2009). *INTERDYME: The software package for interindustry model,* version 1996, version 1997, version 1998, ……, version 2009.

SHANTONG LI AND YINCHU WANG (1999). "The Multisectoral Development Analysis Model (MUDAN) for China". The Practical Macroeconomic Models in China, *China Financial and Economic Press,* Beijing.

INFORUM U.S. MACROECONOMIC REVIEW AND OUTLOOK

JEFFREY F. WERLING[45]

Abstract:
The U.S. economy entered 2011 with considerable momentum and optimism concerning economic growth. The original forecasts for the year – at just above 3.0 percent - reflected this sentiment. Economic growth for the year ended up at only 1.7 percent. At least four factors contributed to this disappointment in growth: fiscal contraction, continuing deleveraging by consumers, political gridlock in Washington, D.C., and financial turmoil in the euro-zone. Unfortunately, as of this writing, each of these four phenomena still weighs heavily on the U.S. economy going forward. This article describes the annual LIFT model projection to 2035. The current forecast calls for higher, but still slow growth of 2.3 percent. The economy will continue a gradual but steady recovery from 2013 to 2015 growing between 2.5 and 3.0 percent.
JEL classification: E17; E66
Keywords: LIFT (Long-term Interindustry Forecasting Model), GDP, Fiscal Policy, Net Lending, Net Worth, Deleveraging, Exchange Rates

1. INTRODUCTION

In July 2011, the Bureau of Economic Analysis (BEA) released revised GDP data showing that the "Great Recession" of 2008-2009 was deeper than previously believed. The GDP details are shown by Figure 1, which plots the level of quarterly real GDP in 2005 dollars from 2006 through the second quarter of this year for both the previous and revised estimates. The revisions were greatest in the teeth of the

45 Executive Director, Inforum/Department of Economics, University of Maryland, College Park.

recession at end of 2008 and into the first quarter of 2009. GDP contracted 8.9 and 6.7 percent on an annualised basis in the final quarter of 2008 and the first quarter of 2009. Previously, BEA reported contractions of 6.8 and 4.9 percent, respectively. According to the recent figures, the level of GDP returned approximately to its previous peak only in the second quarter of 2011.

The new figures tend to be correlating better with employment dynamics. Figure 2 shows the year-on-year percentage change in monthly non-farm employment. By end of recession in the middle of 2009, declines in this indicator reached 5.0 percent, easily outstripping the previous largest post-war fall in the recession of 1982. Indeed, from the peak of 137.9 million jobs at the end of 2007, the economy lost over 7 million jobs over the subsequent two years. If the 3 to 4 million jobs are counted, that otherwise might have been created with potential economic growth from 2008 to 2010, the economy is missing 10 to 12 million jobs. Over the past 18 months, halting growth has created a bit less than 2 million jobs. Indeed, polls show that most Americans believe that the economy has not escaped recession at all.

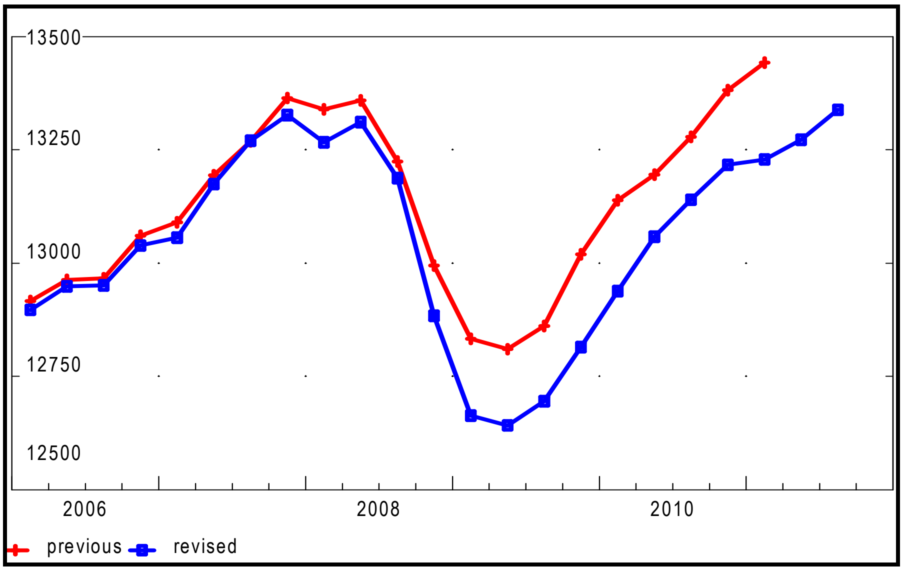


Figure 1: GDP before and after revision (billions of 2005 dollars)

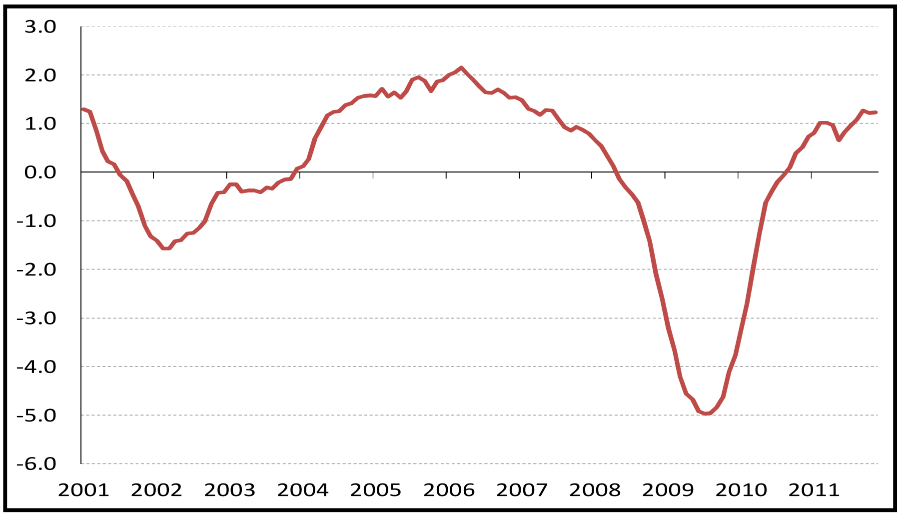


Figure 2: Non-farm Payroll Employment (percent change from year ago)

After a promising start in the second half of 2009 and into the first half of 2010, the recovery has been disappointing. Figure 1 shows that the recovery has faltered in 2011. This deceleration of economic activity was not unexpected by economists, who perceived that federal economic stimulus would be running out by the middle of 2010. Perhaps it could have been better designed or just larger, but ultimately the $787 billion stimulus largely can be credited with sparking recovery in 2009 to 2010, and it saved millions of jobs[46]. Unfortunately, the original stimulus was ultimately too small and too short to counteract fiscal contraction of state and local budgets. In 2009 and 2010, total real federal government nondefense consumption and investment grew by 6.4 and 7.0 percent respectively. For federal defence, these rates were 5.8 and 3.3 percent. Real state and local spending is 40 to 50 percent larger than combined real federal expenditures, and these fell by 0.9 and 1.8 percent in 2009 and 2010 respectively. Therefore, the total government-spending stimulus to GDP growth was anaemic, with government spending posting 1.6 and 0.9 percent growth in the two years (Figure 3).

46 Congressional Budget Office. "Estimated Impact of the American Recovery and Reinvestment Act on Employment and Economic Output From July 2010 Through September 2010." November 2010.

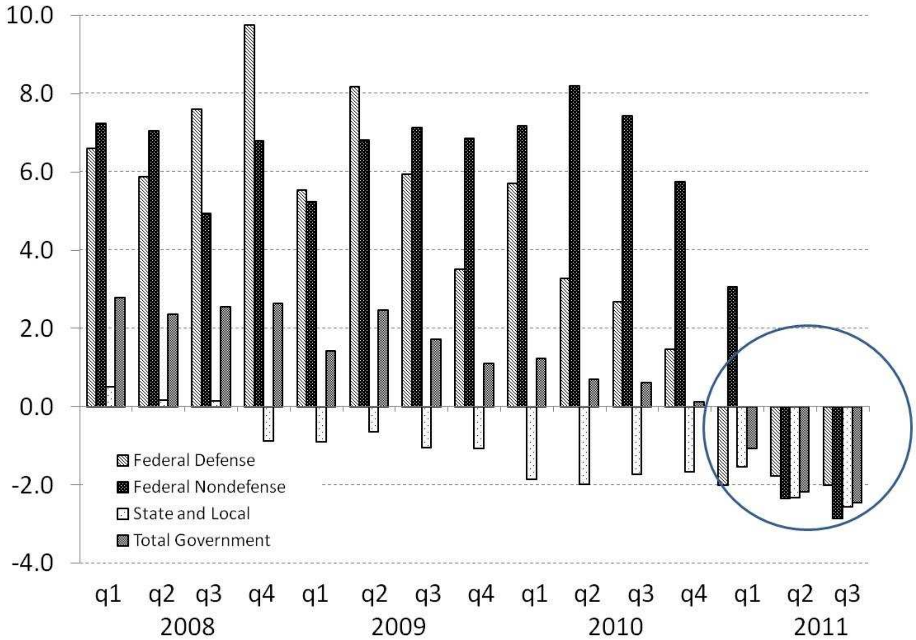


Figure 3: Counter-Cyclical Fiscal Policy Gone Wrong - Real government consumption and investment (percent change from year ago)

The Great Recession was bound to be deep and protracted in any case. When one considers that the source of the recession was the plummeting consumer demand brought about by bursting bubbles in housing wealth and equities, with a corresponding banking crisis to boot, perhaps it is not surprising that recovery has been so lacklustre. As Carmen Reinhart and Kenneth Rogoff note in their book "This Time is Different, [47] " recoveries from recessions brought about by banking crises normally are tepid and protracted. Typically, an excess of nonperforming assets fester on banks' balance sheets, discouraging new lending, even where monetary policy pumps liquidity into the system. In the current economy, it is the overhang of impaired mortgage debt

---

47 Reinhart, Carmen M., and Kenneth S. Rogoff. "This Time *Is Different: Eight Centuries of Financial Folly*." Princeton University Press. 2009.

and housing foreclosures that impede growth, and especially growth in employment. Because many people are trapped in their houses by negative equity, workers are relatively less mobile in this recovery[48]. Moreover, many potential entrepreneurs have been cut off from finance especially because of home equity losses. Since most new jobs come from new businesses, employment formation is discouraged further. Therefore, a more rapid unwinding of impaired mortgage debt, especially a larger emphasis on writing down the principal of existing mortgages, would be more helpful for short run growth in income and employment[49]. A large dose of federal infrastructure investment would help not only to stimulate income and jobs but also to help recovery through increased productivity and competitiveness.

While the economy needs such bold policy initiatives, U.S. political leadership has been tied down by an ideological debate over the long-term trajectory of taxes and spending. While this debate is very important, it mostly is irrelevant to the immediate situation. Preliminary figures show that GDP in the third quarter of 2011 is barely 2.0 percent higher than a year ago. Figure 2 shows that employment growth also has faltered since the beginning of the year. Growth has reached what some economists have called "stall speed." Some worry that brisk recovery cannot be sustained and even about another recession.

2. THE SITUATION IN EUROPE IS MORE DIRE

There are several similarities between the situation in the United States and the economic crisis in Europe. First of all, there is a common root cause of the current difficulties across developed economies: a housing price bubble generated by the so-called savings glut. In short, consumers across several developed economies borrowed heavily from creditors in countries with surpluses such as Japan, China, and

48 Wellisz, Christopher, and Alan Mirabella. "Job Growth Erodes as Housing Bust Pushes Mobility to Record Low." Bloomberg: www.bloomberg.com/apps/news?pid=newsarchive&sid=ajImkJ5FYdQ8

49 Ferreira, Fernando, Joseph Gyourko, and Joseph Tracy, 2010. "Housing busts and household mobility," Journal of Urban Economics, Elsevier, vol. 68(1), pages 34-45, July.

Germany, with borrowing facilitated by new financial "innovations" such as subprime mortgages and collateral debt obligation (CDOs). When the growth of credit could not be sustained, housing and asset prices plummeted, the true net worth of borrowers became transparent, and economies were thrown into deep recession. Even as their revenues fell, governments ran to the rescue of financial institutions and, in some cases, tried to fill some of the void in aggregate demand. Very large official deficits opened across the developed world. What started as private sector prolificacy ended up as sovereign debt problems.

Unfortunately, in too many places these symptoms have been misinterpreted. It is true that Greece's severe structural budget problem not only predated the crisis, but that deficits were at least partly obscured from creditors. This was not the case in other countries however. Spain, Ireland, and even Italy displayed improving fiscal situations in the decade leading up to the crisis, but now they are forced to finance spiralling deficits at ever-higher rates of interest. Since reduced spending and increased taxes result in only lower growth and revenues, there is no way out short of depreciation (so far not an option) or debt default and restructuring. This brings the crisis to a full circle. It turns out that the chief holders of European sovereign debt are the banks that had to be rescued three years ago when the credit boom they initiated went bust. It is most likely that an initial default of a large EU sovereign borrower would lead to a banking crisis that would have to be resolved in the same way. Pre-emptive monetisation might avoid the worst of the pain, but this would mean much more participation from the European Central Bank (ECB) than seen to date. Monetisation, however, may be the only way to avoid disastrous deflation.

3. HOPE REMAINS

If anyone needed reminding, the extensive linkages between the U.S. and European financial systems were dramatically evident in 2008 and 2009. Though U.S. banks and money funds have worked hard to reduce their exposure to Europe over the past nine months, a banking crisis there would have substantial repercussions here. Hope remains, that the EU economies will muddle through with mild recession that will be completed by mid-2012. (See below for USA's international forecasts).

At best, this means more of the same – that is, sluggish growth – for the U.S. economy. It was assumed that Congress would allow the payroll tax cut to be extended for another year and that most of the Bush tax cuts are extended into 2013. These do not do much to improve growth, but at this point their reversal would have a noticeable dampening impact.

For 2012, annual economic growth of 2.3 percent is foreseen, up from 1.8 percent this year, but still entirely too slow to spur employment substantially. Despite an ongoing deleveraging process, there is plenty of pent up demand in the household sector. Unfortunately, uncertainty, unemployment, and political squabbling are weighing heavily on consumers. Real growth of consumer spending is expected to grow by only 2.0 percent. These figures are shown in Table 1.

Equipment and software investment will remain a bright spot and again should grow at a double-digit clip next year. As the construction sector begins to recover from its deep hole, both non-residential structures and residential investment will grow slowly at 6.2 percent and 4.4 percent respectively.

Given growth-choking turmoil in Europe, exports growth will decelerate next year to 3.6 percent in real terms. Dollar depreciation – eventually against even the Chinese Yuan and other Asian currencies – will enhance growth in subsequent years. Real import growth also will be slow next year, at 3.2 percent. It remains mostly below 4 percent through the long-term forecast horizon.

Once again, in 2012, government consumption and investment will contract, creating a significant drag to overall growth. State and local governments will begin to see positive growth by 2013, but federal spending growth will be anaemic at best until the middle of the decade. Total government demand will contract by at least 1.1 percent in 2012, but could revive by 0.5 percent in 2013.

Table 1: Fall 2011 Forecast Summary

Real (Inflation-Adjusted) Quantities, Average Annual Growth Rates, Percent

	00-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-20	20-25	25-35
Gross domestic product	2.0	-3.5	3.0	1.8	2.3	2.7	2.9	3.1	2.8	2.2	2.4
Personal consumption	2.4	-1.9	2.0	2.2	2.0	2.1	2.4	2.6	2.4	2.0	2.2
Nonresidential structures	0.7	-21.2	-15.8	5.1	7.2	8.9	6.5	5.8	4.8	2.2	2.1
Equipment investment	2.2	-16.0	14.6	10.8	12.5	5.3	3.0	4.8	5.1	3.8	2.7
Residential investment	-3.3	-22.2	-4.3	-1.7	4.9	8.1	8.3	14.0	7.5	1.2	2.4
Exports	4.2	-9.4	11.3	6.8	3.6	4.9	7.7	6.6	5.7	4.8	4.1
Imports	3.4	-13.6	12.5	4.7	3.2	3.5	3.6	4.3	3.7	3.2	2.6
Government	2.2	1.7	0.7	-1.9	-1.1	0.5	0.7	0.8	0.9	0.8	1.0
GDP deflator	2.6	1.1	1.2	2.2	1.9	1.8	1.8	2.1	2.1	2.2	2.1
Consumption deflator	2.4	0.2	1.8	3.2	2.2	2.0	2.4	2.3	2.4	2.4	2.2
Population	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.9
Labor force	1.0	-0.1	-0.2	-0.2	0.3	0.9	1.1	1.1	0.9	0.8	0.9
Employment	0.4	-4.5	-0.6	0.7	0.9	1.3	1.4	1.6	1.4	0.9	1.0
Labor productivity	1.8	2.5	2.8	0.9	1.3	1.5	1.5	1.4	1.3	1.3	1.3
Potential GDP	3.0	2.2	1.6	2.2	1.8	1.7	2.0	2.4	2.3	2.3	2.3

	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2035
Unemployment Rate	5.8	9.3	9.6	8.9	8.5	8.2	8.0	7.6	5.2	5.4	5.3
INTEREST RATES											
Treasury Bills, 3-month	1.4	0.2	0.1	0.1	0.2	1.5	3.0	3.0	3.5	3.5	3.5
Yield, 10 yr. Treasury bonds	3.7	3.3	3.2	2.8	2.5	4.5	4.8	4.6	5.0	5.0	4.8

Nominal Quantities, Billions of $

	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2035
Current account	-684	-382	-484	-470	-538	-597	-598	-617	-745	-842	-901
(% of GDP)	-4.8	-2.7	-3.3	-3.1	-3.4	-3.6	-3.5	-3.4	-3.2	-2.9	-2.0
Federal net borrowing	-762	-1453	-1469	-1387	-1227	-1062	-1012	-923	-839	-766	-765
(% of GDP)	-5.3	-10.4	-10.1	-9.2	-7.8	-6.4	-5.9	-5.1	-3.6	-2.7	-1.7

Compared to earlier recoveries, the overall rates of growth anticipated over the coming years are relatively sluggish. Once again, the tattered household balance sheet is fingered as the culprit. As shown in Figure 4, recent gains in stock prices helped richer households regain much of their financial wealth. On the other hand, given still-falling housing prices, many middle class and poorer households are still well below water. Moreover, the durability of recent financial gains is threatened by renewed slowing in the economy and political uncertainty. Therefore, the economy faces a Catch 22 situation. Faster economic growth needs a boost of consumer spending, but the stagnation of net worth weighs on consumer confidence. Without increases in disposable income and housing prices that might be spurred by economic growth, consumers will remain reluctant to spend. For a generation planning for retirement in the next twenty years, and for the generation expected to pay for that retirement, building wealth will have to happen the old-fashion way, through savings.

