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Global Warming Model Results 1996

Stack:	Row:	Section:	Shelf:	Position:
S	20	4	11	1

U.S. DEPARTMENT OF ENERGY

OFFICE OF THE SECRETARY

586-7700
FAX: 586-9626

TO: Jeff Frankel

Phone:

Fax: 395-6947

FROM: Mark Mazur

Phone: 586-7700

Fax: 586-9626

PAGES: 2 **(including cover)**

Jeff-
Here's the list of
folks I promised.
Mary Thomas has phone
numbers in an "IAT" file
on her desk. Mark

Modelers

Phil Tseng	DOE
Ron Early	DOE/EIA
Bill Hohenstein	EPA
Tracy Terry	EPA

Modelers/Technology

Eric Petersen	DOE
Skip Leitner	EPA

Modeler Overseers

Al McGartland	EPA
Howard Gruenspecht	DOE
Marc Chupka	DOE

Kibitzers

Mark Mazur	DOE
Jon Gruber	Treasury
Ray Squiteri	Treasury
Peter Orszag	NEC
Jay Shogren	CEA
Jeff Frankel	CEA
Joe Minarik	OMB
T. J. Glauthier	OMB
Bob Tucillo	OMB
Steve Seidel	WHTFCC
Judi Greenwald	WHTFCC
Ed Montgomery	Labor
Jeffrey Hunker	Commerce
Dave Henry	Commerce
Victoria Greenfield	State

Meet with Shackleton

~~Glautier~~

- targets indexed to (1) GNP (2) progress on concentration levels (3) temperature

- fuel prices + tradable permits on power plants (coal)
- int tradability
- domestic tradability

Questions for modelers

- polluting activities migration
- techn. response low in so, high in [illegible]

- one country vs. OECD ~~half of world~~ vs all [illegible]
- gas tax vs. BTU vs carbon vs emissions
- Budget balancing vs. permits or 100% recycling

American Petroleum Institute
1220 L Street Northwest
Washington, D.C. 20005
(202) 682-8545
Fax: (202) 682-8408

Russell O. Jones, Ph.D.
Senior Economist
Policy Analysis and Strategic Planning

WEFA GROUP

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Ford

Alan F. Eisenberg

Economic Analyst
Corporate Economics
Governmental Affairs
PROFS: EISENBER

The American Road
Dearborn, MI 48121
Telephone: 313/322-4420
Fax: 313/248-7615

EV Ehrlich 10/18/96

Models for G.W.

Mining AAA
Southern

GCC

Actos

Al McClarnin CGE
David Gardner

EPA

? DOE

DEF BD FE neutral ?
relative baseline

Base load demand for power from utilities (vs. "peak load")
Retirement of coal plants over next 20 yrs.
nuclear (40 yr. licenses)

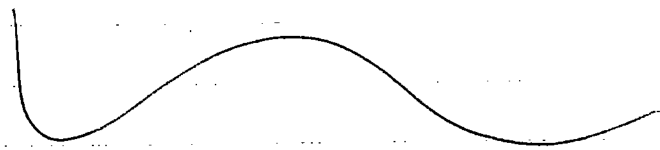
Ev E

UEFA

Trading of SO_2 emission permits. Lessons for GW.
Priming the pump made a big diff.

Heat rate have already been trying to reduce it, to save money

McClarnin on CGEs DOE, via nat. labs. CGEs ~~Rich~~ rich in energy technology
will have putty-clay versions in addition to putty putty.
Need CGEs to capture CR



Shackleton

re Global warming & models

E X E C U T I V E   O F F I C E   O F   T H E   P R E S I D E N T

17-Oct-1996 01:07pm

TO: Jeffrey A. Frankel

FROM: Francine P. Obermiller
Council of Economic Advisers

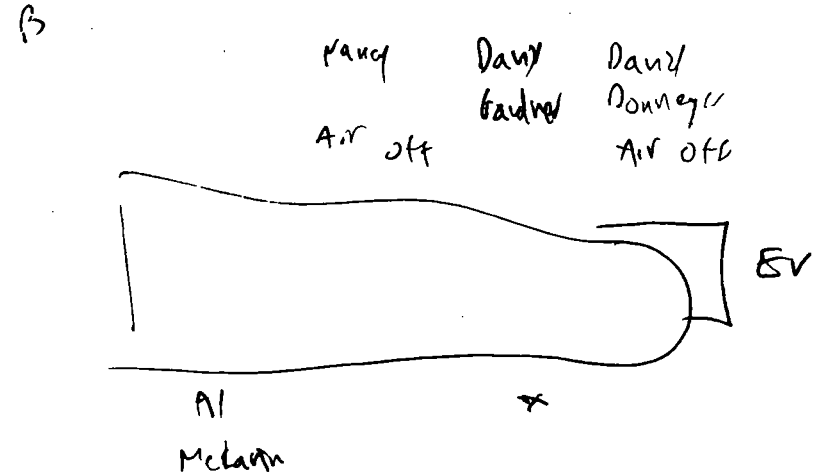
SUBJECT: PH: Roger Brinner #617-860-6661

Caller: Roger Brinner
Of: Work: 617-860-6661
Phoned.

10/29/96

GI CC

Mtg w EE EPA



Michael Shelby on speakerphone

Al McL.

Comfortable with 4 mo

(1) o Marvel Macro + techn.-specifics very detailed

perfectly forward looking — can input a SR + LR elast (+ disc. rate) but don't have to

"backstop techn" supported by Nat. Labs

− but ag manuf. + service sectors + all other

(2) o 2nd gen Battelle SGM CGE

+ worldwide + 20 regions of world + 12 sectors in U.S. of which 8 are energy

Best on expectns, from perfect foresight to static.