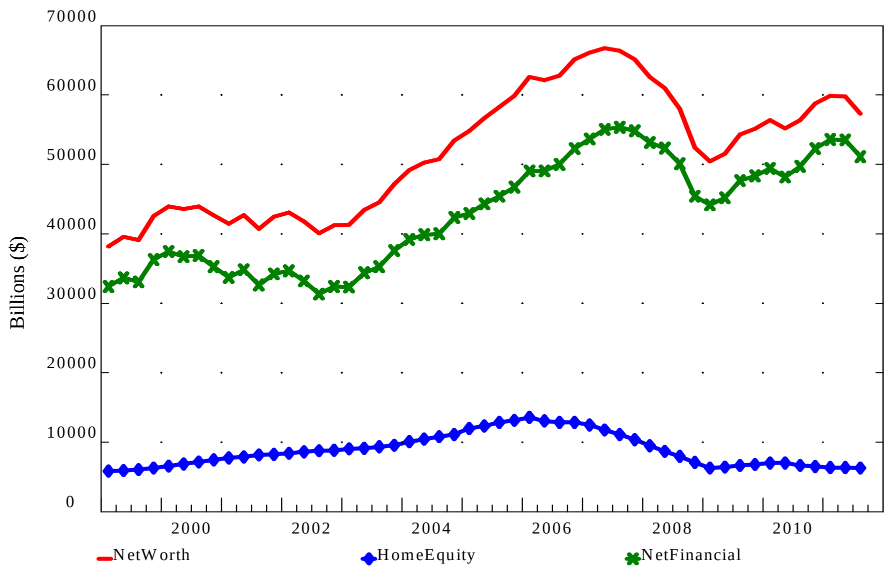


Figure 4: Net Worth and Home Equity (Billions of dollars)

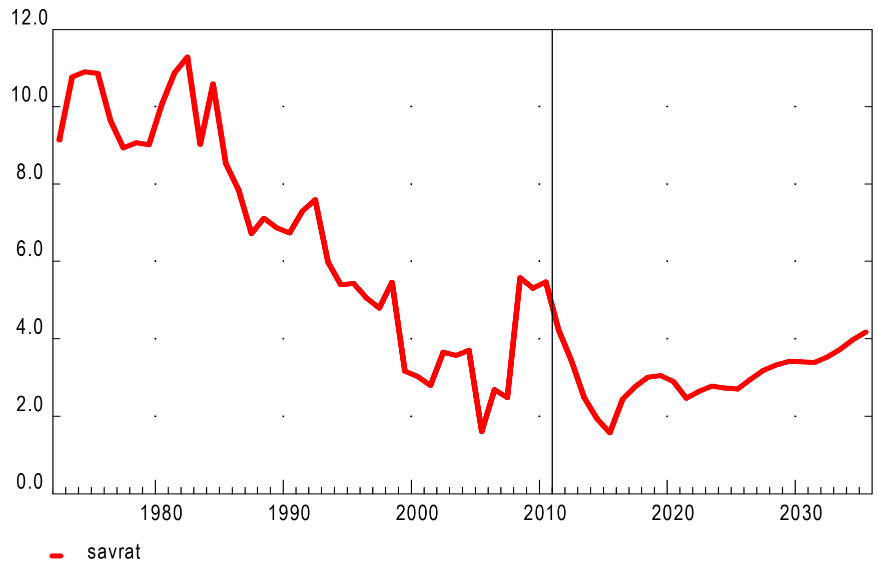


Figure 5: Personal Savings Rate (percent)

Indeed, once again it is stressed that, at least compared to the last decade (2000-2009), household spending growth will remain subdued not only over the next couple of years, but over the next decade or more. Figure 5 displays the household savings rate over the forecast horizon until 2035. As employment and income grow, the rate will fall from around 6.0 percent in 2010 to around 3.0 percent in 2015-2016. It will remain there through the following decade until the baby-boomers finish entry into retirement. In contrast to the free spending days of the bubble decade, the rate remains above 2.5 percent, at the least, because of a new and lower growth environment for consumer credit, income growth, and government benefits.

This restrained behaviour in the consumption sector reflects the calibration of a LIFT forecast to exhibit sustainability of the economy's basic nominal balances as a percent of GDP. Figure 6 is a complicated but important graph depicting the long-term trajectories for net lending (or borrowing) as a percent of GDP for the private sector (which includes both household and corporate business sectors), the government sector (federal plus state and local), and for the economy as a whole. Each line shows the excess of income over consumption and capital investment expenditures for the sector as a percent of GDP[50]. The line marked "national" is equal to the current account deficit, or the economy's net lending abroad, which of course has been mostly negative over the past four decades. It is the sum of the household, business, and government (including state and local governments) net lending.

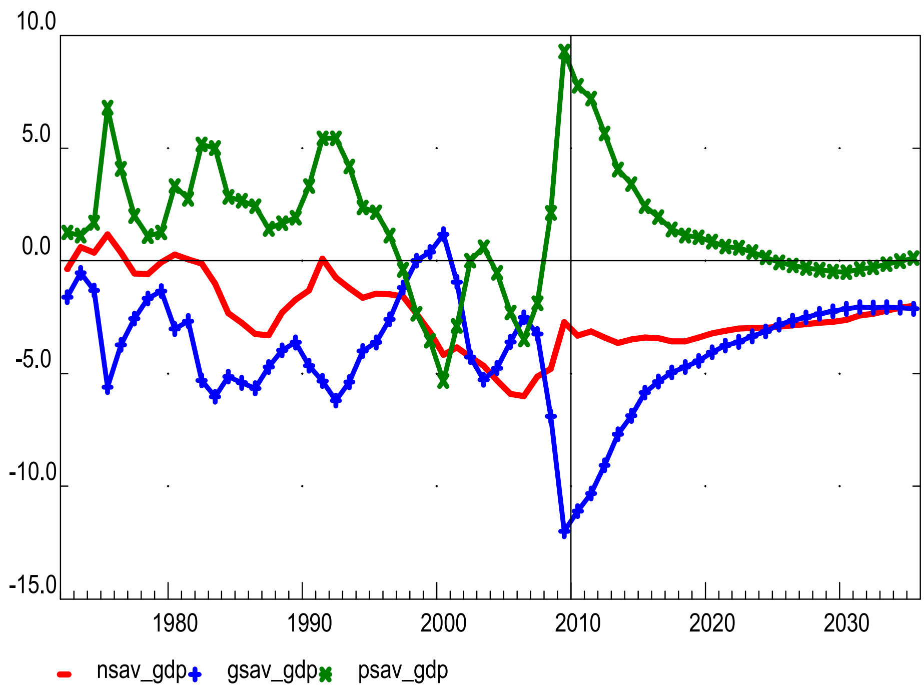


Figure 6: Net Lending

[50] This figure is different from savings in that it includes expenditures for investment out of savings.

Remember that these balances are the residuals produced by complex processes in the real and price sides of the economy. They feed back into the economy and into each of the others in important ways. The first principle to note is how unique is the current situation. Recession meant that the current account deficit as a percent of GDP fell from almost 6 percent in 2007 to less than 3 percent over the past two years. A substantial deleveraging in the private sector that took place among businesses as well as consumers drove this retrenching. In 2009, the private sector lent, on a net basis, an unprecedented 9.0 of its current income. The ratio was negative throughout most of preceding decade.

In contrast, net borrowing by the Federal government sector reached another unprecedented post-war level of 10.4 and 10.1 percent of GDP in 2009 and 2010, respectively. In 2007, the number was 2.3 percent. Much of this increase was due to the fall of the denominator, GDP. However, from 2007 to 2009, federal revenues slipped by 3 percent of GDP and federal expenditures grew around 5 percent of GDP.

Apparently, many observers believe that continuing private sector deleveraging is a direct result of government prolificacy (Ricardian equivalence). In this case, however, the collapse in private demand clearly preceded and surpassed the run up in government deficits. Private sector deleveraging was due to the collapse of asset values, especially in housing. It is believed that the lions' share of the increase in government expenditure was due to automatic stabilisers reacting to a decrease in aggregate demand and employment, and, to a smaller extent, the $787 billion stimulus initiated in 2009. Given the ineffectiveness of monetary policy in the midst of deleveraging – interest rates have been very low for very long – fiscal expansion of this magnitude was necessary to reverse the recession and to preserve jobs. [51]

Nevertheless, just like an apple falling from a tree, "natural" economic forces will compel a rebalancing of global current accounts, and within the country, a rebalancing of relative expenditure among the

51 Congressional Budget Office. "Estimated Impact of the American Recovery and Reinvestment Act on Employment and Economic Output from July 2011 through September 2011," November 2010. http://www.cbo.gov/ftpdocs/125xx/doc12564/11-22-ARRA.pdf

private and government sectors. This process, at least, is that represented by Figure 6. After recovery reduces net borrowing to about 5 percent of GDP in 2016, the government sector embarks on an agonising slow, but steady, course to zero net borrowing. The private sector finishes deleveraging by 2015 where net lending settles to about 2 percent of GDP for the rest of the forecast. On an aggregate basis, the current account slowly but surely converges to zero.

Of course, real economies rarely adjust to disequilibrium in such a smooth manner. For example, without some evidence of real-life rebalancing, either through market or through political processes, it is doubtful that international bond investors will be patient enough to allow a tranquil rebalancing process. Nevertheless, given that the main objective of the long-term LIFT forecast is to trace the structural development of the economy given plausible aggregate trends, these assumptions on nominal balances are integral for ensuring that the model solution for economic growth, structural change, relative prices, and general inflation mutually are consistent.

4. EXOGENOUS ASSUMPTIONS AND THEIR IMPLICATIONS FOR THE FORECAST

INFORUM's macroeconomic and industry forecasts are determined by the endogenous economic relationships embodied in the LIFT model and by the assumptions made for key exogenous variables. Over the short run, various cyclical factors, such as interest rates and employment growth; international issues such as trading partner growth, oil prices, and exchange rates; or monetary and fiscal policy, can exert significant influences over the outlook. In developing the longer-term outlook, however, the general strategy is to assume that the economy reaches a full employment, noninflationary growth path even as it struggles to recover from its current enormous fiscal and savings imbalances. This long-term growth path and its associated trends are determined using informed and reasonable projections for the exogenous variables. For convenience, the exogenous assumptions for key inputs are divided into six main groups that are summarised below.

5. U.S. POPULATION AND LABOUR FORCE CHARACTERISTICS

For the December 2011 Lift Outlook, population data from the U.S. Census Bureau is used. Historical population data from Census covers the years 1990 through 2010. Census projections of population from 2011 through 2050 were used[52]. These projections grow somewhat faster than the Social-Security Administration (SSA) based population figures used in 2009. In 2035, the population of 389.5 million people is 13 million, or 3.5 percent, more than the population projections used for earlier LIFT forecasts. Similarly, the labour force is 3.3 percent larger in 2035.

Table 2: Population and the Labour Force - Average Annual Growth Rates

	00-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-20	20-25	25-35
Population	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.9
Labor Force	1.0	-0.1	-0.2	-0.2	0.3	0.9	1.1	1.1	0.9	0.8	0.9
Employment	0.4	-4.5	-0.6	0.7	0.9	1.3	1.4	1.6	1.4	0.9	1.0

6. ENERGY PRICES

The November 2011 STEO[53] was used for the near term growth of nominal energy prices through 2012 and Annual Energy Outlook published in September 2011 for the growth of real energy prices (relative to the GDP deflator) for 2013 and later. The table below shows the projected nominal energy prices. Domestic crude oil prices (Refiners' Acquisition Costs) are projected to stabilise next year and then grow somewhat faster than general inflation throughout the forecast period. Natural gas prices are forecast to grow faster than general inflation but slower than those for crude oil do.

---

52 Hist. est. at www.census.gov/popest/national/asrh/2009-nat-af.html. Projec. at www.census.gov/population/www/projections/downloadablefiles.html.

53 Short-Term Energy Outlook, November 2011, U.S. Energy Information Administration.

Table 3: Energy Price Outlook

	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2035
Crude oil ($/bbl), dom. purc.	98.5	59.5	78.0	102.5	101.5	106.0	110.9	116.3	144.6	176.1	228.5
Crude oil imports ($/bbl)	92.8	59.2	75.9	99.7	98.8	103.2	107.9	113.1	140.7	171.4	222.3
Natural gas wellhead ($/Mcf)	8.0	3.7	4.2	4.0	4.1	4.2	4.3	4.5	5.5	7.1	10.3

7. FISCAL POLICY

To project federal spending, projections from other sources, or on behavioural or "accounting" relationships, were relied on. For example, outlays for unemployment insurance rely on the number of people unemployed and an assumption about the real yearly transfer per unemployed person. Federal interest payments depend on interest rates and the federal debt. The Medicare and Social Security outlay projections are guided by the reports published by the official trust fund for each program. Expenditures usually are expressed as shares of nominal GDP. Old-age, survivors, and disability income (OASDI) transfer payments have been just above 4 percent of GDP over the last 20 years and gradually will climb to about 5.5 percent by 2025 and to over 6.3 percent by 2035. Medicare similarly will increase from 3.5 percent of GDP this year to 4.5 percent in 2020 and 6.7 percent in 2035. Federal defence and nondefense spending growth, along with state and local spending growth, are displayed in Table 4.

State and local government expenditures are constrained by the requirement that their budgets must be balanced. This means that expenditures will continue to fall this year as governments cut expenditures on goods and services, impose furloughs, and lay off employees.

Restrained fiscal policy is projected in this forecast, but with policy not drastically constrained. Defence employment (both civilian and military) will be falling slowly throughout the forecast. Initially the fall in defence mainly is due to conclusion of the wars in Iraq and Afghanistan. In 2010, non-defense federal employment rose quite a bit; this was only temporary, however, because of the many temporary hires to conduct the population census that year, and so non-defence employment fell again in 2011. For 2012 stability is anticipated, and very modest growth expected beyond.

Table 4: Assumptions for Real Government Consumption and Investment (Excludes transfer payments, interest payment and grants-in-aid) - Average Annual Growth Rates, Percent

	00-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-20	20-25	25-35
Gross Domestic Product	2.0	-3.5	3.0	1.8	2.2	2.7	3.0	3.2	2.8	2.2	2.4
Gov't consumption & investment	2.2	1.7	0.7	-1.9	-1.1	0.5	0.7	0.8	0.9	0.8	1.0
Federal Defense	4.8	5.8	3.3	-1.5	-2.5	-1.3	-0.1	0.1	0.2	0.2	0.3
Federal Nondefense	3.1	6.4	7.0	-0.9	-1.4	0.4	0.5	0.6	0.6	0.5	0.7
State & Local	1.1	-0.9	-1.8	-2.4	-0.5	1.3	1.1	1.1	1.2	1.0	1.3

8. INTEREST RATES

Short-term interest rates will remain at historic lows – essentially zero for the three-month Treasury bill (T-bill) – for a while longer. Traditional monetary policy is still pushing on the proverbial string of a liquidity trap. In the short term, rates will rise significantly only when both growth and inflation are safely revived, perhaps by the middle of 2013. The Federal Reserve purchases of federal debt (Quantitative Easing or QE2) mean that ten-year bond yield will remain low as well, below 4.0 percent until 2013. Interest rate projections are shown in Table 5.

Over the long run, the three-month T-bill rate is set to reflect a 1.5 percent real premium over the GDP inflation trend of 2.0 percent. The long-term 10-year rate runs about 5 percent through the forecast horizon, or 3 percent in real terms.

Table 5: Interest Rates

	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2035
Treasury Bills, 3-month	1.4	0.2	0.1	0.1	0.2	1.5	3.0	3.0	3.5	3.5	3.5
Yield, 10 yr. Treasury bonds	3.7	3.3	3.2	2.8	2.5	4.5	4.8	4.5	5.0	5.0	4.8

9. EXCHANGE RATES

INFORUM's International System of models (IS) and its Bilateral Trade Model (BTM) connect the US forecast with the rest of the world. Exchange rates technically are exogenous in the IS forecast, which is made in conjunction with formulation of the US outlook. The exchange rates are endogenous, however, to the overall forecasting process. What is meant by that? First, an exogenous path for each exchange rate is set and the impact on the forecast across economies observed. If the results lead to implausible current account balances over time, the exogenous forecast is modified. The situation can be quite complicated. Getting the dollar right might upset the Canadian balances or Mexican balances or produce untoward effects on Japan. Thus, adjusting one currency means observing indirect effects on other economies.

The great imponderable this coming year is, of course, the value of the euro. It was assumed that some kind of stability would be attainable. From 2013-2015 the value of the euro will be recovering significantly.

Little change is forecasted in the value of Japanese Yen over the coming decades. It currently is at historic highs.

As noted earlier, the more sustainable path for borrowing on the national external account will require a sustained weakening in the US dollar. It is contended, as many economists do, that China's renminbi (Yuan) is substantially undervalued—thus yielding China a trade surplus from which it buys large amounts of US Treasury notes. In fact, China and the US do have the largest imbalances among the major economies of the world today. The projections of exchange rates are shown in Table 6. Of the major trading partners, only the Mexican currency fails to gain on the dollar.

Table 6: Exchange Rate Assumptions (Negative values signify dollar depreciations)

	00-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-20	20-25	25-35
Euro	-5.6	5.1	5.2	-4.0	0.0	-4.7	-4.8	-5.0	-2.8	-0.2	-0.2
Canadian dollar	-4.1	6.9	-9.7	-6.5	-2.0	-1.7	-1.3	-1.0	-0.7	-0.5	-0.5
Mexican peso	2.1	21.0	-6.5	-7.0	-2.0	-1.3	-0.7	0.0	0.0	0.0	0.0
Japanexe yen	-0.5	-9.5	-6.2	-7.0	1.0	0.0	-0.8	-1.5	-1.5	-0.8	-0.4
Chinese yuan	-2.2	-1.7	-0.9	-4.5	-6.5	-5.0	-3.5	-2.0	-1.4	-0.7	-0.5
British pound	-2.4	17.4	0.9	-4.0	0.0	-4.7	-4.8	-5.0	-2.8	-0.2	-0.2
South Korean wo	-0.3	15.9	-9.4	-7.0	-5.0	-2.5	-1.7	-1.0	-1.0	-0.8	-0.6

10. FOREIGN ECONOMIC GROWTH

Table 7 shows projections for economic growth for USA's major trading partners.

The short-run forecast is for Europe to face a mild recession. This one comes on the heels of a much more substantial recession that occurred only three years ago. Several European countries have yet to regain pre-recession levels of GDP. It is expected that the downturn will be more pronounced in Italy and Spain than for the more northern countries.

Japan still is recovering from last year's terrible earthquake and tsunami. It is expected to see China undergoing a major change next year. The housing investment boom will end. The slowdown in exports will be substantial as well. The result will be a sharp decline in growth. Over the longer term, China's growth is expected to moderate even more as it becomes more and more constrained by the approaching plateau in labour force and population levels.