+ disagg. households. Allows BD, transfers ... easily

putty clay

− only 12

(3) o G^3 also worldwide McK + Wilcoxen

perfectly forward looking

Like Jorg, but between putty-p + putty-clay. Some limits on K transfer within sectors with small adj. costs

High elast.s

U.S. 12 sectors

Probably will use (1) – (3); not others. except to have many in box a show

o MERGE DOE wants it

less sectors, less regional disag.

Used for "when-flexibility" set up to do it.

e.g. only 2 energy sectors: elec. + non-elec.

o Jorg DGSMs older versn proprietary

GICr

Mon.

EE on world / Emis. Trady

) Z

Targets Desin

Dan T: guidance for US deleg. in Geneva

Possible Discussion Items:
Some Tool-box Issues in Assessing Implications of Climate Change Policies

Too prominent in June exercise,

- **Revenue Recycling:** In evaluating the cost of policies to limit greenhouse gas emissions (GHG), how should the large amounts of revenue generated by GHG taxes or tradable permits be handled in the models? How would the domestic implications of international transfers under an international tradable permits scheme be addressed?

- **Energy Sector Expectations:** What is the role of expectations in energy sector decision making, especially with respect to continued operation of existing physical capital and investment in new or replacement capital? What are the potential magnitudes of disinvestment/investment under carbon limitation scenarios, and what are the macroeconomic implications? Are there historical events which would provide some insight?

- **Technology Assumptions:** What technology assumptions are in the base case? How might technology research, development and diffusion change under a carbon tax or tradeable permits scenario? What other factors might effect technology innovation patterns?

- **Money Supply, Trade, and Foreign Exchange:** What explicit assumptions need to be made concerning the modeling of money supply (Federal Reserve responses), trade, and foreign exchange in assessing carbon taxes or tradeable permit mechanisms?

- **Potential GDP:** What are the key factors determining future economic activity and how should these be handled within models?

- **Energy Price Impacts:** How are changes in energy prices induced by carbon limitation policies introduced within models, and is this modeling approach reasonable?

- **Transition Costs in CGE Modeling:** What modeling efforts are needed to identify and estimate transition costs not identified in computable general equilibrium modeling?

- **Compliance and Enforcement:** Under a tradable permits scheme, how is monitoring, compliance, and enforcement achieved, compared to costless implementation assumed in models, and what are the modeling and policy implications?

ecf1.doc

Jorgenson

SR Macro

L. Meyer model   DRI model

Even CBO, Commerce etc. don't use these to forecast more than 2 yrs. out

CGE

Shoven-Whalley   Robinson

Ray: mkt-clearing

focus on relative prices, but no believable story about LR

Neoclassical growth
Cass-Koopmans. Optimizing consumers

e.g. Auerbach-Kotlikoff

3 categories of questions

(1) Big picture

Nordhaus 13 eq.
behavioral s

(2) uncertain RPF sizer

Different regions

Regionalized version of Nordhaus
- RICE
- MERGE   had DOE
- G3   had EPA

Ray: low cost & high elast.

Jorgenson
has detail on sectors
of U.S. economy

Manne & Richels

Wilcoxen & McKibbin replicate Jorg. for 8 regns,
macro is MSG

detail about trade

Bottoms-up

Japan is most costly
energy taxes already high + capital, so e high, so already very efficient.

(3) impact on policy
implement by
carbon tax
tradeable permits

CO_2 turns out to be a coal tax, which Clinton met first (before BTU tax). But Byrd said no.
Moved to BTU
Sub. high % increase for resi?

Ranking (1) Carbon tax (2) BTU tax (3) ad valorem energy tax about half as efficient

Don't just care about 2020
intertemp linkages:
(1) I
(2) asset pricing link
(3) intertemp allocation of C

Disaggregation

How large fits on 486
not putty clay
Fixed coeff. CGE, DRI
Jorgenson

induced techn. ch in 35 sectors depends on rel. prices

LBL Berkeley next yr initiate program to incorporate "bottoms up" approach into DJ model.
In July 1997

Optimal environmental policy would tax coal heavily (NOx, particulates...) even aside from global warming
Pigouvian taxes (tho very uncertainty, because externalities measured by Viscusi based on EPA internal documents.
(20-50% of mitigation costs
Tax $10–$100 (out of $20 p) ton coal.

Hotelling effect: tax effects p but not

policies { command & control
J Have done { tax policy
{ Tradeable permit

How long take? ½ hr.
Easy to modify? yes
in house will be a version 6/30/97 at LBL
& many in govt. are familiar with it.

Bottoms up
existing techn. only
takes into account lower P from reduced D
"Rebound effect" ruled out (real income)

Joe does want to meet
with ~~them~~ Dale Jorgenson.

So, Jorgenson will be
talking to ~~the~~
~~whole~~ group.

Big picture Bill Nordhaus
MIT Press

Solow model
Cass-Koopmans
MIT alt version

"integrated assessment" physics + econ

SP

Nordhaus EPA
now DOE

Viscusi for EPA interactions

MEMORANDUM

COUNCIL OF ECONOMIC ADVISERS

Oct 17, 1996

TO: JOE STIGLITZ, ALICIA MUNNELL, JEFF FRANKEL

FROM: RAY PRINCE

SUBJECT: Jorgenson model

Attached are pages from three papers where the results from Jorgenson's model have been reported. The first table shows that the Jorgenson model (DGEM) estimates of the carbon tax needed to meet any given emissions target are lower than most. (For example, $25-30 for stabilizing at 1990 levels by 2010 compared to an average of $75-100).

The other pages demonstrate that despite the lower tax, the story that comes from Jorgensen's model is compatible with the story from other models: that the cost of climate change policies could be much lower if revenues from a tax are used to reduce corporate income taxes or provide an investment tax credit. I do not know if he has analyzed a scenario where permits are distributed by some allocation formula, but others who have tell a similar story, i.e. the costs are lower if the permits are given to companies.

These results from Jorgensen's and other models represent a potential dilemma since there exists a fairly strong sentiment in some quarters to recycle any revenues toward consumers. So far, the arguments made to support a distribution toward consumers are based on a very limited static welfare analysis plus an assumption that rates of diffusion will increase.

In any case, two questions that would be helpful to rais with Jorgenson are (1) why his estimates of the carbon tax needed to attain a given target are generally below those of most other models, and (2) to what extent he thinks the impacts of reducing corporation taxes versus deficit reduction or reducing personal income tax rely on an assumption of perfect capital mobility.

c: M. Mazur

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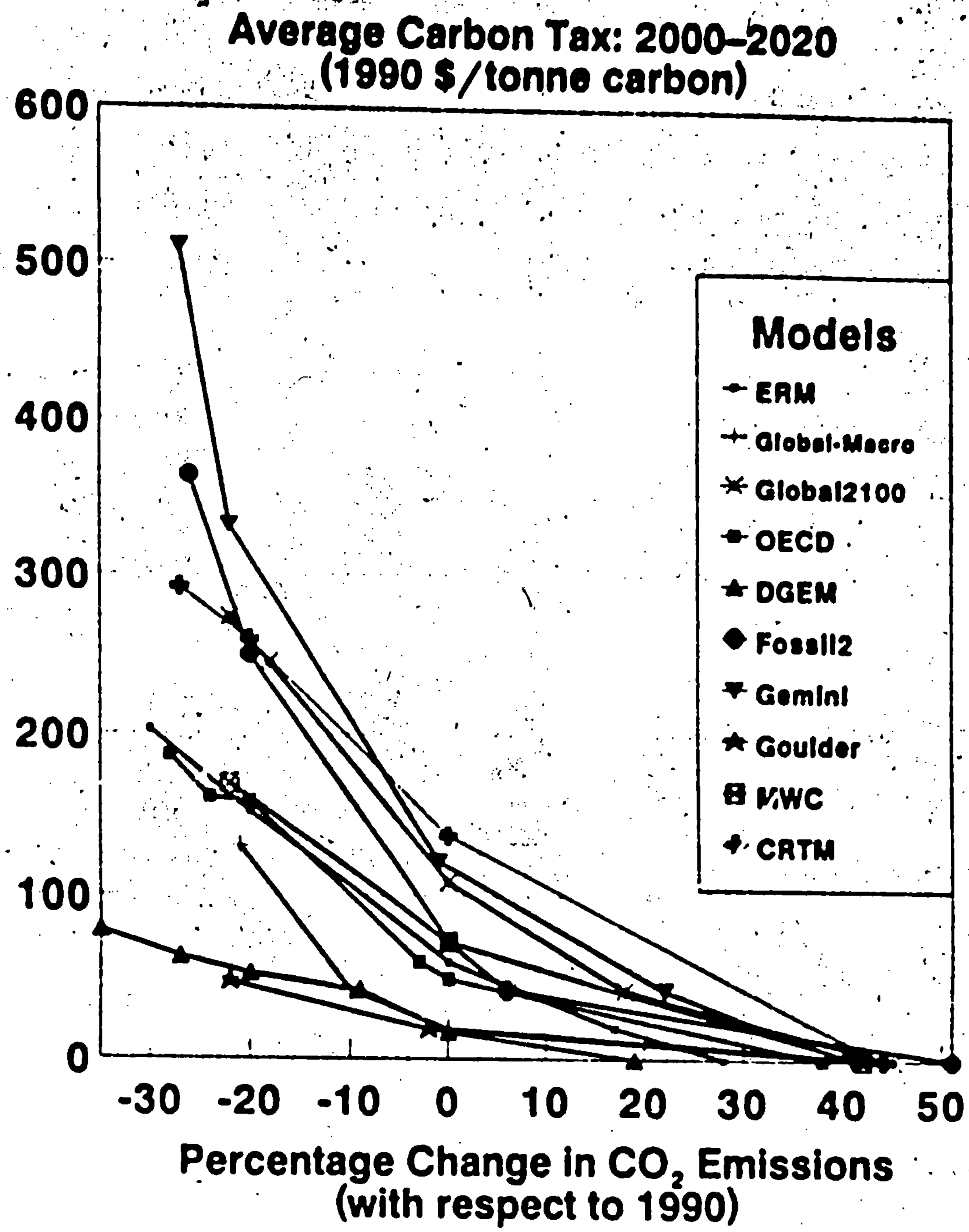

FIGURE 1. CARBON TAXES REQUIRED TO ACHIEVE CARBON-EMISSION REDUCTIONS IN THE UNITED STATES IN 2020

ENERGY EXTERNALITIES, SOCIAL COST PRICING AND TAX RECYCLING

Prepared by:

Dale W. Jorgenson
Richard J. Goettle and Daniel E. Gaynor
Peter J. Wilcoxen and Daniel T. Slesnick

Prepared for presentation at:

The Climate Change Analysis Workshop
Hosted by the U.S. Departments of
Agriculture, Commerce, Energy and State
and the U.S. Environmental Protection Agency
The Springfield Hilton
Springfield, Virginia

6-7 June 1996

1. Introduction

This analysis examines the environmental and economic consequences of using the U.S. tax system to internalize the externalities associated with energy production and use. The methodology employs the Jorgenson-Wilcoxen-Slesnick (JWS) inter-temporal general equilibrium model. For energy externalities, damage estimates are developed from published sources. The effects of these are measured by comparing simulations of the economy over the interval, 1995-2100. In these simulations, selected tax and tariff rates are varied and the resultant solution paths are compared to those from a base or reference case.