Table 7: Foreign Economic Growth

	2008	00-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-20	20-25	2025
Total All Listed Countries	34640	2.4	-2.4	3.8	2.8	2.1	2.6	3.1	3.0	2.2	2.3	49933
United States	13164	2.0	-3.5	3.0	1.8	2.2	2.7	3.0	3.2	2.8	2.2	19023
Canada	1089	2.2	-1.8	2.4	1.5	2.0	3.5	3.1	2.5	1.3	1.8	1443
Mexico	763	3.2	-7.0	5.5	3.7	2.9	3.5	5.2	5.3	5.5	5.1	1535
North America	15016	2.1	-3.6	3.1	1.9	2.3	2.8	3.1	3.2	2.9	2.3	22000
Austria	386	2.2	-4.9	3.1	1.4	0.3	1.6	1.1	1.4	1.7	1.6	473
Belgium	320	2.0	-2.5	1.5	1.3	0.2	0.9	0.1	-0.2	1.1	2.6	388
France	1921	1.5	-2.5	1.5	2.2	0.1	0.1	1.8	1.6	1.8	2.1	2449
Germany	3020	1.6	-4.6	3.1	2.9	0.1	1.3	2.1	2.5	1.7	2.0	3889
Italy	1802	0.6	-5.4	0.5	0.8	-0.6	0.0	0.7	0.4	0.1	1.5	1878
Spain	1159	2.5	-1.7	0.5	0.6	-0.8	0.8	2.2	1.3	0.3	1.8	1324
United Kingdom	2104	2.5	-4.7	-0.5	0.0	0.0	1.7	0.9	2.4	1.6	1.4	2435
Europe	10713	1.7	-4.0	1.4	1.5	-0.1	0.9	1.5	1.7	1.3	1.8	12836
Japan	4637	0.2	-5.7	3.4	0.0	2.1	1.0	2.9	1.7	0.3	1.2	5260
Korea	1014	5.2	2.8	7.9	5.1	3.6	4.2	5.5	5.2	3.1	3.2	1931
China	3260	11.4	11.2	12.4	11.5	6.3	6.9	5.9	5.3	3.1	3.3	7905
East Asia	8911	3.8	1.5	7.5	5.4	4.1	4.0	4.6	3.8	2.0	2.5	15096
World Trade (B2005 US$)	13091	5.5	-10.2	10.3	7.0	4.9	4.0	6.4	6.3	4.3	4.6	26519
Oil demand (2005 = 100)	103	1.2	-4.3	0.4	2.8	0.7	2.8	3.5	2.4	1.2	1.5	128

ALLOCATING CARBON EMISSIONS AND RAW MATERIALS TO FINAL CONSUMPTION USING A MULTI-REGIONAL INPUT-OUTPUT MODEL[54]

KIRSTEN S. WIEBE[55] AND CHRISTIAN LUTZ

Abstract

The Global Resource Accounting Model (GRAM) is an environmentally-extended multi-regional input-output model, covering 48 sectors in 53 countries and two regions. Next to CO2 emissions, GRAM also includes different resource categories. Using GRAM, it is possible to estimate the amount of carbon emissions and raw materials embodied in international trade for each year between 1995 and 2005. These results include all origins and destinations of emissions and materials, so that these can be allocated to countries consuming the products that embody carbon emissions and raw materials. Net-CO2 imports of OECD countries increased by 80% between 1995 and 2005. These findings become particularly relevant, as the externalisation of environmental burden through international trade might be an effective strategy for industrialised countries to maintain high environmental quality within their own borders, while externalising the negative environmental consequences of their consumption processes to other parts of the world.

JEL classification: C67, F18, Q56

54Acknowledgements: This paper is based on publications in Economic Systems Research and the Journal of Industrial Ecology. The authors thank Clopper Almon, Jeff Werling and four anonymous reviewers for their very valuable comments. Special thanks to Manfred Lenzen, editor of Economic Systems Research, for his very detailed and constructive comments.

55 Gesellschaft Für Wirtschaftliche Strukturforschung Mbh, Heinrichstr. 30, 49080 Osnabrück, Germany Corresponding Author Wiebe@Gws-Os.Com.

Keywords: Multi-regional input-output model, carbon footprint, trade, consumption-based carbon emissions

1. INTRODUCTION

In order to assess global environmental consequences of production and consumption in a specific country or world region, it is necessary to fully take into account international trade relations. Only thereby possible shifts of environmental burden, resulting from changing global patterns of production as well as trade and consumption, can be illustrated. Currently, carbon emissions and raw material extraction are allocated to the countries in which they occur. However, there is a major drawback of this approach, which is mainly emphasised by emerging economies and least developed countries. The critique is that a significant share of the increase in emissions produced and raw material extracted in emerging economies and least developed countries are due to export demand. In other words, emissions within these countries are generated and raw materials are extracted when producing export goods. International trade, its embodied emissions and raw materials and the resulting implicit carbon and material trade should therefore also be considered in the allocation of emissions and raw material requirements to countries. A consumption-based accounting of emissions and materials is often considered to be fairer, as it is not the producing, but the consuming country's demand that drives GHG emissions and raw material extraction. Calculating consumption-based emissions and material requirements though is more challenging than calculating production-based emissions and material requirements as all direct and indirect trade relations have to be considered.

The Global Resource Accounting Model (GRAM) is a multi-regional input-output (MRIO) model that allows for calculating consumption-based emissions and material requirements for 53 countries and 2 regions, disaggregated into 48 sectors, for each year between 1995 and 2005. The countries that are modelled explicitly cover about 95% of world GDP and 95% of global emissions.

The paper is organised as follows: the next section shortly introduces environmentally extended multi-regional input-output modelling. Section 3 gives a detailed description of the application of environmentally extended multi-regional input-output theory in the

GRAM model. In Section 4 the reasons why not RAS was applied to GRAM are discussed. Section 5 presents some results and the last section discusses shortcomings and further application possibilities of GRAM.

2. ENVIRONMENTALLY-EXTENDED MULTI-REGIONAL INPUT-OUTPUT THEORY

A number of studies examined the distribution of environmental pressures between different world regions due to the economic specialisation in the international division of labour, applying methods of physical accounting and environmental-economic modelling. Several studies found empirical evidence for increasing externalisation of environmental burden by industrialised countries through trade and increasing environmental intensity of exports of non-OECD countries (see, for example, Ahmad and Wyckoff, 2003; Davis and Caldeira, 2010; Hertwich and Peters, 2009; Lenzen et al., 2004; Nakano et al., 2009; Nansai et al., 2008; Nijdam et al., 2005; Peters et al., 2004; Peters and Hertwich, 2006: 2008a: 2008b; Turner et al. 2007; Wiedmann, 2009a: 2009b; Wiedmann et al., 2007: 2008). These findings become particularly relevant, as the externalisation of environmental burden through international trade might be an effective strategy for industrialised countries to maintain high environmental quality within their own borders, while externalising the negative environmental consequences of their consumption processes to other parts of the world (see, for example, Ahmad and Wyckoff, 2003; Giljum and Eisenmenger, 2004; Muradian et al., 2002). The global environmental responsibility is increasingly addressed by environmental policy strategies of the European Union and the OECD. One of the overall objectives of the renewed EU Sustainable Development Strategy (EU SDS) is to "actively promote sustainable development worldwide and ensure that the European Union's internal and external policies are consistent with global sustainable development and its international commitments" (European Council, 2006, p. 20).

Theoretically constructing a multi-regional input-output model from the basic closed-economy one-country input-output model is straight forward (McGregor et al. 2008). Starting from the usual matrix notation

$$\mathbf{x}_c = (\mathbf{I} - \mathbf{A}_c)^{-1}\mathbf{y}_c \,. \tag{1}$$

with output vector $\mathbf{x}_c$, final demand vector $\mathbf{y}_c$ and input-coefficient matrix $\mathbf{A}_c$, with subscript c corresponding to country c, the input-coefficient matrix $\mathbf{A}_c$ for S sectors in country c is expanded with a global input-coefficient matrix $\mathbf{A}$ for S×C sectors, where S is the number of sectors per country and C is the number of countries. The global input-coefficient matrix $\mathbf{A}$ consists of the domestic input-coefficient matrices $\mathbf{A}_{ii} = \mathbf{A}_{c(dom)}$ and the partitioned import coefficient matrices $\mathbf{A}_{ij} = \mathbf{A}_{ic(imp)}$, with $\mathbf{A}_c = \mathbf{A}_{c(dom)} + \mathbf{A}_{c(imp)} = \mathbf{A}_{c(dom)} + \sum_i \mathbf{A}_{ic(imp)}$. Final demand in this MRIO is displayed in matrix $\mathbf{y}$, which is setup equivalent to matrix $\mathbf{A}$. Output matrix $\hat{\mathbf{x}}$ then is estimated using the usual Leontief equation:

$$\begin{pmatrix} \hat{\mathbf{x}}_{11} & \hat{\mathbf{x}}_{12} & \cdots & \hat{\mathbf{x}}_{1C} \\ \hat{\mathbf{x}}_{21} & \hat{\mathbf{x}}_{22} & \cdots & \hat{\mathbf{x}}_{2C} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{\mathbf{x}}_{C1} & \hat{\mathbf{x}}_{C2} & \cdots & \hat{\mathbf{x}}_{CC} \end{pmatrix} = \begin{pmatrix} \mathbf{I}-\mathbf{A}_{11} & -\mathbf{A}_{12} & \cdots & -\mathbf{A}_{1C} \\ -\mathbf{A}_{21} & \mathbf{I}-\mathbf{A}_{22} & \cdots & -\mathbf{A}_{2C} \\ \vdots & \vdots & \ddots & \vdots \\ -\mathbf{A}_{C1} & -\mathbf{A}_{C2} & \cdots & \mathbf{I}-\mathbf{A}_{CC} \end{pmatrix}^{-1} \begin{pmatrix} \mathbf{y}_{11} & \mathbf{y}_{12} & \cdots & \mathbf{y}_{1C} \\ \mathbf{y}_{21} & \mathbf{y}_{22} & \cdots & \mathbf{y}_{2C} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{y}_{C1} & \mathbf{y}_{C2} & \cdots & \mathbf{y}_{CC} \end{pmatrix} \tag{2}$$

Vector $\hat{\mathbf{x}}_{ii}$ represent domestic production to satisfy domestic demand, and vectors $\hat{\mathbf{x}}_{ij}$ are production in country i to satisfy country j's final demand.

Calculating embodied emissions $\mathbf{P}$ and material $\mathbf{R}^l$ is then done by pre-multiplying the Leontief inverse (e.g. Peters and Hertwich 2008) with the intensity vectors $\mathbf{e}_c$ and $\mathbf{m}_c^l$ stored in diagonal matrices $\mathbf{E}_c$ and $\mathbf{M}_c^l$:

$$\begin{pmatrix} \mathbf{p}_{11} & \mathbf{p}_{12} & \cdots & \mathbf{p}_{1C} \\ \mathbf{p}_{21} & \mathbf{p}_{22} & \cdots & \mathbf{p}_{2C} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{p}_{C1} & \mathbf{p}_{C2} & \cdots & \mathbf{p}_{CC} \end{pmatrix} = \begin{pmatrix} \mathbf{E}_1 & 0 & \cdots & 0 \\ 0 & \mathbf{E}_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \mathbf{E}_C \end{pmatrix} \begin{pmatrix} \mathbf{I}-\mathbf{A}_{11} & -\mathbf{A}_{12} & \cdots & -\mathbf{A}_{1C} \\ -\mathbf{A}_{21} & \mathbf{I}-\mathbf{A}_{22} & \cdots & -\mathbf{A}_{2C} \\ \vdots & \vdots & \ddots & \vdots \\ -\mathbf{A}_{C1} & -\mathbf{A}_{C2} & \cdots & \mathbf{I}-\mathbf{A}_{CC} \end{pmatrix}^{-1} \begin{pmatrix} \mathbf{y}_{11} & \mathbf{y}_{12} & \cdots & \mathbf{y}_{1C} \\ \mathbf{y}_{21} & \mathbf{y}_{22} & \cdots & \mathbf{y}_{2C} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{y}_{C1} & \mathbf{y}_{C2} & \cdots & \mathbf{y}_{CC} \end{pmatrix} \quad (3)$$

$$\begin{pmatrix} \mathbf{r}_{11}^{l} & \mathbf{r}_{12}^{l} & \cdots & \mathbf{r}_{1C}^{l} \\ \mathbf{r}_{21}^{l} & \mathbf{r}_{22}^{l} & \cdots & \mathbf{r}_{2C}^{l} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{r}_{C1}^{l} & \mathbf{r}_{C2}^{l} & \cdots & \mathbf{r}_{CC}^{l} \end{pmatrix} = \begin{pmatrix} \mathbf{M}_1^{l} & 0 & \cdots & 0 \\ 0 & \mathbf{M}_2^{l} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \mathbf{M}_C^{l} \end{pmatrix} \begin{pmatrix} \mathbf{I}-\mathbf{A}_{11} & -\mathbf{A}_{12} & \cdots & -\mathbf{A}_{1C} \\ -\mathbf{A}_{21} & \mathbf{I}-\mathbf{A}_{22} & \cdots & -\mathbf{A}_{2C} \\ \vdots & \vdots & \ddots & \vdots \\ -\mathbf{A}_{C1} & -\mathbf{A}_{C2} & \cdots & \mathbf{I}-\mathbf{A}_{CC} \end{pmatrix}^{-1} \begin{pmatrix} \mathbf{y}_{11} & \mathbf{y}_{12} & \cdots & \mathbf{y}_{1C} \\ \mathbf{y}_{21} & \mathbf{y}_{22} & \cdots & \mathbf{y}_{2C} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{y}_{C1} & \mathbf{y}_{C2} & \cdots & \mathbf{y}_{CC} \end{pmatrix} \quad (4)$$

Vectors $\mathbf{p}_{ii}$ and $\mathbf{r}_{ii}^{l}$ represent emissions/material embodied in domestic production to satisfy domestic demand, and vectors $\mathbf{p}_{ij}$ and $\mathbf{r}_{ij}^{l}$ are emissions/material embodied in the production of country i to satisfy country j's final demand. Hence, pollution matrix $\mathbf{P}$ and material requirements matrices $\mathbf{R}^{l}$ contain results for 53 individual countries and two regions, and 48 producing sectors per country/region. Pollution/material embodied in exports and imports of a country are then simple row and column sums, respectively, in matrices P and R, without the entry on the diagonal, which represents domestic pollution for domestic consumption. Embodied CO2 exports of country s therefore are $\sum_j \langle \mathbf{p}_{sj} \rangle - \langle \mathbf{p}_{ss} \rangle$, where $\langle \mathbf{p}_{ij} \rangle$ denotes the sum of the elements of vector $\mathbf{p}_{ij}$, while the country s' imports are $\sum_i \langle \mathbf{p}_{is} \rangle - \langle \mathbf{p}_{ss} \rangle$. More details of this approach with regard to its application will be given in the following section on GRAM. A more detailed technical description of GRAM can be found in Wiebe et al. (2012a, b).

3. THE GLOBAL RESOURCE ACCOUNTING MODEL (GRAM)

The Global Resource Accounting Model (GRAM) is a multi-regional input-output (MRIO) model, covering 53 countries and 2 regions and 48 sectors per country/region. See Table A1 in the Appendix for a list of countries that are explicitly modelled. GRAM is a static model in so far that it calculates historical data of CO2 emissions by consuming country for each year between 1995 and 2005. The results are detailed in such a way that the countries and sectors of origin can be identified within the model. Furthermore, it is possible to determine the production paths with highest embodied carbon emissions using structural path analysis.
GRAM is a "true" MRIO model, as defined by Giljum et al. (2008), incorporating one global input coefficient matrix $\mathbf{A}$. It therefore differs from the other form of MRIO models that include one I-O model per country, which is solved separately from the others, and then linked to the other country models via international trade. This method is for example used in Ahmad and Wyckoff (2003) or Nakano et al. (2009). GRAM implicitly includes international trade in the inter-industry requirements matrix, which is calculated from monetary input-output tables and bilateral trade data of the OECD. The central equation of the model is equation (4), through which the system can be solved at once and not iteratively as in Ahmad and Wyckoff (2003).

The heart of the model is the multi-regional input-coefficient matrix $\mathbf{A}$, which has size 2640×2640. The OECD IOTs distinguish between 48 sectors; given the modelling of 55 countries or regions, which result in a total of 2640 sectors. Matrix $\mathbf{A}$ can be subdivided into 55 by 55 sub matrices $\mathbf{A}_{ij}$. For j=i these matrices correspond to the domestic input-coefficient matrices, that is the sub matrices $\mathbf{A}_{ii}$ on the diagonal of the A-matrix are the domestic input-coefficient matrices, that can be directly calculated from the OECD input-output tables (OECD, 2009). The OECD input-output tables (IOTs) distinguish between domestic input requirements and imported input requirements, as well as domestic final demand and imported final demand. The virtue of this is that domestic as well as imported input coefficients can be directly calculated from this data, which is the first step in the model. After having calculated the coefficient matrices, the output vectors as given in the OECD IOTs are completely disregarded and the remaining calculations are all based on the input-coefficient matrices $\mathbf{A}_{ij}$ and the final demand data. Sectoral output used in the remaining calculations is estimated by $\hat{\mathbf{x}} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y}$.[56]

To fill the multi-regional input-coefficient matrix $\mathbf{A}$ for the off-diagonal sub matrices it is necessary to combine the imported coefficient matrices A(imp)j from the input-output data with the bilateral trade data from which import shares for each sector have been calculated. The input-output coefficients are calculated from data in basic prices while the import shares are calculated from data in cif. According to Guo et al. (2009) using these trade coefficients is still possible because in the final results the sector of destination is ignored.

Let a_{ij}^{mn} be the entry in the mth row and nth column of matrix $\mathbf{A}_{ij}$, $a_{(imp)j}^{mn}$ be the entry in the mth row and nth column of the import coefficient matrix $\mathbf{A}_{(imp)j}$, and let m_{ij}^{n} be the import share of country i in country j's imports of good n, i.e. the entry (i,j) in the import share matrix of good n: M^n. Then a_{ij}^{mn} is calculated as

$$a_{ij}^{mn} = m_{ij}^{n} a_{(imp)j}^{mn} \forall n, j. \qquad (5)$$

Creating the multi-regional final demand matrix $\mathbf{y}$ is done by applying the same method to the imported final demand matrices to disaggregate them according to countries of origin. Note that the final demand vectors do not include export demand, i.e. it is the sum of columns c2 through c7 in the OECD IOT final demand tables. Production necessary to satisfy export demand is implicitly calculated as the sum of the imports of all other countries. Matrix $\mathbf{y}$ has size 2640×55, where the columns represent the countries in which final demand is generated. As the OECD IOTs distinguish between 48 sectors, and each imported final

56 For those years/countries for which input-output tables are available, the "true" output vector $\mathbf{x}$ is known. A quick comparison of the calculated and the original data shows that the sum over all sectors of output $\hat{\mathbf{x}}$ deviates from the OECD data by about 5% in the UK, less than 3% in Germany and not even 1% for the US for 2000. See Appendix for more detail.

demand vector (which is given in the original data) is disaggregated among 54 countries of origin using the import shares, the resulting columns of matrix y have 54 times 48 entries (corresponding to imports that satisfy final demand) plus 48 entries (directed at domestic production for final demand), resulting in a total of 2640 entries per column.