The tax changes considered herein necessarily entail increased government revenues, the disposition of which is of central importance to the adjustments that follow such actions. Five revenue recycling alternatives are examined. The first involves reducing the *average* tax rate on labor income. This represents a vertical shift in the labor-income-tax schedule or, equivalently, a reduction in the "zero" bracket rate on labor income. Its use essentially replaces a lump-sum tax with increased taxes on energy. The second alternative reduces the *marginal* tax rate on labor income. The third alternative proportionally lowers sales tax rates on all non-energy purchases. The fourth and fifth alternatives focus on capital formation by proportionally reducing all tax rates on capital income in the one case and all property tax rates in the other. These last four options replace one set of distorting taxes with another.

The remainder of this paper is organized as follows. Section 2 documents the externality assumptions and the resulting energy taxes and tariffs adopted for analysis. Sections 3, 4 and 5 present the major findings for the environment, the economy, and household and social equity, respectively.

Table 12
Selected Macroeconomic Results

Average percent change from base, 1995-2100

Combined High	Tax Option	Real GDP	Consumption	Investment
	Property	-0.34	+0.08	+4.38
	Capital	-0.67	-0.17	+3.67
	Average Labor	-7.23	-5.25	-9.68
	Non-energy Sales	-3.01	-2.33	-4.79
	Marginal Labor	-0.41	+0.00	-3.58

Combined Alternate High	Tax Option	Real GDP	Consumption	Investment
	Property	+0.07	+0.45	+4.67
	Capital	-0.24	+0.21	+3.99
	Average Labor	-6.30	-4.47	-8.45
	Non-energy Sales	-2.49	-1.78	-3.90
	Marginal Labor	-0.06	+0.33	-2.80

Combined Medium	Tax Option	Real GDP	Consumption	Investment
	Property	+0.31	+0.66	+3.91
	Capital	+0.06	+0.48	+3.36
	Average Labor	-4.97	-3.38	-7.08
	Non-energy Sales	-1.83	-1.17	-3.30
	Marginal Labor	+0.10	+0.52	-2.46

Combined Low	Tax Option	Real GDP	Consumption	Investment
	Property	+0.30	+0.39	+1.20
	Capital	+0.24	+0.35	+1.08
	Average Labor	-1.00	-0.60	-1.52
	Non-energy Sales	-0.21	-0.05	-0.56
	Marginal Labor	+0.22	+0.34	-0.38

Table 14
Selected Industry Output Effects

Percent change from base, end-point average 1995&2100

Combined High	Property Tax	Capital Tax	Average Labor Tax	Non-energy Sales Tax	Marginal Labor Tax
Agriculture	7.6	7.5	5.3	16.5	10.4
Metal mining	-6.6	-7.0	-15.3	-1.1	-10.1
Coal mining	-88.8	-88.9	-89.4	-89.2	-88.8
Oil, gas	-26.3	-26.4	-28.1	-26.8	-25.6
Non-fuel mining	-7.0	-7.3	-14.2	-4.6	-8.4
Construction	-0.4	-0.9	-11.0	-4.5	-3.4
Food	13.7	13.7	14.4	24.5	20.3
Tobacco	14.2	14.1	11.8	21.6	16.6
Textiles	-5.1	-5.3	-8.8	4.6	-2.4
Apparel	-12.0	-11.9	-8.5	-3.5	-2.6
Lumber	-30.2	-30.5	-37.6	-32.5	-32.2
Furn, fixtures	-9.5	-10.1	-21.7	-15.5	-14.8
Paper	-6.2	-6.3	-9.0	1.2	-2.7
Print, publish	1.5	1.4	-1.0	8.1	6.5
Chemicals	-11.7	-11.9	-14.8	-5.2	-9.0
Petroleum	-42.5	-42.6	-43.9	-43.3	-42.2
Rubber, plastics	-7.0	-7.3	-13.5	-0.5	-5.5
Leather	-12.1	-12.0	-10.2	-4.4	-2.6
Stone, clay, glass	-7.4	-7.8	-16.2	-7.2	-9.0
Primary metals	-4.3	-4.7	-12.7	2.0	-5.6
Fabricated metals	2.8	2.5	-5.8	5.5	2.2
Non-elec mach	0.6	0.1	-10.5	0.8	-2.4
Electric equip	1.9	1.4	-8.8	0.5	-0.4
Motor vehicles	2.7	2.1	-10.4	0.7	-3.1
Other trans eqp	-1.6	-1.9	-7.9	1.6	0.9
Instruments	3.1	2.6	-7.3	1.2	0.8
Misc mfg	-1.6	-1.8	-8.3	-1.3	-1.2
Transportation	-4.7	-4.8	-7.7	-1.1	-1.9
Communications	5.7	5.5	0.6	8.0	7.0
Electric services	-52.8	-52.8	-54.3	-53.6	-52.1
Gas services	-45.0	-45.1	-46.8	-45.4	-45.1
Trade	1.7	1.6	-1.9	2.9	4.6
F, I, RE	3.5	3.4	0.7	6.9	7.8
Services	1.2	1.2	1.2	6.6	9.4
Gov't enterprises	-1.2	-1.4	-3.9	3.7	2.9

The Efficiency Value of Carbon Tax Revenues

By Robert Shackleton, Michael Shelby, Alex Cristofaro, Roger Brinner, Joyce Yanchar, Lawrence Goulder, Dale Jorgenson, Peter Wilcoxen, Peter Pauly and Robert Kaufmann

Carbon tax $15 in 1990
rising to $39.80 in 2010

The views expressed in this paper are those of the authors and do not represent the views of the U.S. Environmental Protection Agency.

Draft November 5, 1992

Comments welcome. Please send comments to

Robert Shackleton
U.S. Environmental Protection Agency
PM-221, Room 3220-I
401 M St., S.W.
Washington, D.C. 20460
Tel. (202) 260-8958
Fax (202) 260-6405 or 260-0512

Moreover, in the macro models, the same mechanisms yield the greatest gains in terms consumption. In the general equilibrium models, however, the results are somewhat m ambiguous. In the Goulder model, the consumption loss over the period 1990-2010 is minimi through personal income and payroll tax cuts; while in the Jorgenson-Wilcoxen mo consumption rises more if carbon taxes are recycled through labor tax cuts.