Using equation (2), output matrix $\hat{\mathbf{x}}$ which has the exact same dimension as the final demand matrix $\mathbf{y}$, can be calculated. For calculating $\hat{\mathbf{x}}$ it's assumed that final demand y and the input coefficient matrix $\mathbf{A}$ is known, but not the true $\mathbf{x}$. By using the calculated output $\hat{\mathbf{x}}$ only, it is ensured that the model is consistent. The column total (of column s) gives worldwide production that is necessary to satisfy final demand in country s. Subdividing column s into 55 vectors, explicitly shows the sector and country in which production to satisfy final demand in country s occurred. $\hat{\mathbf{x}}_{21}$ for example, is the sectoral production in country 2 to satisfy country 1's final demand.

The OECD IOTs are not available for all years covered by the model (1995 to 2005) and all countries explicitly modelled (see Table A1 for data availability), so that the global input requirements matrix had to be filled using assumptions on the underlying economic structure. For those countries for which there is no IOT, the structure is based on neighbouring countries or countries with a similar economic background. The sectoral final demand structure is estimated in the same way. Note that the final demand vectors only distinguish between domestic, imports and exports, but not between household consumption, government consumption, investments, etc. Data for imported final demand is directly taken from the IOTs if these are available or from the structure of the example countries for those without IOT data. Exports are then defined as the sum of all other countries' imports. Further, the IOTs are in basic prices in local currency and converted to US dollar using market exchange rates from the IFS (IMF, 2009). Import shares are based on data in cif prices.

The time gaps have been filled using the assumption of a linear change in production structures that is the matrices have been linearly interpolated for those years in between two years for which an IOT is available. For the marginal years the I-O structure of the first or last available year, respectively, was taken.

Carbon emissions data for fossil fuel combustion (coal & peat, gas, oil, and others) is taken from the International Energy Agency (IEA 2008c). The data is only available for highly aggregated economic sectors, not corresponding to the IOT sectoral classification. The IEA also publishes energy balances (EB) for all countries that are explicitly modelled (IEA 2008a,b). The EBs contain physical data on the use of different energy carriers on a sectoral level that almost corresponds to the sector structure of the OECD data displayed in Table A3 in the appendix. This physical data is used to split emissions, which are available for four energy carriers, but only on more aggregated economic sector level, according to the sectoral classification of the OECD data. Note that it is therefore assumed that the emissions associated with the use of one unit of the respective energy carrier are the same across sectors, but with differing energy mixes. Emission intensities $\mathbf{e}_c$ are then calculated for each sector by dividing total emissions, i.e. the sum over all energy carriers, of this sector by total output of the sector, which is calculated within the model.

Raw material extraction data is available at www.materialflows.net. The data used here is from SERI (2010). Four material categories are distinguished: biomass, fossil fuels, metals and industrial minerals, and construction minerals. The extracting sectors in the IOTs for these materials are assumed to be sectors "1 Agriculture", "2 Mining and Quarrying (Energy)", "3 Mining and Quarrying (Non-Energy)", and "30 Construction". The materials are allocated to the 48 IOT sectors according to the share of monetary flows to these sectors in the total output of the extracting sector. After splitting the material data among the 48 sectors, material intensities for each material category and each sector are calculated and stored in material intensity vectors $\mathbf{m}_c^l$ for material l in country c.

Note that the MRIO model calculates the materials embodied in internationally traded products in Raw Material Equivalents (RMEs). RMEs express the amount of used raw materials required along the whole production chain of an imported or exported product (for more details on the RME approach, see the OECD/EUROSTAT handbook on material flow accounting, OECD 2007).

4. "TO RAS OR NOT TO RAS"

GRAM development has mainly been driven by data availability, consistency of datasets and computability. It has been built on recent OECD approaches (Nakano et al. 2009), which make use of OECD I-O and bilateral trade data, which is "harmonised" but not fully balanced. The possibility to easily compare results to OECD work has been an advantage in development of GRAM. But the database has two major shortcomings compared to the labour/research intensive databases that are currently constructed during the EXIOPOL (EXIOPOL 2008, Tukker et al. 2009) and the WIOD (2010) project: first, regarding the construction of the off-diagonal vectors in the global final demand matrix and second regarding the construction of the off-diagonal matrices in the global input coefficient matrix $\mathbf{A}$.

Using the general assumption that imports into a country are better documented than exports, it is assumed that import data is superior to export data. Hence, only the final demand matrices of the import I-O tables reported by the OECD are used, to calculate the off-diagonal vectors in the global final demand matrix. As – at least in theory – exports of country A to country B must equal imports of country B from country A (leaving aside data problems arising from different price concepts), exactly that is assumed, i.e. total exports of country A simply are the sum over imports of all other countries. Given that exports are also reported in the OECD IOTs, it should actually be ensured that the sum over all imports from other countries is equal to the export data reported for each sector. This can be done in two ways: Either by simply determining imports of the region rest of the world (RoW) as the difference between the sum of imports from the other countries and total exports of the current country, or using a RAS procedure to make the import data fit the export data. For the construction of the final demand matrix, it was opted to simply assume that the import data is correct, as its unchanged use is important for tracing consumer responsibility and it allows comparison to OECD studies, which use unchanged OECD I-O tables, and completely disregarded the export data. Final demand exports then are the sum over all non-diagonal vectors $\mathbf{y}_{ij}, j \neq i$.

This also holds for the construction of the global coefficient matrix. By disregarding the available data for value added, including the transition from basic prices to purchasers' prices, and total output, it is ensured that global production equals global consumption of CO2 emissions. That is the value added that is implicitly calculated satisfies $v_j^n = x_j^n - x_j^n \sum_{i=1}^{C} \sum_{m=1}^{S} a_{ij}^{mn}$ for all sectors n in all countries j, because only estimated output $\hat{\mathbf{x}}$ calculated from the constructed coefficient matrix $\mathbf{A}$ and the constructed final demand matrix $\mathbf{y}$, is used. This calculated value added $\hat{\mathbf{v}}$ will by no means equal the reported value added $\mathbf{v}$ in the OECD IOTs, see analysis in Appendix B. But rather than assuming that the value added as reported in the IOTs (and estimated for those countries, for which no OECD IOT exist) is correct, the model is based on the assumption that the estimate of the production structure in $\mathbf{A}$ is correct. This assumption is the main methodological difference between the model and the MRIO tables constructed by the WIOD and EXIOPOL projects. They take data on the row and column sums of the global inter-industry flow matrix that is known and use a coefficient matrix that has been constructed similarly to the $\mathbf{A}$ as an initial estimate only. This initial estimate is then used as an input into different advanced RAS procedures, so that the table is balanced in the sense that given output vector $\mathbf{x}$, final demand vector $\mathbf{y}$ and matrix $\mathbf{A}$ satisfy $\mathbf{x} = \mathbf{Ax} + \mathbf{y}$ and the column sums of the $\mathbf{A}$ matrix plus value added equal production[57]. The outcome of RAS procedures, even though it complies with "known" output, final demand and value added vectors, might however not well reflect the production structure without careful and time consuming cross checking as in WIOD or EXIOPOL, as can be seen from a very simple example in Miller and Blair (2009, Chapter 7.4), pp. 320-324.

For calculating the emissions embodied in production, the production structure itself is what is important. The procedure used to construct input coefficient matrix $\mathbf{A}$, which is the production structure,

57 This only emphasizes the main difference between their approaches and the approach as per this paper. Summarizing the exact procedures they use is beyond the scope of this paper; hence the reader is referred to the original papers of EXIOPOL (2008), Tukker et al. (2009) and WIOD (2010).

is straight forward, so that the coefficients are easily traceable. The aim is at quantifying emissions associated with production. This can be done in basically any price concept as long as this is the same for all sectors and countries. If the price concept of output changed, so would the reported output data, but accordingly the emission intensities.

Summarising, the approach is simpler and the values of the coefficients in $\mathbf{A}$ are easier traceable, because no RAS algorithm is used, but the calculated output and the implicitly determined value added do not comply with the data reported in the OECD IOTs. The corresponding errors in output and value added are reported in Appendix B.

5. EMISSION AND MATERIAL EXTRACTION RESPONSIBILITIES

GRAM allows for the calculation of aggregated indicators of production versus consumption of CO2 emissions and embodied raw materials of countries and world regions, taking into account emissions that occur along international production chains. Thereby, comprehensive trade balances, as displayed in Table 1, of embodied CO2 emissions and raw materials for individual countries or regions can be calculated and the main net-importers and net-exporters of CO2 emissions and raw materials in the world economy can be constructed. The trade balances show production-based carbon emissions ("CO2 Production") and consumption-based carbon emissions ("CO2 Consumption") on the left and raw material extraction and embodied material consumption on the right. The numbers for domestic production correspond to the numbers of the IEA sectoral approach plus marine bunkers and international aviation. The OECD countries are CO2 and embodied raw material net importers, which means that the sum of goods they consume has higher embodied CO2 emissions and raw materials than the sum of goods they produce. The non-OECD countries are generally net exporters of both embodied CO2 and materials, which means that due to production processes in these countries more CO2 is emitted and more raw materials are extracted than the CO2 and raw materials embodied in the products they consume domestically. GRAM results thus show the extent to which a country's final demand is responsible for emissions produced and raw materials extracted abroad. These types of calculations are the empirical basis for the discussion as to whether producer or consumer countries are responsible for related environmental impacts.

The main output of GRAM is the 2640×55 pollution matrix P and embodied material matrix R. These can easily be aggregated into a 55×55 CO2 and embodied materials trade matrix, displaying the CO2 and embodied materials exporting countries in the rows and the CO2 and embodied materials importing countries in the columns. From this matrix it is straight forward to calculate the corresponding trade balances for all countries. Imports are column sums, minus the diagonal element, and exports are row sums, again minus the diagonal element. The entries on the diagonal are the emissions that are produced and consumed within the same country. See Table 2 for a three-region version of pollution matrix P. The countries are aggregated into three groups of countries: the OECD countries, a group of newly emerging economies, Brazil, Russia, India, China, South Africa, and Argentina (in the following called BRICSA), and the rest of the world (RoW).

GRAM is closed on the global level, which means that global carbon consumption equals global carbon production and worldwide carbon exports equal worldwide imports, global material extraction equals global material consumption and global material exports equal global material imports. This can nicely be seen from rows "Exports" and "Imports" and "Net-Exports" of the carbon balances in Table 1 below: the absolute values pf OECD net-exports of embodied carbon emissions and raw materials are equal to the Non-OECD net-exports and vice versa. This consistency is due to its "true" MRIO nature, i.e. the use of the global Leontief inverse. In Nakano et al. (2009), who use an iterative solving procedure for their linked single-region input-output models, worldwide carbon production is higher than worldwide carbon consumption in both years of their analysis (p. 7, Table 1).

Table 1: Embodied carbon/material trade balances for 1995, 2000 and 2005[58]

in million tons CO2	**OECD**	**BRICSA**	**RoW**	*in million tons RME*	**OECD**	**BRICSA**	**RoW**
1995				**1995**			
CO2 Production	10863	6026	6031	Domestic extraction	20746	13386	12293
Consumption	12490	4721	5709	Domestic consumption	25173	11597	9655
CO2 Exports	368	1589	1123	RM embodied in exports	580	2554	3448
CO2 Imports	1995	283	801	RM embodied in imports	5008	765	809
Net-Exports	-1627	1305	322	Net-Exports	-4427	1789	2638
2000				**2000**			
CO2 Production	11687	6322	6375	Domestic extraction	22167	14485	14066
CO2 Consumption	13856	4837	5691	Domestic consumption	27966	12217	10536
CO2 Exports	446	1862	1390	RM embodied in exports	643	3126	4380
CO2 Imports	2615	378	706	RM embodied in imports	6442	857	850
Net-Exports	-2169	1484	684	Net-Exports	-5799	2269	3530
2005				**2005**			
CO2 Production	12138	8632	7315	Domestic extraction	22824	18077	16535
CO2 Consumption	15241	6478	6366	Domestic consumption	30327	15025	12085
CO2 Exports	519	2702	1679	RM embodied in exports	737	4311	5479
CO2 Imports	3622	548	730	RM embodied in imports	8241	1258	1028
Net-Exports	-3103	2154	949	Net-Exports	-7503	3053	4451

58 Carbon balances for all countries listed in Table A1 for the years 1995 to 2005 are provided by the authors upon request.

Table 2: Carbon trade[59] between OECD, BRICSA and the rest of the world (RoW)

	1995				2005			
Mio t CO2	**OECD**	**BRICSA**	**RoW**	**Production**	**OECD**	**BRICSA**	**RoW**	**Production**
OECD	9327	213	155	9695	10389	316	203	10908
BRICSA	1078	4104	290	5472	2323	5448	394	8165
RoW	917	193	2484	3595	1300	239	3108	4646
Consumption	11322	4510	2929		14011	6003	3705	
% of consumption	**OECD**	**BRICSA**	**RoW**	**OECD Net-Imports** *Mio t CO2*	**OECD**	**BRICSA**	**RoW**	**OECD Net-Imports** *Mio t CO2*
OECD	82%	5%	5%		74%	5%	5%	
BRICSA	10%	91%	10%	865	17%	91%	11%	2006
RoW	8%	4%	85%	762	9%	4%	84%	1097

The two matrices in the upper part of Table 2 are carbon trade matrices for the three regions OECD, BRICSA, and RoW. Entry (i,j) reflect exports from region i to region j, in accordance with pollution matrix P in the model. While in 1995 82% of the CO2 emissions associated with OECD consumption were produced within the OECD countries, this number decreased to 74% in 2005. That means that embodied emissions in imports to the OECD did not only increase due to an increase in total trade volume (which is reflected in increasing carbon imports and exports), but also relative to CO2 emissions associated with both production and consumption within the OECD countries. This increase in net-imports of CO2 into OECD countries, in the fourth and eighth column in the lower part of Table 2, shows the additional amount of carbon trade that took place between 1995 and 2005. In 1995 the OECD net-imports of CO2 from the BRICSA countries (865 Mt) and the Rest of the World (RoW) (762 Mt) amount to 1627 Mt. This number almost doubles until 2005 to 3004 Mt. About three quarters of this increase stems from imports from the BRICSA countries. That means that three quarters of total additional carbon imports of the OECD were produced in only six countries. The OECD countries are responsible for 28% of the emissions produced in the BRICSA countries in 2005. This number was about 20% in 1995. The fraction of emissions in RoW induced by

59 The complete P-matrix can be obtained from the authors upon request.

consumption in OECD countries slightly increases between 1995 and 2005, from 25% to 28%. This means that the OECD countries consume increasingly more CO2 embodied in goods that are produced in the BRICSA countries, and hence, increase in carbon imports into the OECD countries mainly occurs in the BRICSA countries and not so much in the remaining RoW countries.

Most of the increase in carbon consumption in the OECD is absorbed by increased carbon imports from the BRICSA countries, which doubled between 1995 and 2005, whereas CO2 embodied in exports from OECD countries to the BRICSA countries hardly changed over that decade (that is carbon emissions embodied in imports from OECD, the dotted black line in the top left graph in Figure 1). CO2 emissions embodied in exports of the BRICSA countries to the rest of the world (RoW) exceed CO2 emissions embodied in imports from RoW, as well.

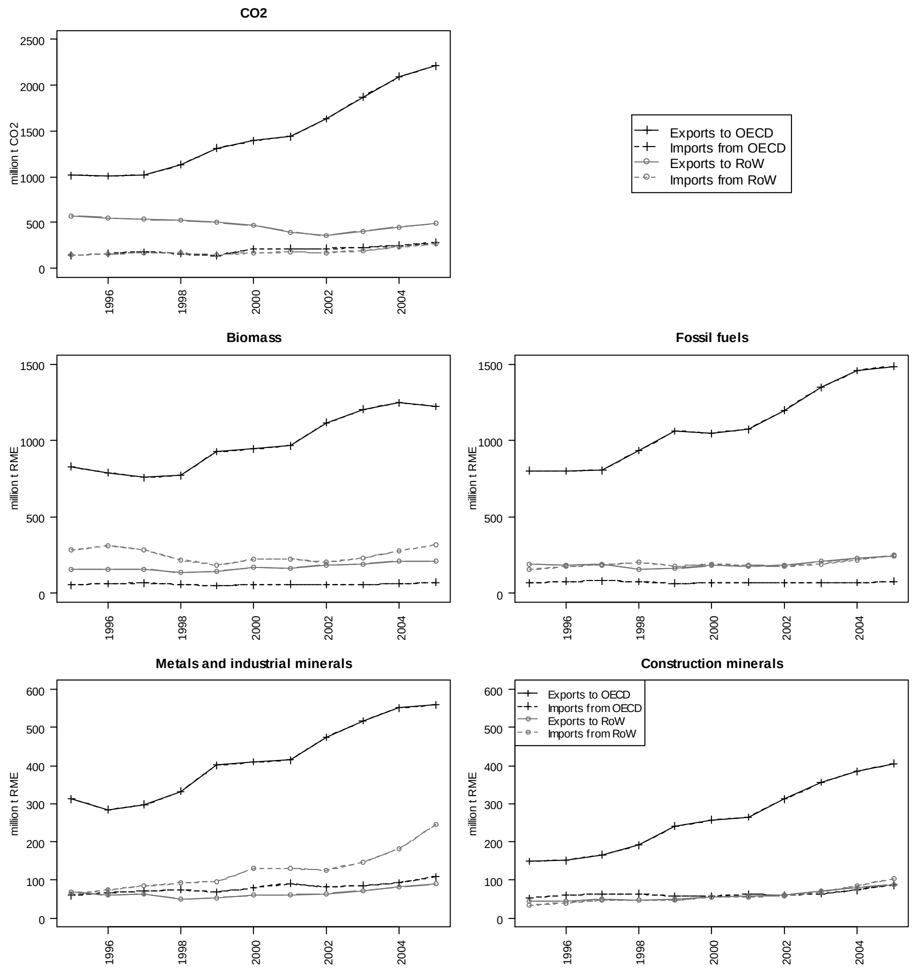


Figure 1: Embodied carbon emissions and raw materials in BRICSA's trade

Figure 2 displays carbon production and carbon consumption per capita, for the three country groups RoW, OECD and BRICSA. Notably, carbon production per capita in the OECD countries (about 9 t CO2) is significantly lower than carbon consumption (increasing from about 10.5 t CO2 in 1995 to 11.5 t CO2 in 2005). Carbon production per capita (about 2 t CO2) in the rest of the world is slightly higher than carbon consumption (1.8 t CO2). Per capita carbon production is higher than carbon consumption in all BRICSA countries, though Russia emits by far the largest amount of CO2 per capita.