GNP Loss, 1990-2010
(Percentage of discounted constant price GNP)

	DRI	LINK	J/W	Goulder
Lump Sum Tax Cuts	-0.58%	-0.46%	-0.62%	-0.24%
Revenue Raising (Deficit Reduction)	-0.40%	-1.02%		-0.24%
Personal Income Tax Cuts	-0.56%	-0.53%	-0.16%	-0.16%
Corporate Income Tax Cuts	0.40%	-0.11%	0.60%	-0.17%
Payroll Tax Cuts				-0.18%
(Employee Only)	-0.58%	-0.53%		
(Employer Only)	0.19%	-0.25%		
Investment Tax Credit	1.55%	1.67%		0.00%

Consumption Loss, 1990-2010
(Percentage of discounted constant price consumption)

	DRI	LINK	J/W	Goulder
Lump Sum Tax Cuts	-0.39%	-0.46%	-0.32%	-0.18%
Revenue Raising	-0.75%	-0.87%		-0.18%
Personal Income Tax Cuts	-0.39%	-0.51%	0.29%	-0.12%
Corporate Income Tax Cuts	-0.16%	-0.10%	0.17%	-0.17%
Payroll Tax Cuts				-0.10%
(Employee Only)	-0.39%	-0.51%		
(Employer Only)	0.17%	-0.25%		
Investment Tax Credit	0.40%	1.41%		-0.16%

Welfare Loss

	J/W Welfare	J/W Social Welfare[20]	Goulder Welfare
Lump Sum Tax Cuts	-0.83%	-0.94 to -0.70%	-0.44%
Revenue Raising			-0.44%
Personal Income Tax Cuts	1.01%	0.48 to 0.33%	-0.39%
Corporate Income Tax Cuts	0.19%	-0.06 to -0.08%	-0.36%
Payroll Tax Cuts			-0.39%
Investment Tax Credit			-0.27%

The welfare changes shown in the last table are more ambiguous. The results fron Goulder model are similar to those from the macro models: the welfare losses associated w carbon tax clearly are minimized through an investment tax cut. However, the results fron Jorgenson-Wilcoxen model imply that the welfare loss is minimized (or rather, the welfare ga maximized) through labor tax cuts. The results differ mainly because of the difference in cons model. In terms of foregone GNP, the cost varies from about 1.0% of the discounted stream of GNP to -1.7% of GNP. That is, at worst the carbon tax lowers GNP by 1.0% percent, and in the best case GNP is raised by 1.6%. In terms of foregone consumption, the cost varies from about 0.9% of the discounted stream of GNP to -1.4% of GNP. With only two exceptions, the consumption cost of a particular option is lower than the GNP cost.

GNP Cost per Metric Tonne of Carbon, 1990-2010
(Constant 1990 dollars)

	DRI	LINK	J/W	Goulder
Lump Sum Tax Cuts	750.53	1,527.11	191.72	51.41
Revenue Raising	502.64	1,590.78		51.41
Personal Income Tax Cuts	730.64	1,622.97	50.30	35.05
Corporate Income Tax Cuts	-600.72	479.00	-191.75	35.99
Payroll Tax Cuts				38.30
(Employee Only)	762.78	1,622.97		
(Employer Only)	-326.11	1,138.22		
Investment Tax Credit	-3,395.61	-400,816.58		-0.75

Consumption Cost per Metric Tonne of Carbon, 1990-2010
(Constant 1990 dollars)

	DRI	LINK	J/W	Goulder
Lump Sum Tax Cuts	236.51	1,050.80	57.63	21.18
Revenue Raising	437.96	946.87		21.18
Personal Income Tax Cuts	236.73	1,089.59	-52.52	14.14
Corporate Income Tax Cuts	114.77	314.17	-32.25	19.97
Payroll Tax Cuts				11.47
(Employee Only)	237.68	1,089.59		
(Employer Only)	-137.06	788.57		
Investment Tax Credit	-415.71	-234,658.85		19.15

Furthermore, in three of the models some of the scenarios yield a gain in GNP ove baseline along with a reduction in carbon emissions. This implies a negative cost to reducin emissions. In some cases, such as the investment tax credit scenario in the LINK model, the GNI and consumption gains are large relative to the cut in emissions, implying a very large negativ cost for a small reduction in emissions.[21] Even where emissions are cut at the cost of a clear los of GNP, the appropriate measure of costs is not clear cut because both GNP and emissions follov

[21] In preliminary scenarios with one of the models, both GNP and emissions rose; this would imply a positive cost for reducing emissions, but th measure would be meaningless since emissions would not be reduced at all. For a complete description of the social welfare function used in this stud see Jorgenson, Slesnick and Wilcoxen (1992).

Ev E.

How fin. adj.
Sectoral
K stock
tech. prog. + expectns
want allow results to be dominated by deficit reductn

up N June ITC & corp income tax

Have to be in-shop Already at DOE & EIA
others inside on-premises
Fable Claw of Jorgenson

DRI has been used by EIA & DOE. very abused
different sets of results Twisted
Doesn't see using DRI. 3rd set of ms

Predisposed to CGE. but no adj.

Ray P with message to Joe yesterday Joe or me.
EE don't want to be the one running the models. closing a transaction
Hope to be out by winter. EPA - DOE co chairs

2 or 3 best from each dept | AC McGlavin very good | Phil Tseng | Mr techn implementn
Policy | Asst Adm David Gardner Sierra club but reasonable | Actg Asst Sec Policy Eval. Mark Chupka | adm regulatn sectoral detail INT. effects

Talk out strengths & weaknesses
1st wk of Nov

CALL:

ROGER BRINNER (617-860-6661)
TELL HIM THAT JAF HAS THE MATERIALS THAT HE BROUGHT WHEN HE MET WITH ALICIA AND WILL BE READING THEM. BUT, IF HE WILL BE IN WASHINGTON ANYTIME SOON, JAF WOULD LIKE TO MEET WITH HIM TO BE BRIEFED ON HIS MODELS ON GLOBAL CLIMATE CHANGE. (IF HE OFFERS TO COME ESPECIALLY TO SEE JAF, TELL HIM I CAN SET IT UP. THEN CHECK W/JAF TO SEE IF HE WANTS TO TALK TO HIM ON THE PHONE FIRST.