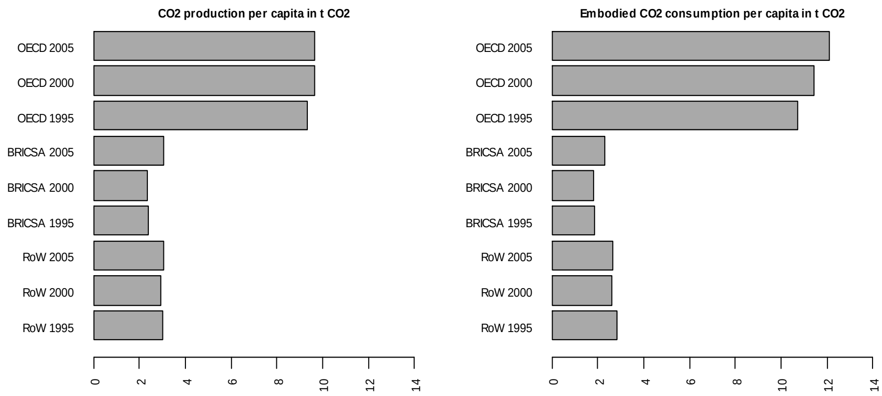


Figure 2: Production- versus consumption-based per capita carbon emissions

Materials embodied in trade between BRICSA and OECD countries develop similar to carbon exports as can be seen from comparing the graphs in Figure 1. Embodied biomass and fossil fuel imports from the OECD countries remain more or less constant, while exports to the OECD countries strongly increase. The latter is also true for metals and industrial minerals, and construction minerals, while embodied imports of these increase slightly. Raw material imports from OECD countries were between 50 and 100 Mt RME per year per material category during 1995 to 2005. The magnitude of exports though differs, with biomass and fossil fuel exports starting off at about 800 Mt RME and increasing to about 1200 Mt and 1500 Mt RME, respectively, while metals and industrial mineral exports increase from about 300 to 580 Mt RME and construction mineral exports from less than 200 to about 400 Mt RME. Total embodied material exports to OECD countries increased by 85% from 2 billion t RME in 1995 to 3.7 billion t RME in 2005, while embodied material imports only grew by 50% from 230 to 340 Mt RME.

While carbon exports to the Rest of the World (RoW) were higher than carbon imports, this relation does not hold for embodied materials. For both biomass and metals and industrial minerals imports from RoW exceed exports. There is an especially large increase of imports of metals and industrial minerals, while exports only increase slightly, if at all. For fossil fuels and construction minerals embodied material imports and exports to RoW are almost equal.

Figure 3 shows the per capita composition of material extraction and embodied material consumption. Again, per capita consumption of embodied materials is lower than material extraction in the BRICSA countries, whereas consumption in the OECD countries is significantly higher than extraction, especially for biomass, fossil fuels and metals and industrial minerals.

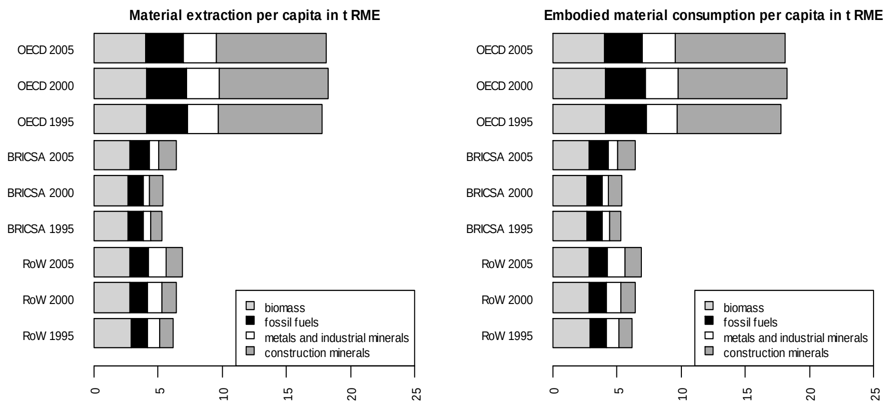


Figure 3: Per capita material extraction versus per capita material consumption

Figures 2 and 3 show that switching from producer to consumer responsibility worsens the per capita responsibility in the OECD countries and improves it for all BRICSA countries, as per capita carbon emissions and material consumption in all four categories increase for the OECD, while they decrease for BRICSA as a total and for each individual country.

6. DISCUSSION AND POSSIBILITIES

This paper has brought together the two key environmental categories CO_2 emissions and materials within one consistent framework of analysis, enabling a comparative analysis of global trends of these two environmental factors in terms of their embodiment in trade. For CO_2 emissions and materials the analyses reveal similar patterns of increasing specialisation of economies along the global production chains. OECD countries have been able to almost stabilise their domestic production of emissions and extraction of materials between 1995 and 2005. Taking into account the further increase in monetary production (GDP), OECD countries have realised an impressive decoupling of monetary drivers and physical production (see, for example, UNEP 2011). The data have shown that this argument does not hold from a consumer point of view. At least part of the increase of CO_2 emissions and material extraction in BRICSA countries is related to the consumption of products in the OECD. Outsourcing of environmentally-intensive stages of production is being identified as one main strategy to achieve such a decoupling in the OECD countries, while increasing demand in the OECD is one important driver for growing CO_2 emissions and resource use in the emerging BRICSA countries. This paper confirms the increasingly important role of international trade for the environmental performance of countries. In particular, it has illustrated that the OECD countries have improved their performance partly due to shifts of environmental pressures into the group of BRICSA countries. This increase is more pronounced for emissions, metals and minerals, but is also visible for fossil fuels and biomass.

A current limitation of GRAM is induced by data gaps, especially for the two regions OPEC and Rest of the World, where trade data gaps had to be completed within the model using simplifying assumptions. Further, trade in services data is only readily available for the years from 2000 onwards, hence the structure from 2000 was used to approximate trade in services for the years 1995 to 1999. An approximation of the input-output structure was made for 13 countries and the two regions, as no OECD input-output tables were available. These data gaps will be filled in future versions of GRAM as soon as better data is available. Also left for future improvement is the interpolation method to calculate the input-output tables for the years for which they are not provided by the OECD.

Further, the GRAM results can be used for Structural Path Analysis (SPA). By using SPA in environmentally extended input-output models, production paths with the highest embodied CO2 emissions can be identified, as is for example done in Lenzen et al. (2007), Minx et al. (2008), Peters and Hertwich (2006). SPA is computationally involving and can only be made for a few destination countries at a time. The algorithm used for GRAM is based on Peters and Hertwich (2006). Calculations for Austria show that the energy sector has highest direct and indirect emissions, followed by the transport sector, machinery and equipment, and construction (Bruckner et al., 2009). Analyses for other countries will follow.

REFERENCES

AHMAD, N. AND WYCKOFF, A. (2003). *Carbon dioxide emissions embodied in international trade.* STI Working Paper DSTI/DOC, 15, OECD, Paris.

BANG, J.K., HOFF, E., PETERS, G. (2008). EU consumption, global pollution. A report written by WWF's Trade and Investment Programme and the Industrial Ecology Programme at the *Norwegian University of Science and Technology*.

BRUCKNER, M., GILJUM, S., LUTZ, C., WIEBE, K.S. (2009). Die Klimabilanz des österreichischen Außenhandels - Endbericht. *SERI,* Vienna.

DAVIS, S.J. AND CALDEIRA, K. (2010). Consumption-based accounting of CO2 emissions. *Proceedings of the National Academy of Sciences*, 107, 5687-5692.

European Council (2006). *Renewed EU Sustainable Development Strategy.* 10117/06, Brussels.

EXIOPOL (2008). A new environmental accounting framework using externality data and input-output tools for policy analysis. Website www.feem-project.net/exiopol/, *European Commission.*

GILJUM, S. AND EISENMENGER, N. (2004). North-South trade and the distribution of environmental goods and burdens: a biophysical perspective. *Journal of Environment and Development,* 13(1), 73-100.

GILJUM, S., LUTZ, C., JUNGNITZ, A. (2008). The Global Resource Accounting Model (GRAM). A methodological concept paper. *SERI Studies, 8, Sustainable Europe Research Institute,* Vienna.

GUO, D., WEBB, C., YAMANO, N. (2009). Towards harmonised bilateral trade data for inter-country input-output analysis: Statistical issues. STI Working Paper, 2009/4 (DSTI/DOC (2009)4), *Organisation for Economic Co-operation and Development (OECD), Directorate for Science, Technology and Industry, Economic Analysis and Statistics Division,* Paris, France.

HERTWICH, E.G. AND PETERS, G. (2009). Carbon footprint of nations: A global, trade-linked analysis. *Environmental Science & Technology,* 43(16), 6414-6420.

IEA (2008a) Energy Balances of Non-OECD Countries, 1960-2007. *International Energy Agency,* Paris, France.

IEA (2008b) Energy Balances of OECD Countries, 1960-2007. *International Energy Agency,* Paris, France.
IEA (2008c) CO2 Emissions from Fuel Combustion, 1960-2007. *International Energy Agency,* Paris, France.
IMF (International Monetary Fund) (2009) *International Financial Statistics (IFS).* available at: http://www.imfstatistics.org/.
LENZEN, M., PADE, L.-L., MUNKSGAARD, J. (2004). CO2 multipliers in multi-region input-output models. *Economic Systems Research*, 16, 391-412.
LENZEN, M., WIEDMANN, T., FORAN, B., DEY, C., WIDMER-COOPER, A., WILLIAMS, M., OHLEMÜLLER, R. (2007). Forecasting the Ecological Footprint of Nations: a blueprint for a dynamic approach. *ISA Research Report*, 07-01, The University of Sydney, Stockholm Environment Institute, University of York.
LEONTIEF, W. (1970). Environmental Repercussions and the Economic System. *Review of Economics and Statistics*, 52, 262-272.
MCGREGOR, P. G., SWALES, J. K. AND K. TURNER. (2008). The CO2 ´trade balance` between Scotland and the rest of the UK: Performing a multi-region environmental input-output analysis with limited data. *Ecological Economics* 66: 662-673.
MILLER, R.E., BLAIR, P.D. (2009) Input-output analysis – Foundations and extensions. Second Edition. *Cambridge University Press.*
MINX, J., PETERS, G., WIEDMANN, T., BARRETT, J. (2008) GHG emissions in the global supply chain of food products. Paper presented at the *International Input-Output Meeting on Managing the Environment,* Seville, Spain.
MURADIAN, R., O'CONNOR, M., MARTINEZ-ALIER, J. (2002). Embodied pollution in trade: estimating the 'environmental load displacement' of industrialised countries. *Ecological Economics*, 41(1), 51-67.
NAKANO, S., OKAMURA, A., SAKURAI, N., SUZUKI, M., TOJO, Y., YAMANO, N. (2009). The Measurement of CO2 Embodiments in International Trade: Evidence from the Harmonized Input-Output and Bilateral Trade Database. STI Working Paper, 2009/3 (DSTI/DOC(2009)3), *Organisation for Economic Co-operation and Development (OECD), Directorate for Science, Technology and Industry, Economic Analysis and Statistics Division,* Paris, France.

NANSAI, K., KAGAWA, S., KONDO, Y., SUH, S. (2008). Global Link Input-Output Model: Its Accounting Framework and Applications, *Proceedings of the 8th International Conference on EcoBalance,* Tokyo, Japan.
NIJDAM, D.S., WILTING, H.C., GOEDKOOP, M.J., MADSEN, J. (2005). Environmental Load from Dutch Private Consumption. How Much Damage Takes Place Abroad? *Journal of Industrial Ecology*, 9(1-2), 147-168.
OECD (2007). OECD/EUROSTAT Handbook on Material Flow Accounting. *Organisation for Economic Co-operation and Development*, Paris.
OECD (2008). STAN Bilateral Trade Database (Edition 2006): 1988-2004. *Organisation for Economic Co-operation and Development*, Paris.
OECD (2009). Input-Output Tables (Edition 2009): 1995 - 2005. *Organisation for Economic Co-operation and Development*, Paris.
PETERS, G.P. AND HERTWICH, E. (2004). Production Factors and Pollution Embodied in Trade: Theoretical Development. Working Papers, 5/2004, *University of Science and Technology (NTNU),* Trondheim, Norway.
PETERS, G. AND HERTWICH, E. (2006). Structural Analysis of International Trade: Environmental Impacts of Norway. *Economic Systems Research*, 18(2), 155-181.
PETERS, G.P. AND HERTWICH, E.G. (2008a). CO2 Embodied in International Trade with Implications for Global Climate Policy. *Environmental Science & Technology*, 42(5), 1401-1407.
PETERS, G.P. AND HERTWICH, E.G. (2008b). Trading Kyoto. *Nature Reports Climate Change*, 2, 40-41.
SERI. (2010). Global Material Flow Database. 2010 Version. Available at www.materialflows.net. Vienna: *Sustainable Europe Research Institute.*
TUKKER, A., POLIAKOV, E., HEIJUNG, R., HAWKINS, T., NEUWAHL, F., RUEDA-CANTUCHE, M., GILJUM, S., MOLL, S., OOSTERHAVEN, J., BOUWMEESTER, M. (2009). Towards a global multiregional environmentally extended input-output database. *Ecological Economics* 68, 1928-1937.
TURNER, K., LENZEN, M., WIEDMANN, T., BARRETT, J. (2007) Examining the Global Environmental Impact of Regional Consumption Activities - Part 1: A Technical Note on Combining Input-Output and Ecological Footprint Analysis. *Ecological Economics*, 62(1), 37-44.

UNEP. (2011). Decoupling natural resource use and environmental impacts from economic growth. A report of the *Working Group on Decoupling to the International Resource Panel*. *United Nations Environment Programme.*

WIEBE, K.S., M. BRUCKNER, S. GILJUM AND C. LUTZ. (2012a). Calculating energy-related CO2 emissions embodied in international trade using a global input-output model. *Economic Systems Research: forthcoming*

WIEBE, K.S., M. BRUCKNER, S. GILJUM, C. LUTZ AND C. POLZIN. (2012b). Carbon and materials embodied in the international trade of emerging economies: A multi-regional input-output assessment of trends between 1995 and 2005. *Journal of Industrial Ecology: forthcoming*.

WIEDMANN, T. (2009a). A first empirical comparison of energy Footprints embodied in trade - MRIO versus PLUM. *Ecological Economics*, 68(7), 1975-1990.

WIEDMANN, T. (2009b) A review of recent multi-region input–output models used for consumption-based emission and resource accounting. *Ecological Economics*, 69(2), 211-222.

WIEDMANN, T., LENZEN, M., TURNER, K., BARRETT, J. (2007). Examining the Global Environmental Impact of Regional Consumption Activities - Part 2: Review of input-output models for the assessment of environmental impacts embodied in trade. *Ecological Economics*, 61 (1), 15-26.

WIEDMANN, T., WOOD, R., LENZEN, M., MINX, J., GUAN, D., BARRETT, J. (2008) Development of an Embedded Carbon Emissions Indicator - Producing a Time Series of Input-Output Tables and Embedded Carbon Dioxide Emissions for the UK by Using a MRIO Data Optimisation System. Report to the *UK Department for Environment, Food and Rural Affairs*, Defra, London.

WIOD (2010). *World Input-Output Database.* Website www.wiod.org, Groningen, The Netherlands and ten other institutions.

YAMANO, N. AND AHMAD, N. (2006) The OECD's Input-Output Database - 2006 Edition. STI Working Paper, 2006/8 (DSTI/DOC(2006)8), *Organisation for Economic Co-operation and Development (OECD), Directorate for Science, Technology and Industry, Economic Analysis and Statistics Division*, Paris, France.

APPENDIX A

Table A1: Country coverage in GRAM and data availability

No.		Country	First available BTD year	IOT availability (OECD)
1	at	Austria	1995	1995/2000/2004
2	be	Belgium	1988	1995/2000/2004
3	lu	Luxembourg	1999	1995/2000/2005
4	dk	Denmark	1988	1995/2000/2004
5	fi	Finland	1988	1995/2000/2005
6	fr	France	1988	1995/2000/2005
7	de	Germany	1988	1995/2000/2005
8	gr	Greece	1988	1995/1999/2005
9	ie	Ireland	1988	1998/2000
10	it	Italy	1988	1995/2000/2004
11	nl	Netherlands	1988	1995/2000/2005
12	pt	Portugal	1988	1995/2000/2005
13	es	Spain	1988	1995/2000/2004
14	se	Sweden	1988	1995/2000/2005
15	gb	United Kingdom	1988	1995/2000/2003
16	cz	Czech Republic	1993	2000/2005
17	hu	Hungary	1992	1998/2000/2005
18	pl	Poland	1992	1995/2000/2004
19	sk	Slovak Republic	1997	1995/2000
20	tr	Turkey	1989	1996//2002
21	ic	Iceland	1988	Norway
22	no	Norway	1988	1995/2000
23	ch	Switzerland	1988	2001
24	ca	Canada	1988	1995/2000
25	mx	Mexico	1990	2003 (not OECD)
26	us	United States	1990	1995/2000/2005
27	jp	Japan	1988	1995/2000/2005
28	kr	Korea	1994	2000
29	au	Australia	1988	1998/99/2004/05
30	nz	New Zealand	1989	1995/96/2002/03
31	bg	Bulgaria		Slovakia
32	cy	Cyprus		Greece
33	ee	Estonia	1995	1997/2000/2005
34	lv	Latvia		Poland
35	lt	Lithuania		Poland
36	mt	Malta		Greece
37	si	Slovenia	1994	2000/2005
38	ro	Romania		Slovakia
39	cn	China	1992	1995/2000/2005
40	hk	Hong Kong, China	1992	Korea
41	id	Indonesia	1989	1995/2000/2005
42	in	India	1988	1993/94/1998/99
43	my	Malaysia	1989	Korea
44	ph	Philippines	1996	Korea
45	sg	Singapore	1989	Korea
46	th	Thailand	1988	Korea
47	tw	Chinese Taipei	1990	1996/2001
48	ar	Argentina	1993	1997
49	br	Brazil	1989	1995/2000/2005
50	cl	Chile	1990	Brazil
51	za	South Africa	2000	1993/2000
52	il	Israel	1995	1995
53	ru	Russian (Federation of)	1996	1995/2000
54	op	OPEC excl. Indonesia		Indonesia
55	rw	Rest of the world		Argentina

Table A2: Industry classification of OECD IOTs

ISIC Rev. 3 code	IO industry	Description
1+2+5	1	Agriculture, hunting, forestry and fishing
10+11+12	2	Mining and quarrying (energy)
13+14	3	Mining and quarrying (non-energy)
15+16	4	Food products, beverages and tobacco
17+18+19	5	Textiles, textile products, leather and footwear
20	6	Wood and products of wood and cork
21+22	7	Pulp, paper, paper products, printing and publishing
23	8	Coke, refined petroleum products and nuclear fuel
24ex2423	9	Chemicals excluding pharmaceuticals
2423	10	Pharmaceuticals
25	11	Rubber and plastics products
26	12	Other non-metallic mineral products
271+2731	13	Iron & steel
272+2732	14	Non-ferrous metals
28	15	Fabricated metal products, except machinery and equipment
29	16	Machinery and equipment, nec
30	17	Office, accounting and computing machinery
31	18	Electrical machinery and apparatus, nec
32	19	Radio, television and communication equipment
33	20	Medical, precision and optical instruments
34	21	Motor vehicles, trailers and semi-trailers
351	22	Building & repairing of ships and boats
353	23	Aircraft and spacecraft
352+359	24	Railroad equipment and transport equipment n.e.c.
36+37	25	Manufacturing nec; recycling (include Furniture)
401	26	Production, collection and distribution of electricity
402	27	Manufacture of gas; distribution of gaseous fuels through mains
403	28	Steam and hot water supply
41	29	Collection, purification and distribution of water
45	30	Construction
50+51+52	31	Wholesale and retail trade; repairs
55	32	Hotels and restaurants
60	33	Land transport; transport via pipelines
61	34	Water transport
62	35	Air transport
63	36	Supporting & auxiliary transport activities; activities of travel agencies
64	37	Post and telecommunications
65+66+67	38	Finance and insurance
70	39	Real estate activities
71	40	Renting of machinery and equipment
72	41	Computer and related activities
73	42	Research and development
74	43	Other Business Activities
75	44	Public administration and defence; compulsory social security
80	45	Education
85	46	Health and social work
90-93	47	Other community, social and personal services
95+99	48	Private households with employed persons & extra-territorial organisations & bodies

Source: Yamano and Ahmad (2006) Table 3: OECD I-O Database. Industry classification and concordance with ISIC Rev. 3, 2006 edition

Table A3: Energy balance sectors and emission data

Energy Balance		CO2 Emissions	
Row	**Sector name**	**Row**	**Sector name**
1	Production		
2	Imports		
3	Exports		
4	International marine bunkers	13	Memo: International Marine Bunkers
5	Stock changes		
6	Total primary energy supply		
7	Transfers		
8	Statistical differences		
9	Main activity producer electricity plants	2	Main Activity Producer Electricity and Heat
10	Autoproducer electricity plants	3	Unallocated Autoproducers
11	Main activity producer CHP plants	2	Main Activity Producer Electricity and Heat
12	Autoproducer CHP plants	3	Unallocated Autoproducers
13	Main activity producer heat plants	2	Main Activity Producer Electricity and Heat
14	Autoproducer heat plants	3	Unallocated Autoproducers
15	Heat pumps	2	Main Activity Producer Electricity and Heat
16	Electric boilers	2	Main Activity Producer Electricity and Heat
17	Chemical heat for electricity production	2	Main Activity Producer Electricity and Heat
18	Gas works	4	Other Energy Industries
19	Petroleum refineries	4	Other Energy Industries
20	Coal transformation	4	Other Energy Industries
21	Liquefaction plants	4	Other Energy Industries
22	Non-specified (transformation)	4	Other Energy Industries
23	Own use		
24	Distribution losses		
25	Total final consumption		
26	Industry sector		
27	Iron and steel	5	Manufacturing Industries and Construction
28	Chemical and petrochemical	5	Manufacturing Industries and Construction
29	Non-ferrous metals	5	Manufacturing Industries and Construction
30	Non-metallic minerals	5	Manufacturing Industries and Construction
31	Transport equipment	5	Manufacturing Industries and Construction
32	Machinery	5	Manufacturing Industries and Construction
33	Mining and quarrying	5	Manufacturing Industries and Construction
34	Food and tobacco	5	Manufacturing Industries and Construction
35	Paper, pulp and printing	5	Manufacturing Industries and Construction
36	Wood and wood products	5	Manufacturing Industries and Construction
37	Construction	5	Manufacturing Industries and Construction
38	Textile and leather	5	Manufacturing Industries and Construction
39	Non-specified (industry)	5	Manufacturing Industries and Construction
40	Transport sector		
41	International aviation	14	Memo: International Aviation
42	Domestic aviation	6 minus 7	Transport minus Road
43	Road	7	Road
44	Rail	6 minus 7	Transport minus Road
45	Pipeline transport	6 minus 7	Transport minus Road
46	Domestic navigation	6 minus 7	Transport minus Road
47	Non-specified (transport)	6 minus 7	Transport minus Road
48	Other sectors		
49	Residential	9	Residential
50	Commercial and public services	8 minus 9	Other Sectors minus Residential
51	Agriculture/forestry	8 minus 9	Other Sectors minus Residential
52	Fishing	8 minus 9	Other Sectors minus Residential
53	Non-specified (other)		
54	Non-energy use		
55	Non-energy use in industry/transformation/energy		
56	Memo: feedstock use in petrochemical industry		
57	Non-energy use in transport		
58	Non-energy use in other sectors		
59	Electricity output in GWh		
60	Elec output-main activity producer ele plants		
61	Elec output-autoproducer electricity plants		
62	Elec output-main activity producer CHP plants		
63	Elec output-autoproducer CHP plants		
64	Heat output in TJ		
65	Heat output-main activity producer CHP plants		
66	Heat output-autoproducer CHP plants		
67	Heat output-main activity producer heat plants		
68	Heat output-autoproducer heat plants		

APPENDIX B: VALUE ADDED AND OUTPUT ESTIMATIONS

This appendix shows on the one hand that the estimated value added cannot be negative and on the other hand the deviations of the estimated value added and output vectors from the original data.

Given coefficient matrices $\mathbf{A}_{jj}$ and $\mathbf{A}_{(imp)j}$ that are calculated from the original data, the column sums of matrix $\mathbf{A}_j = \mathbf{A}_{jj} + \mathbf{A}_{(imp)j}$ are always smaller than one, that is for a_j^{mn} being the entry in the mth row and nth column of matrix $\mathbf{A}_j$, resulting in $\sum_{m=1}^{S} a_j^{mn} = \sum_{m=1}^{S} a_{jj}^{mn} + \sum_{m=1}^{S} a_{(imp)j}^{mn} < 1$, with S being the number of sectors. Now using import shares m_{ij}^n of country j importing good n from country i, that naturally fulfil $\sum_{i=1}^{C} m_{ij}^n = 1$, with $m_{jj}^n = 0$, for a total of C countries, the result is that the column sum of the global matrix A for sector n in country j is (using equation (5))

$$\begin{aligned}\sum_{i=1}^{C}\sum_{m=1}^{S} a_{ij}^{mn} &= \sum_{m=1}^{S} a_{ii}^{mn} + \sum_{i=1,i\neq j}^{C}\sum_{m=1}^{S} a_{ij}^{mn} \\ &= \sum_{m=1}^{S} a_{ii}^{mn} + \sum_{i=1,i\neq j}^{C}\sum_{m=1}^{S} m_{ij}^{n} a_{(imp)j}^{mn} \\ &= \sum_{m=1}^{S} a_{ii}^{mn} + \sum_{m=1}^{S} a_{(imp)j}^{mn} < 1.\end{aligned}$$

Now, given that the column sums of matrix A are always smaller than one, if they were smaller than one in the original data, and $v_j^n = x_j^n - x_j^n \sum_{i=1}^{C}\sum_{m=1}^{S} a_{ij}^{mn}$, it leads to $\frac{v_j^n}{x_j^n} > 0$ because $\sum_{i=1}^{C}\sum_{m=1}^{S} a_{ij}^{mn} < 1$.

Table A4 shows descriptive statistics of the deviations of sectoral output and sectoral value added from the original data. Note that next to the use of cif prices only, some of the deviation can also be due to exchange rate imprecision. As expected, due to the use of cif prices, both calculated value added and output, are on average higher than the

OECD data. For 50% of the sectors, the deviation is between -7.1% and 13.6% for output and between -7.6% and 12.9% for value added. For the total of 2124 sectors for which data is available in the OECD input-output tables the deviation is below -100% for output of only 1 sector and value added of 25 sectors. The positive deviations are more frequent and higher, that is the deviation is more than +100% for 132 sectors for both output and value added, with the highest deviation being in sector "17 Office, accounting & computing machinery" for Greece in 2000 and 2005, and Luxembourg in 1995 and 2000, and in sector "19 Radio, television & communication equipment" for Luxembourg in 1995, 2000 and 2005. About 80% of the observations of value added and output deviations are within -50% to +50%. When cutting off the highest and lowest 10% the interval is (-0.43,+0.59) for value added and (-0.33,+0.61) for output deviations. Leaving out the lowest and highest 5% slightly decreases the lower bounds, but more than doubles the upper bounds, reflecting the right skew of the deviations, which can also be seen in Figures A1 and A2.

Table A4: Descriptive statistics of deviations from OECD data

	Output	**Value Added**
Min.	-1.019	-38.550
1st Qu.	-0.071	-0.076
Median	0.005	0.004
3rd Qu.	0.136	0.129
Max	181.100	181.100
Mean	0.558	0.393
Total number of Observations	2124	2124
Number of Observation < -1	1	25
Number of Observation > 1	132	132

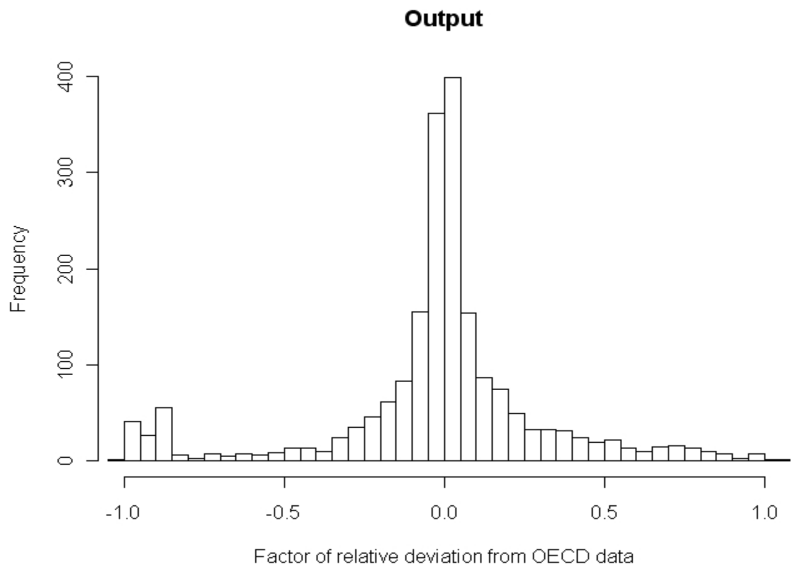


Figure A1: *Frequency of deviations for sectoral output*

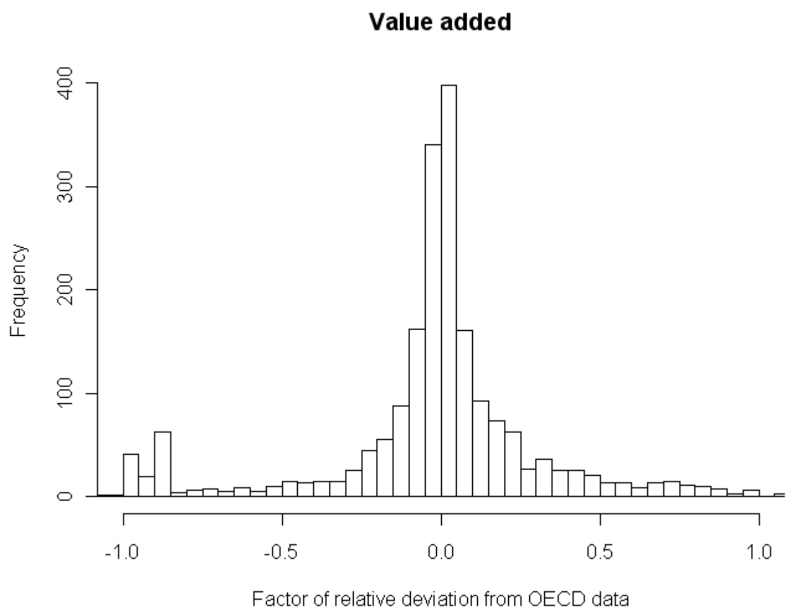


Figure A2: Frequency of deviations for sectoral value added

FORECASTING INTERNATIONAL OIL PRICE USING AN ECM MODEL

HAIYING WU AND SHENGCHU PAN[60]

Abstract
This paper intends to empirically examine the significance of China's oil demand for international crude oil prices based on quarterly data from 1995 to 2010. Equation on the West Texas Intermediate (WTI) price is constructed by applying dynamic modelling techniques and error correction model (ECM) form. The estimation shows that WTI spot price is determined by OPEC oil production capacity, oil imports of U.S. and China, U.S. crude oil inventory and exchange rate index of U.S. dollar. The rapid growth of China's oil imports has already started to influence global oil prices, while its extent is much lower than that of U.S. and OPEC factors. It is expected that the WTI spot price may sustain around 94 dollar per barrel through 2011.
JEL classification: C32, C53, E37
Keywords: *Crude oil prices, China's demand, ECM model*

60 Haiying Wu, PhD candidate, Central University of Finance & Economics, Beijing, China. Senior Research Fellow, Institute of World Economics and Politics, Chinese Academy of Social Sciences. Email: Wu.haiying@263.net; Shengchu Pan, Professor, Central University of Finance & Economics, Beijing, China. Email: pan_shengchu@263.net

1. INTRODUCTION

The global oil price, represented by West Texas Intermediate (WTI) crude oil price, experienced a remarkable fluctuation since middle 2004. It soared to the peak $147 per barrel in July 2008, and dropped down less $40 in early 2009, then rapidly surge back to near $100 in middle 2011. Such extraordinary price variation brought dramatic uncertainty to the global economy, which leads to considerable concerns on oil price forecasts among research communities.

Demand factors seem to play an increasing role in oil price determinant since 2004. During that period, strong economy growth worldwide, before financial crisis and depression thereafter, occurred with the sharp rise and fall in oil prices. Meanwhile, non-OECD oil consumption increased by more than 40 percent between 2000 and 2010, when China and India gained the largest oil consumption growth. Such new characteristics should be considered in oil price models.

China's oil consumption and imports has risen sharply in recent years, due to its rapid and continuous economy growth. China has 219 million vehicles in August 2011, the second largest vehicle capacity in the world. Furthermore, China's imports of crude oil and petroleum products reached 5.6 million barrels per day in 2010, accounting for 8.9 percent of world oil import markets (See Figure 1). Therefore, China's sharp increment of oil demand is thought to be a key reason for the rising of the international oil price in recent years.

China's strong oil demand makes it possible to have an impact on global oil prices. This paper intends to examine empirically the significance of China's oil demand on global oil prices based on quarterly data from 1995 to 2010. A WTI crude oil spot price equation was built, concerning China's oil imports, applying dynamic modelling techniques and an error correction model (ECM) form. Forecasts of WTI spot price through 2011 are also presented.

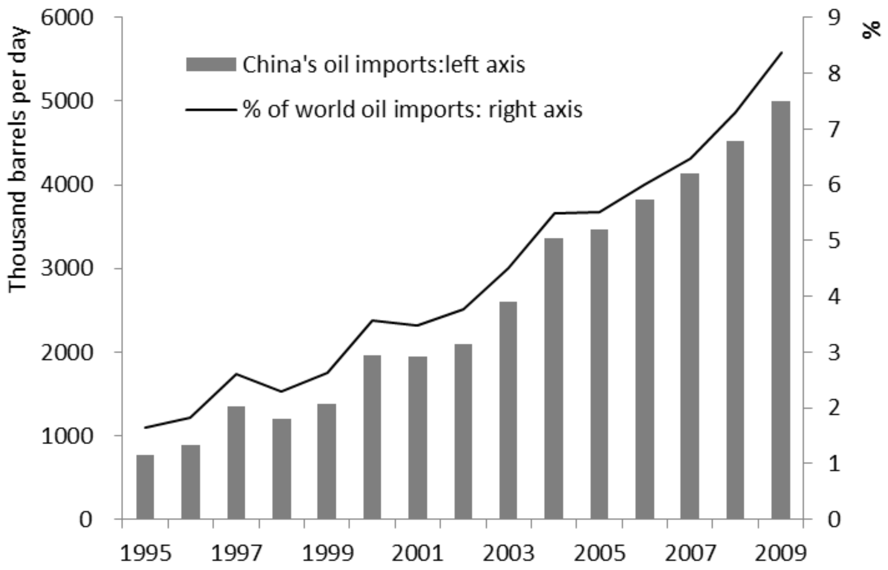


Figure 1 : China's Oil Imports and Market Share
Source: U.S. Energy Information Administration, www.eia.gov.
Note: Oil imports here include imports of crude oil and petroleum products.

The rest of this paper is organised as follows. Section II provides a brief literature review on oil price forecasts. Section III presents the World Trade Institute (WTI) price model, including econometric approaches used, variable selection, model specification and estimation. Section IV forecasts the WTI spot price in 2011. Section V concludes the paper.

2. LITERATURE REVIEW

This section briefly reviews some of the recent economic literature on structural oil price models. According to econometric techniques applied, oil price models can generally be classified into two types: time series models and structural models. Time series models forecast oil prices based on their own lag data information by using decomposition of time series variables, while structural models intend to identify which and how variables determine oil prices. Since oil prices are basically determined by supply and demand, variables related to oil supply and demand are often concerned by researchers, such as oil consumption and production, commercial or government oil inventories. Because structural models will be used in the paper, the focus is on this type of models in this section.

From the perspectives of oil demand and supply, different variables are applied in structure models. Among supply factors, OPEC oil production capacity is often used as an indicator of the tightness of global oil markets, since OPEC crude oil production accounts for about 40 percent of the world total, and 60 percent of the world oil exports comes from OPEC.

In empirical literature, Kaufmann (2004) and Dees et al. (2007) examined whether OPEC behaviour really affects real oil prices. In their quarterly forecasting models for periods 1986-2000 and 1984-2002 respectively, OPEC quota, OPEC excess production capacity, capacity utilisation rate and ratio of OECD oil inventory level to OECD demands were adopted. After acquiring accurate static and dynamic forecasts of oil prices, they concluded that OPEC behaviour did affect real oil prices. Similarly, OPEC oil production capacity and oil capacity rate of OPEC were used in Kaufmann (1995). OPEC oil quota and OPEC excess production capacity were applied in Zamani (2004). Except for OPEC production capacity, oil capacity rate of the United States is another explanatory variable in supply sides (Kaufmann, 1995).