DALE JORGENSEN (HARVARD 617-495-0833/4661)
HE IS PARTICULARLY IMPORTANT SO, IF HE WANTS TO TALK TO JAF, PUT HIM THROUGH.
ASK HIM IF HE IS GOING TO BE IN WASHINGTON ANYTIME SOON. IF SO, COULD HE MAKE A PRSENTATION ON HIS MODEL OF GLOBAL WARMING (TO JAF ONLY) PROBABLY 1 HOUR.

LARRY GOULDER (STANFORD 415-723-3706).
ASK HIM IF HE IS GOING TO BE IN WASHINGTON ANYTIME SOON. IF SO, COULD HE MAKE A PRSENTATION ON HIS MODEL OF GLOBAL WARMING (TO JAF ONLY) PROBABLY 1 HOUR.

Global W

us Some subsidy elemt in U.S.
E.g. coal miners disability pgm.

Energy not priced to reflect environmt
esp. coal (particulates + sulfur)

3rd way Permits (tradable) polluters get them for coal
Eileen Claussen has moved to State
+ Katie
Efficiency
permit onto pre-pay av. utilizn
Rep. 6 parameters

Goulder & Ray Cobb D.C like Jorgenson
not ectrc bigger, ectrcly est
Full flaw intertemporal

Colleague of N at Yale Rob Mendelsohn very good
Forestry ("Env.") serious study
Benefits side
foreshadow.
GlobalW benefit for U.S. corn belt move N wheat belt into Canada
Nordhaus & Mendelsohn

N leaves out uncertainty Bill Cline
RFF Billy Peyser with sophisticated model of uncertainty. optn pricing => delay.
Uncertainty about discount rate
+ growth rate low rates have pos. probability
=> act sooner DJ: worth doubling level of taxes

Set up by A. Jones Fdtn, Charlo Va. very green.
Rich Richels + A. Manne EPRI, Regional.

JEFFREY FRANKEL
315

TRANSMISSION COVER SHEET

OFFICE OF ECONOMIC AFFAIRS

DATE: 3/28/97

TO: F. J. Glauthier

FAX NO. 395-4639

TRANSMITTING 27 PAGES (INCLUDING COVER SHEET)

FROM:

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UNDER SECRETARY FOR ECONOMIC AFFAIRS
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WASHINGTON, D.C. 20230
TELEPHONE NO. (202) 482-3727
FAX NO. (202) 482-0432

RE/COMMENTS:

SGM Results for the IAT

March 24, 1997

Results for the following new runs:

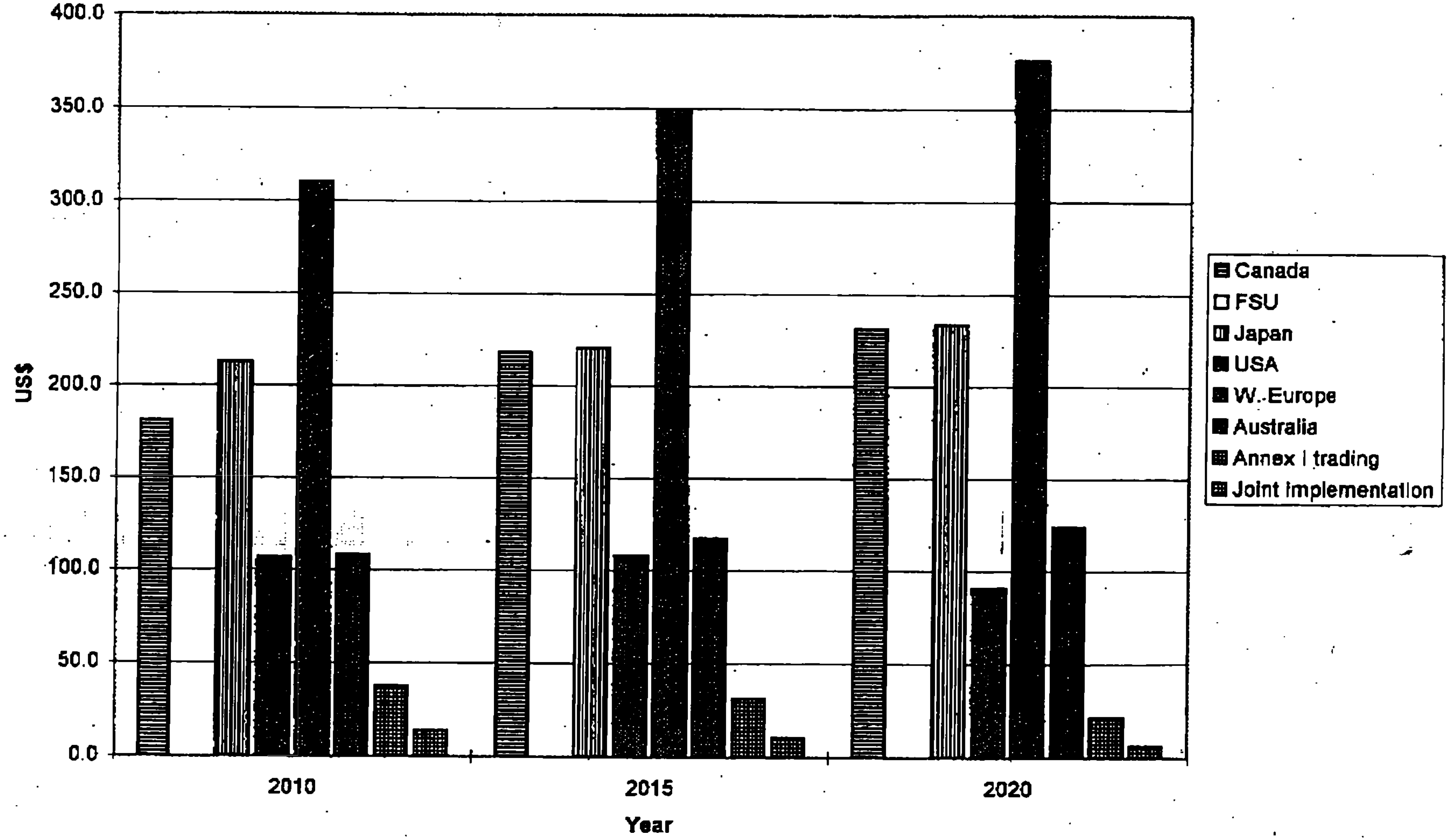
- Annex I Trading and Global JI for Stabilization in 2010 at 1990 Carbon Emission Levels