In terms of oil demand determinants, world oil demand was used in Kaufmann (1995), and non-OECD oil demand was applied in Zamani (2004). The former model built between 1956 and 1989, while the latter was over the period from 1988 to 2004. Up to the present, however, oil price forecasts need to pay more attention on oil demands from developing countries. One of reasons is that oil consumption in OECD countries decreased between 2000 and 2010, while non-OECD oil consumption increased more than 40 percent.

As the balance between oil supply and demand, oil inventory is another important factor which can affect oil prices. It captures expected seasonality and general trends in production and demand, as well as unexpected supply or demand shifts. Inventory is the immediate "supply" when needed and can also become a demand to cushion fears of shortages.

Therefore, almost every oil forecasting model chooses oil inventory as an explanatory variable. For example, OECD oil inventory level or its ratio to OECD demands appeared in Kaufmann (1995, 2004) and Dees et al. (2007). The effects of relative oil inventory on oil prices were continuously demonstrated in Ye et al. (2002, 2005, 2006, and 2009) models. WTI crude oil spot price was determined in these monthly series models. From the early 1990's until the early 2000's, crude oil prices were explained and forecasted using only OECD inventory data (Ye et al. 2002 and 2005). During that time, OPEC had excess production capacity which could be used to meet unexpected demand increases. As world demand grew rapidly, however, this excess capacity diminished. Thus an excess production capacity variable was added in the oil forecast model (Ye et al. 2006). An additional variable, the cumulative excess capacity, is derived and incorporated into the new forecast model to capture the so-called Duesenberry Ratchet Effect (A short-run crude oil price forecast model with ratchet effect) observed in crude oil markets in recent years, reflecting the changing behaviours on both demand and supply sides (Ye et al. 2009).

The oil price model in this paper is based on the period 1995-2010. China's rapid oil demand is especially examined, reflecting China's strong economy growth on international oil prices. Meanwhile, OPEC production capacity, U.S. crude oil inventory and U.S. dollar index are applied in the model. The error correction mechanism used in the model is also adopted in some models mentioned above (see Zamani, 2004, Kaufmann, 2004 and Dees et al., 2007).

3. ESTIMATION OF WTI SPOT PRICE

3.1 Econometric techniques used in WTI model

We apply dynamic modelling techniques and error correction model (ECM) to specify the oil price equation. Hendry (1998) states that the autoregressive distributed lag model (ADL) is the most general form of all linear models, and an error correction model can be generated by rewriting an ADL model. For a simple example, the ADL model in (1) is equivalent to the ECM model given by (2) (Hendry, 1998).

$$y_t = \beta_0 + \beta_1 z_t + \beta_2 y_{t-1} + \beta_3 z_{t-1} + \varepsilon_t \qquad (1)[61]$$

$$\Delta y_t = \beta_0 + \beta_1 \Delta z_t + (\beta_2 - 1)(y - K_1 z)_{t-1} + \varepsilon_t, \; K_1 = \frac{\beta_1 + \beta_3}{1 - \beta_2} \qquad (2)$$

Where $\varepsilon_t \sim \mathrm{IN}\left[0, \sigma^2\right]$, Δ is the first-order difference, $\Delta y_t = y_t - y_{t-1}$, $y_t = K_1 z_t$ is the long-run equilibrium term indicated by economic theory. $(y - K_1 z)_{t-1}$ is the lagged equilibrium error (ECM variable). $(\beta_2 - 1)$ is the adjustment factor which is expected to be negative and greater than -1.

The ECM model has become widely applied in econometric research fields and is the main reason why it was chosen to build the oil price model.

Econometric techniques can generally be categorised into two types: traditional and dynamic approaches. In the 1930s, the Cowles Commission econometricians in the United States founded and developed traditional econometric techniques. Traditional techniques assume that observed economic time series come from stationary processes whose means and variances are constant over time. As a result, inheriting from economic theories, traditional econometric techniques emphasise using certain statistical methods to estimate and test equation coefficients. The 1950s and the 1960s were the heydays of traditional econometric modelling. In the early 1970s, however, all econometric models failed to predict the short-run dynamic effects of the oil crisis on most fundamental economic variables, prompting econometricians to revaluate traditional econometric techniques (Hendry and Qin, 1998).

In the late 1970s and the early 1980s, the United Kingdom New School econometricians, represented by Professor David Hendry at Cambridge University, founded dynamic econometric techniques. Dynamic econometric techniques overcome many shortcomings of the traditional techniques and became widely applied.

---

61 Equation (1) here corresponds to equation (7.1) in Hendry (1998), and equation (2) relates to equations of (7.87) and (7.88) in Hendry (1998), page358-359.

Firstly, based on the fact that most economic time series are generated from non-stationary processes, dynamic techniques emphasise a model specification corresponding to Data-Generating Process (DGP) instead of traditional techniques' coefficients estimation and testing.

Secondly, dynamic techniques propose to start from DGP, specifying a model through a dynamic "from-general-to-specific" reduction process. Unlike implicit and "artistic" process of traditional model specification, the dynamic process is explicit and can be followed step by step.

Thirdly, the dynamic techniques' error correction model distinguishes factors influencing economic variables into short-run fluctuation and long-run effort. The long-run effort is in line with the long-run inner relations among economic variables which economic theories are expected to indicate. The adjustment factor in front of the long-run equilibrium term describes the dependent variable's correction mechanism on disequilibrium driven by the long-run term. As long as explanatory and explained variables are co-integrated, there will be a unique Granger causality (relating to the investigation of pairs of time series), which is crucial to make conditional forecasts based on the ECM model (Hendry and Qin, 1998).

After 20 years of development and application, dynamic econometric techniques and the ECM model have become widely adopted and applied in econometric research fields.

3.2 Variable Selection

Despite of the sharp violation of oil prices since 2004, demand and supply factors are still the fundamental determinants of global oil prices. Meanwhile, other key variables such as oil inventory and exchange of U.S. dollar should be considered.

3.2.1 Demand variables

As mentioned before, demand factors have begun to play an increasing role in oil price determination in recent years.

Low interests and strong economic growth worldwide before subprime crisis, represented by the United States and China, has largely spurred oil demands and its growth expectation. When financial crisis in 2008 and 2009 dragged the major developed economies into recession and decelerated emerging economies' growth, demands for oil products declined correspondingly, and the oil price suffered a swift and extreme downturn.

Data from U.S. Energy Information Administration shows that oil consumption in the OECD countries declined between 2000 and 2010, while non-OECD oil consumption increased more than 40 percent. Among them, China, India and Saudi Arabia had the largest oil consumption growth. Compared with OECD countries, non-OECD economies tend to have a larger proportion in manufacturing industries, which are more energy intensive than service industries. Meanwhile, vehicle ownership per capita has much room to grow with income rising in non-OECD countries. As a result, non-OECD economic growth tends to be an important factor affecting oil prices in recent years.

China's domestic oil demand and oil imports have increased rapidly since the late 1990's, especially after 2003, making it possible to have an influence on global oil prices. China's increasing oil demand mainly results from its strong economic growth and rising of vehicle ownership per capita. Up to the present, China is the second largest economy and the second largest oil consumer in the world, with China's vehicle capacity ranking only after the United States and its vehicle market 50% larger than that of the U.S. and seven times larger than India's in 2011. In addition, China's rising oil imports has been a major contributor to incremental growth in worldwide import markets (See Figure 2).

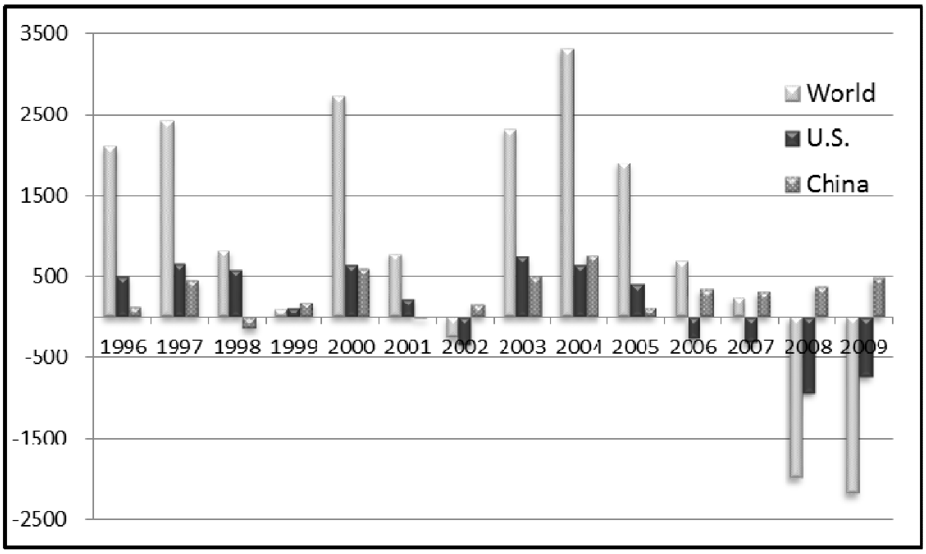


Figure 2: Change in Oil Imports (Thousand Barrels Per Day)
Source: U.S. Energy Information Administration, www.eia.gov.
Note: Oil imports here include imports of crude oil and petroleum products.

It's proposed to test China's influence based on world oil import and export markets. Figure 3 presents oil imports market shares of the largest five economies. It shows clearly that stagnant or some shrunk imports shares appear in Japan, Germany and France. By contrast, China demonstrates an obvious rising trend. The United States, as the largest oil importer, maintains a high proportion share in the world oil import markets with some declined tendency due to financial crisis. Meanwhile, Figure 2 demonstrates that U.S. and China take a great proportion in the whole increment of global oil imports, which means changes in U.S. and China's oil demands may affect crude oil prices significantly. Consequently, oil imports of China and the United States are chosen as the main demand variables to determine the international oil price, representing non-OECD and OECD economies respectively.

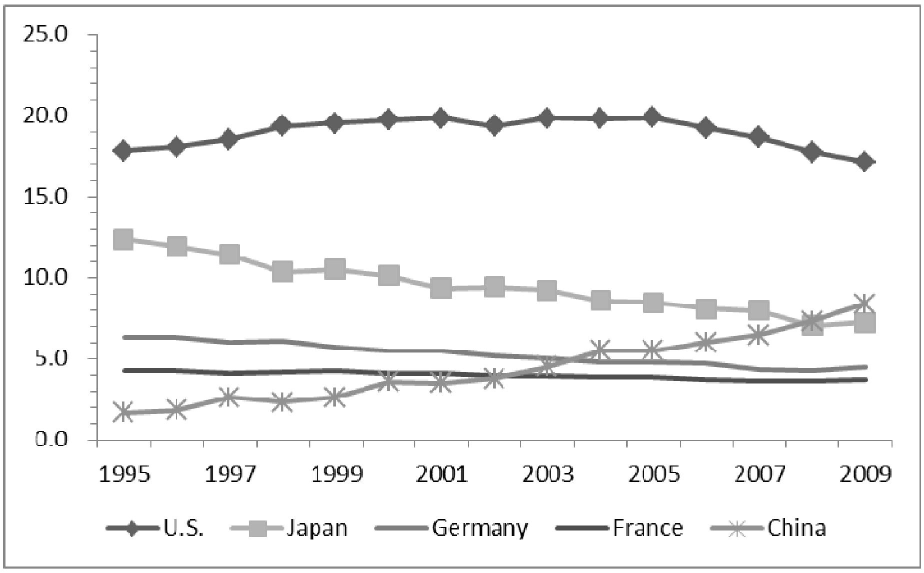


Figure 3: Oil Imports Share (% of World oil imports)
Source: U.S. Energy Information Administration, www.eia.gov.
Note: Oil imports here include imports of crude oil and petroleum products.

3.2.2 Supply variables

Organisation of the Petroleum Exporting Countries (OPEC) is an important factor that affects oil prices. OPEC works together and seeks to actively manage oil production in its member countries by setting production targets, and thus influence world oil supplies and price levels. Historically, crude oil prices rose in times when OPEC production targets were reduced.

OPEC controlled approximately three-quarters of the world's total oil proven reserves in 2007. In addition, OPEC produces about 40 percent of the world's crude oil and its oil exports represent about 60 percent of the total petroleum traded internationally. Therefore, OPEC available production capacity is often used as an indicator of the tightness of global oil supply markets and thus applied in the oil price equation.

3.2.3 Oil inventory

Oil inventories balance oil supply and demand. During periods when consumption exceeds production, crude oil and petroleum products can be supplemented by draws on inventories to satisfy the extra needs. In contrast, when production outstrips consumption, oil products can be purchased as inventories and stored for future use. In both cases, oil inventories can moderate fluctuation of oil prices. In late 2008 and early 2009, for example, the unexpected downturn in world economy led to record crude oil inventories in the United States and other OECD countries, which somewhat lessened the falling of oil prices.

Crude oil inventory owned by the United States has almost the same amount as OPEC production capacity during the same period. Since its large capacity and mostly concerned by market participants, U.S. crude oil inventory is chosen as an explanatory variable in the oil price model.

3.2.4 U.S. dollar index

Several hypotheses support an inverse relationship between the exchange rate of U.S. dollar and crude oil prices. The first is simply because oil benchmarks are traditionally priced in U.S. dollars, and dollar depreciation directly decreased the effective oil price outside the United States. This declined cost may increase consumer demand for oil, which leads to upward prices.

A second potential reason is dollar depreciation reduces real returns on dollar-denominated assets, which may increase foreign investing in commodities like oil. Investors of the United States may also turn to buy oil as a hedge against dollar inflation due to the dollar depreciation or inflation expectation.

Finally, U.S. dollar depreciation will decline the effective profits of non-U.S. oil producers, when measured in foreign currencies. To counter this, these oil producers may target a higher dollar oil price to maintain their real revenue and purchasing power.

U.S. nominal major currencies dollar index is applied in the model. This index is a weighted average of the foreign exchange values of U.S. dollar against the currencies of a large group of major U.S. trading partners.

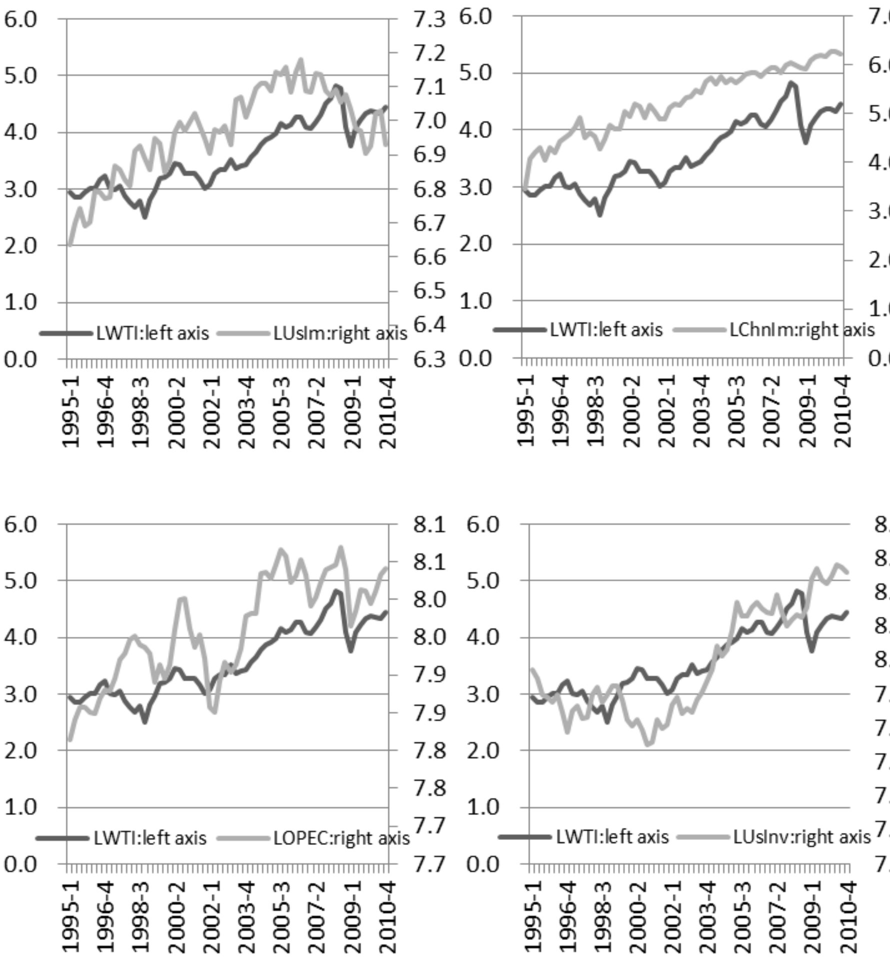
Besides the factors mentioned above, events that have potential to disrupt oil production or flow to market, such as geopolitical events and bad weather, can affect global oil prices.

In summary, it is proposed that the significance of China's oil demand on global oil prices is examined based on world oil import and export markets. Oil imports of the U.S. and China, OPEC production capacity, the U.S. dollar index and U.S. crude oil stocks are chosen to explain the WTI crude oil spot price (See Table 1 and Figure 4). It is expected that oil imports of the U.S. and China have positive effects on the WTI price, while the WTI price will be likely to have negative relations with OPEC production capacity, the U.S. dollar index and U.S. crude oil stocks.

Table 18: List of variables

	Description	**Units**	**Source**
WTI	WTI crude oil spot price	\$/barrel	U.S. Energy Information Administration
UsIm	US crude oil & petroleum product imports	Million barrels	U.S. Energy Information Administration
ChnIm	China's crude oil & petroleum product imports	Million barrels	Wind Database
OPEC	OPEC production capacity	Million barrels	U.S. Energy Information Administration
UsInv	US crude oil stocks	Million barrels	U.S. Energy Information Administration
USD	Nominal major currencies dollar index	March 1973 = 100	www.federalreserve.gov

Note: All variables are quarterly data from 1995 to 2010.


LWTI:left axis
LUsIm:right axis
LWTI:left axis
LChnIm:right axis
LWTI:left axis
LOPEC:right axis
LWTI:left axis
LUsInv:right axis

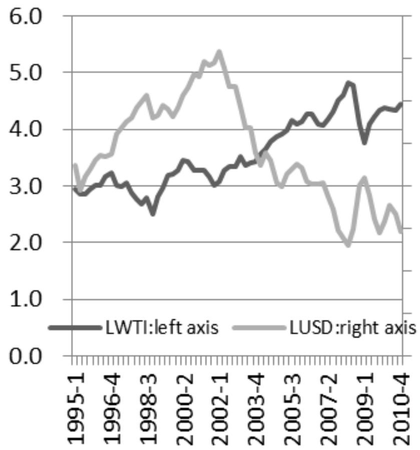


Figure 4: Variables in WTI Equation

Notes: ① Lx means logarithm of x. ②Variables in figures with double axis have been adjusted by means and ranges, which make the two variables' (such as WTI and USD) means and range equal respectively.

4. WTI EQUATION

We first get logarithm value of each variable in table 1, by adding letter L in front of them. Unit root tests on variables are tested and the results are listed in table 2, which shows most variables have unit roots. By first differencing (adding letter D in front of each logarithmic variable), all variables are weakly stationary variables. In estimating the model, PcGive10.0 software (Doornik and Hendry, 2001) is adopted.

Table 2: Unit –root Tests

LWTI	LUsIm	LChnIm	LOPEC	LUsInv	LUSD
-3.59*	-0.92	-3.73*	-2.89	-1.98	-2.68
DLWTI	DLUsIm	DLChnIm	DLOPEC	DLUsInv	DLUSD
-6.35**	-9.83**	-7.97**	-7.30**	-7.65**	-5.67**

*Note: Data are quarterly from 1995-2010. LX represents logarithm of X, and DLX means the first-order difference of LX; LX ADF tests use constant, trend and seasonal dummies, while DLX tests just include constant. ** for 1% significance level, * for 5% significance level.*

Following the ECM dynamic modelling techniques, an autoregressive distributed lagged model with LWTI is then set up as dependent variable.

$$LWTI\ t = f\ (LUsImt,\ LChnIm\ t,\ LOPECt,\ LUsInvt,\ LUSDt) + \varepsilon t \qquad (3)$$

In (3), adequately long lags are used to ensure that εt is a white noise process. Adopting the "general to specific" dynamic approach, the model is gradually reduced and its ECM equation is derived, as the format expressed in model (2). Finally, both the long run elasticity and short run effects of explanatory variables on WTI oil price can be derived. The final reduction results are as follows:

EQ(121) Modelling DLWTI by OLS (using WTI.in7)

The estimation sample is: 1995 (3) to 2010 (4)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
DLWTI_1	0.30795	0.0828	3.72	0.000	0.2068
Constant	2.59910	0.5072	5.12	0.000	0.3313
DLUsInv	-4.66659	0.8767	-5.32	0.000	0.3484
DLUsIm	-1.00806	0.3214	-3.14	0.003	0.1566
DLUSD	-0.746136	0.4331	-1.72	0.091	0.0530
DLChnIm	0.345701	0.08051	4.29	0.000	0.2581
Seasonal	0.156891	0.03379	4.64	0.000	0.2891
Seasonal_1	0.262524	0.04632	5.67	0.000	0.3774
WTI_ECM_1	-0.336819	0.06400	-5.26	0.000	0.3432

sigma	0.0852388	RSS	0.385080024
R^2	0.738371	F(8,53) =	18.7 [0.000]**
log-likelihood	69.5504	DW	1.98
no. of observations	62	no. of parameters	9
mean(DLWTI)	0.023881	var(DLWTI)	0.0237396

AR 1-4 test:	F(4,49) =	2.3403 [0.0680]
ARCH 1-4 test:	F(4,45) =	0.43978 [0.7792]
Normality test:	Chi^2(2) =	5.5207 [0.0633]
hetero test:	F(14,38) =	2.5077 [0.0124]*

DLWTI = + 2.599 + 0.308*DLWTI_1 - 4.667*DLUsInv - 1.008*DLUsIm - 0.7461*DLUSD + 0.3457*DLChnIm + 0.1569*Seasonal + 0.2625*Seasonal_1 - 0.3368*WTI_ECM_1

Where, WTI_ECM = LWTI - 0.58*LChnIm - 1.55*LUsIm + 1.83*LUSD + 1.26*LOPEC (4)

From the above ECM term showed in (4), LWTI = 0.58*LChnIm + 1.55*LUsIm - 1.83*LUSD - 1.26*LOPEC. It indicates that in the long run, the elasticity of the WTI oil price, with respect to China's oil imports, U.S. oil imports, U.S. dollar index and OPEC oil production capacity, is 0.58, 1.55, -1.83 and –1.26 respectively. It means that 1 percent increase in these variables may lead to WTI crude oil spot price increase by 0.58, 1.55, -1.83 and –1.26 percent respectively, other things being equal.

The regression results also demonstrate that China's oil imports do have effects on global oil prices both in the long run and short run. In the long-term, a sustained one percentage point increase of China's oil imports would likely allow the WTI oil spot price to increase by 0.58 percentage points. In the short-term, growth in China's oil imports will also cause the WTI spot price to rise.

Although China's demand for oil affects global oil prices, its strength is the weakest among the other three long determinants, which are the U.S. dollar index, U.S. oil imports and OPEC oil production capacity. Factors from the United States are still the main reasons determining global oil prices.

In the short-term, the growth rate of the WTI price depends on its one period lag value and growth rates of China's oil imports, U.S. oil imports, the oil inventory and the dollar index. Furthermore, there is statistically significant seasonality in the WTI price reflected by seasonal variables.

The equation's adjusted factor of long run equilibrium term is –0.3368, which indicates that it takes nearly three quarters (1/0.3368) for WTI disequilibrium to be adjusted to its equilibrium level.

Deriving the dependent variable DLWTI with LWTI, the LWTI equation can be obtained. The goodness of fit of LWTI is 0.98 (See Figure 8 in Appendix 1). The fitness of DLWTI and recursive analysis of coefficients in DLWTI equation is attached in appendix (See Figure 6-7 in Appendix 1).

5. FORECASTS OF THE WTI CRUDE OIL SPOT PRICE

5.1 Assumptions for exogenous variables

We propose to make forecasts of the WTI spot price through 2011. Assumptions for explanatory variables in the WTI equation in forecasting periods are made as follows:

- OPEC: Data are from Short-term Energy Outlook, August 2011 from U.S. Energy Information Association (EIA). EIA expects OPEC oil production capacity will decline from 33.76 million barrels per day in 2010 to 32.86 million barrels per day in 2011, in large part due to the supply disruption in Libya.
- USD: Data for the first and second quarter in 2011 are actual observations. For the next two quarters, it is assumed that the dollar will keep a slight appreciation with a 1% growth rate in the last quarter, largely due to the European debt crisis.
- UsInv: Based on quarterly growth rates from EIA short-term energy outlook, August 2011.
- UsIm & Chnim: From their own autoregressive distributed lag models.

Quarterly forecasting values for each exogenous variable are given in Table 3.

Table 39: Forecasts of exogenous variables

	U.S. oil imports (MN barrels)	China's oil imports (MN barrels)	OPEC oil productio n capacity (MN barrels)	U.S. crude oil stocks (MN barrels)	U.S. Dollar index (March 1973=100)
2011 Q1	1024	548	3178	3240	71.9
2011 Q2	*1063*	*567*	*2916*	*3282*	*69.6*
2011 Q3	*1075*	*573*	*2948*	*3272*	*70.3*
2011 Q4	*1042*	*583*	*2948*	*3302*	*71.0*

Note: Data in italic type is forecasted based on the assumptions listed above.

5.2 Forecasts of WTI spot price

Replacing the forecasts of each exogenous variable in WTI equation and using Eviews software, quarterly forecasts of the WTI crude oil spot price are derived as showed in Table 4.

Table 4: Forecasts of WTI spot price ($/Barrel)

	Actual price	Point forecasts[1]	Confidence intervals[2]
2011 Q1	93.5	91.7	77.3 - 108.8
2011 Q2	102.2	100.7	84.2 - 120.4
2011 Q3		95.8	80.0 - 114.6
2011 Q4		87.3	73.0 - 104.6

Notes: 1 Dynamic (ex ante) forecasts. 2 The standard error based on error variance only.

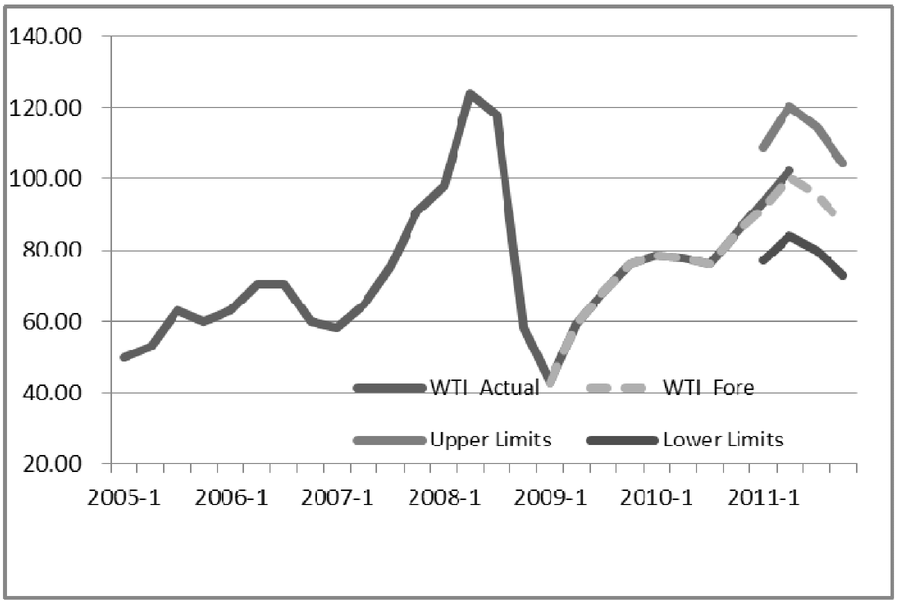


Figure 5: WTI Oil price ($/Barrel)

The forecasts show that the WTI oil spot price will continue rising and hold around $94 per barrel through 2011, with $15 higher than in 2010. The WTI oil spot price might reach the highest point of $101 in the second quarter. Such high price mainly results from the U.S. dollar depreciation in 2011 compared with last year, with the highest 9% depreciation rate in the second quarter. Meanwhile, the shrinking of OPEC oil production capacity, contrasted with the strong growth rate of China’s oil imports, may both contribute to the rising of the oil price in 2011.

6. CONCLUSIONS

This paper adopts dynamic modelling techniques and the error correction model to examine the significance of Chinese oil demand impact on global oil prices, based on quarterly data from 1995 to 2010. The equation of the WTI crude oil spot price is developed and forecasts of the price level in 2011 are presented.

The empirical estimation demonstrates that the rapid growth of China's oil imports has started to influence global oil prices, while the extent is much lower than those of the U.S. and OPEC factors. The Unites States is the largest economy and possesses international reserve, making its dollar index, sizable crude oil inventory and imports demand still contributing greatly to the impact on global oil prices. Furthermore, OPEC available oil production capacity is still a major supply determinant of international oil prices.

Given the assumptions of declined OPEC production, dollar depreciation and robust Chinese oil imports demand in 2011, it is predict that the WTI crude oil spot price would likely keep rising and hold around 94 US dollar per barrel through the whole year, with the highest price of 101 US dollar per barrel in the second quarter.

REFERENCES

DEES, S., KARADELOGLOU, P., KAUFMANN, R.K. AND SANCHEZ M. (2007). Modelling the world oil market: assessment of a quarterly econometric model. *Energy Policy*, Vol.35, pp.178-191.

DOORNIK, J.A. AND D.F. HENDRY, (2001). Econometric Modelling Using Pc-Give 10, London: *Timberlake Consultants Ltd*.

HENDRY, D.F. AND D. QIN, (1998). Dynamic econometrics. *Shanghai People's Publishing House* (in Chinese).

HENDRY, D. F. (1995). Dynamic Economics, Oxford. *Oxford University Press*.

KAUFMANN, R.K.(1995). A model of the world oil market for Project LINK: Integrating economics, geology and politics. *Economic Modelling*,Vol.12, pp.165-178.

KAUFMANN, R.K. (2004). Does OPEC matter? An econometric analysis of oil prices. *The Energy Journal*, Vol.25, pp.67-91.

YE, M., ZYREN J., AND SHORE J. (2002). Forecasting crude oil spot price using OECD petroleum inventory levels. *International Advances in Economic Research*,Vol.8, pp.324-334.

YE, M., ZYREN, J., AND SHORE, J. (2005). A Forecasting model for monthly crude oil spot price. *International Journal of Forecasting*,Vol.21, pp.491–501.

YE, M., ZYREN, J., AND SHORE, J. (2006). Short-run crude oil price and surplus production capacity. *International Advances in Economic Research*, 12(3), pp.390–394.

YE, M., ZYREN, J., BLUMBERG, C. AND SHORE, J. (2009). A short-run crude oil forecast model with ratchet effect. *International Atlantic Economic Society*.

ZAMANI, M. (2004). An econometrics forecasting model of short term oil spot price. Paper presented at the *6th IAEE European Conference*.

APPENDIX 1

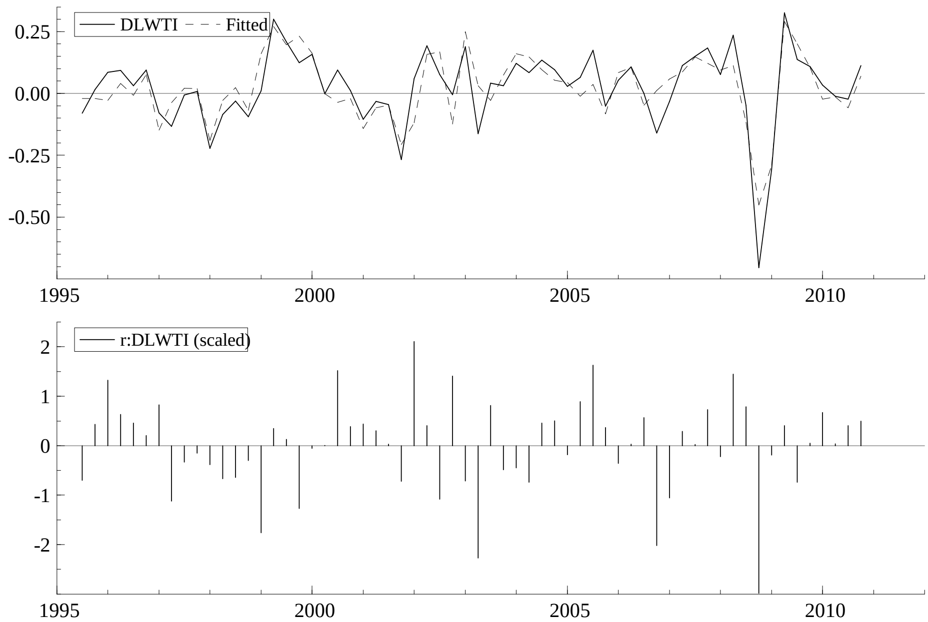


Figure 6: The fitness of DLWTI and its residual distribution

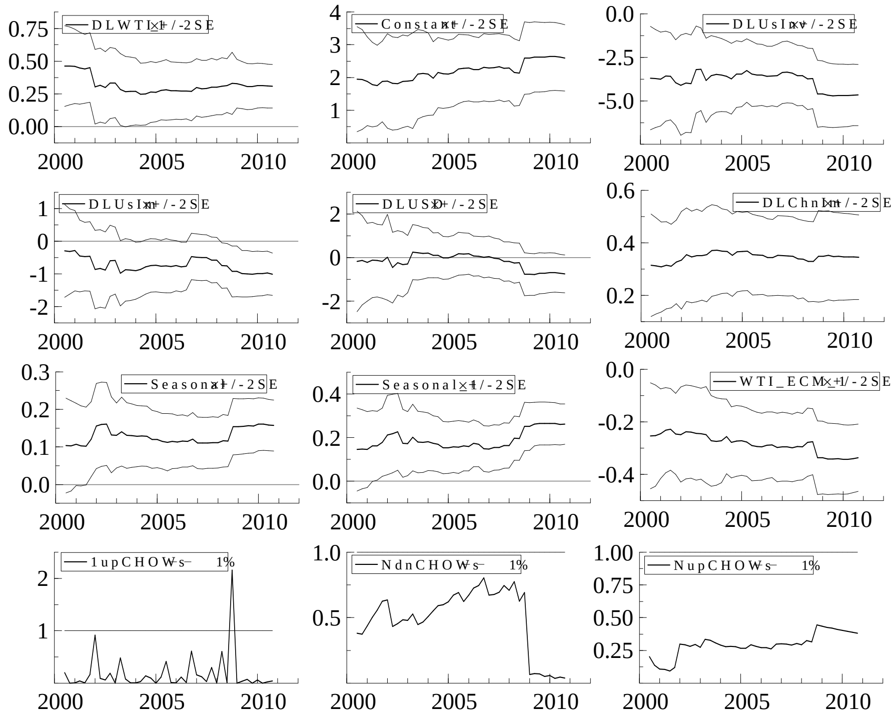


Figure 7: Recursive analysis of coefficients in DLWTI equation and Chow tests (95% confidence interval)
Note: 1up CHOW stands for 1-step Chow test, Ndn CHOWs for Break-point Chow test, and Nup CHOWs for Forecast Chow test.

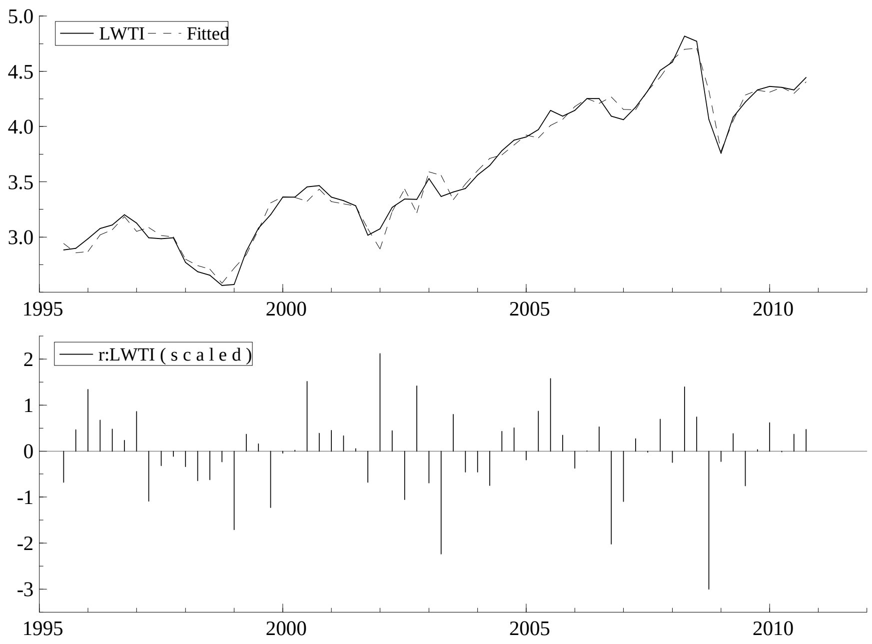


Figure 8: The fitness of LWTI and its residual distribution