- Annex I Trading and No Trading for
  - stabilizing at 1990 levels from 2010 to 2030
  - stabilizing at 1990 levels from 2015 to 2030
  - stabilizing at 1990 levels from 2005 to 2030
  - stabilizing at 10% above 1990 levels from 2010 to 2030
  - stabilizing at 10% below 1990 levels from 2010 to 2030
  - stabilizing at 1990 levels from 2010 to 2030 with 10 year ramp

March 20, 1997

DRAFT

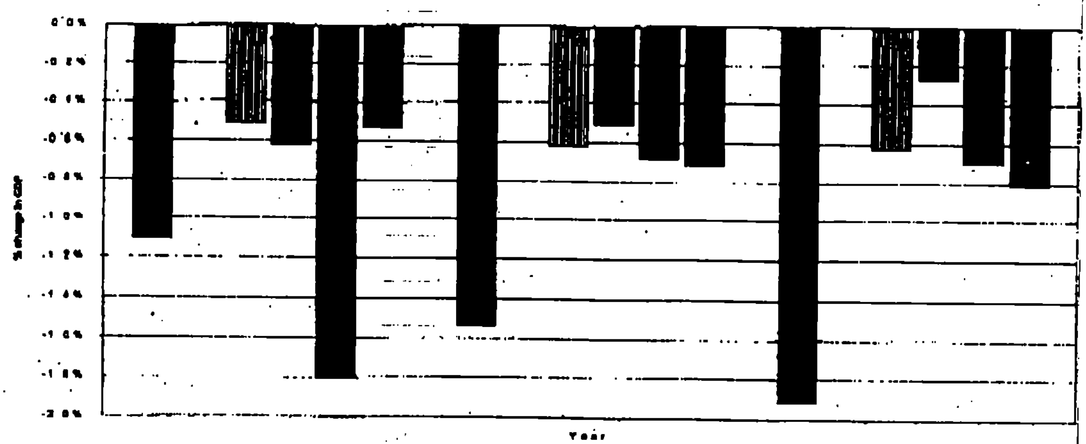
Implied Permit Prices for Stabilization at 1990 Levels without Trading, with Annex I Trading and with Joint Implementation



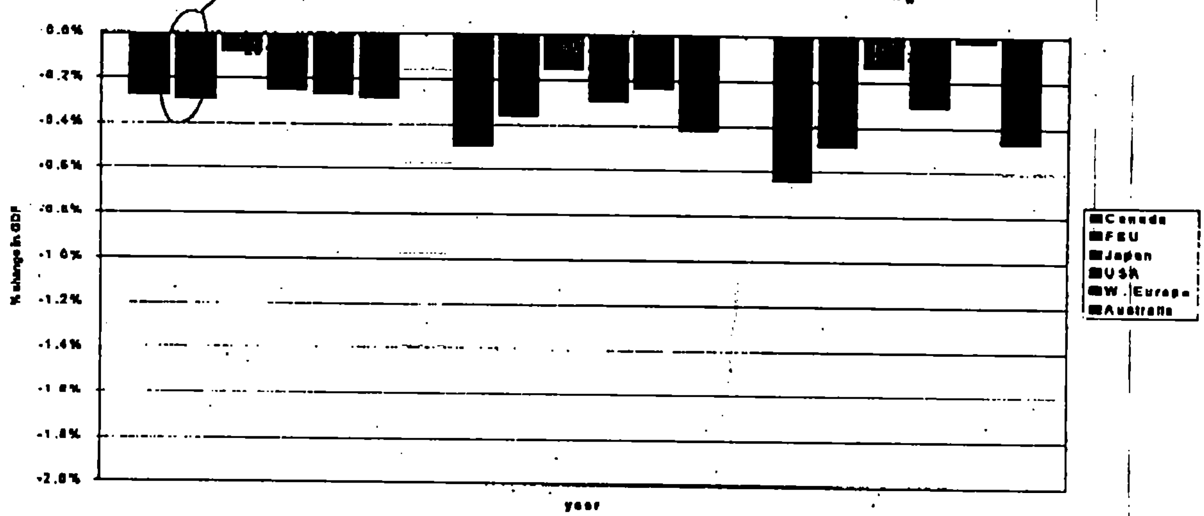
0.75%/yr. additional reduction in C/GDP

FSU carbon emission projections from World Bank, others (Planecon, Hughes, PNL)

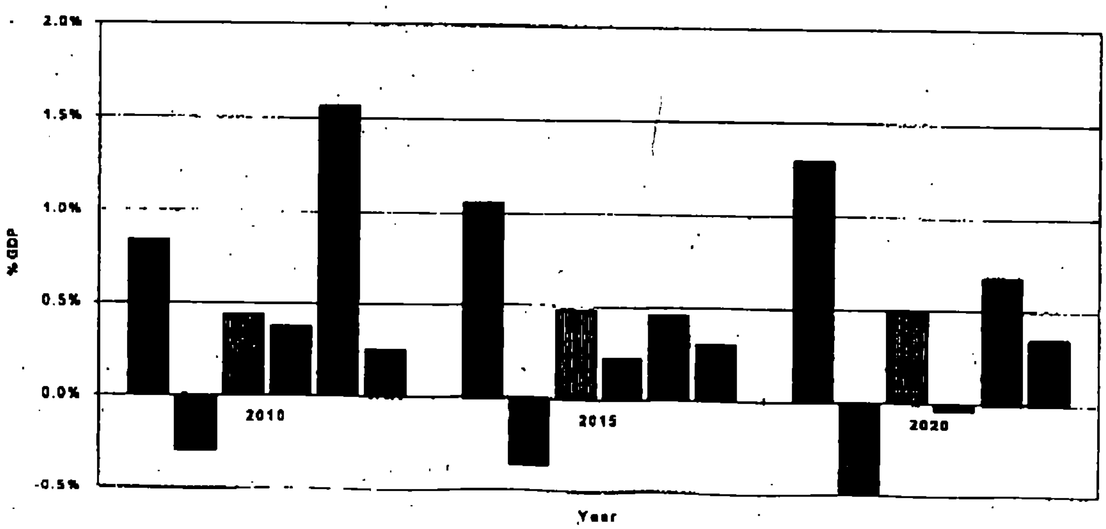
Change in GDP: Stabilizing at 1990 Levels without Trading



Change in GDP: Stabilizing at 1990 levels with Annex I Trading



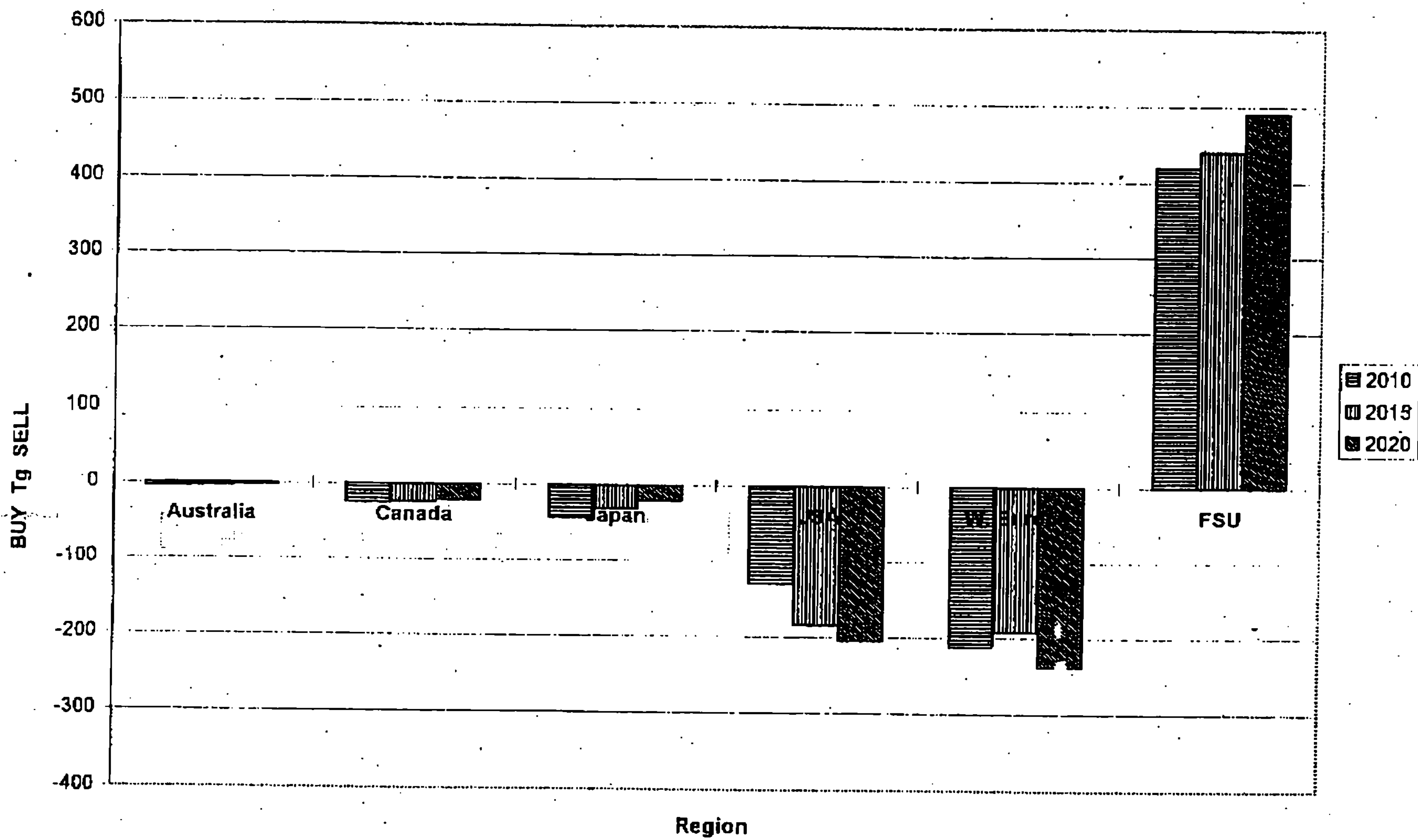
Change in GDP under Annex I trading relative to stabilization without trading



March 20, 1997

DRAFT

Permit Trading Volumes Under Annex I trading



0.75%/yr. additional reduction in C/GDP in Annex I

FSU carbon emission projections from World Bank, others (Planecon, Hughes, PNL)

March 20, 1997

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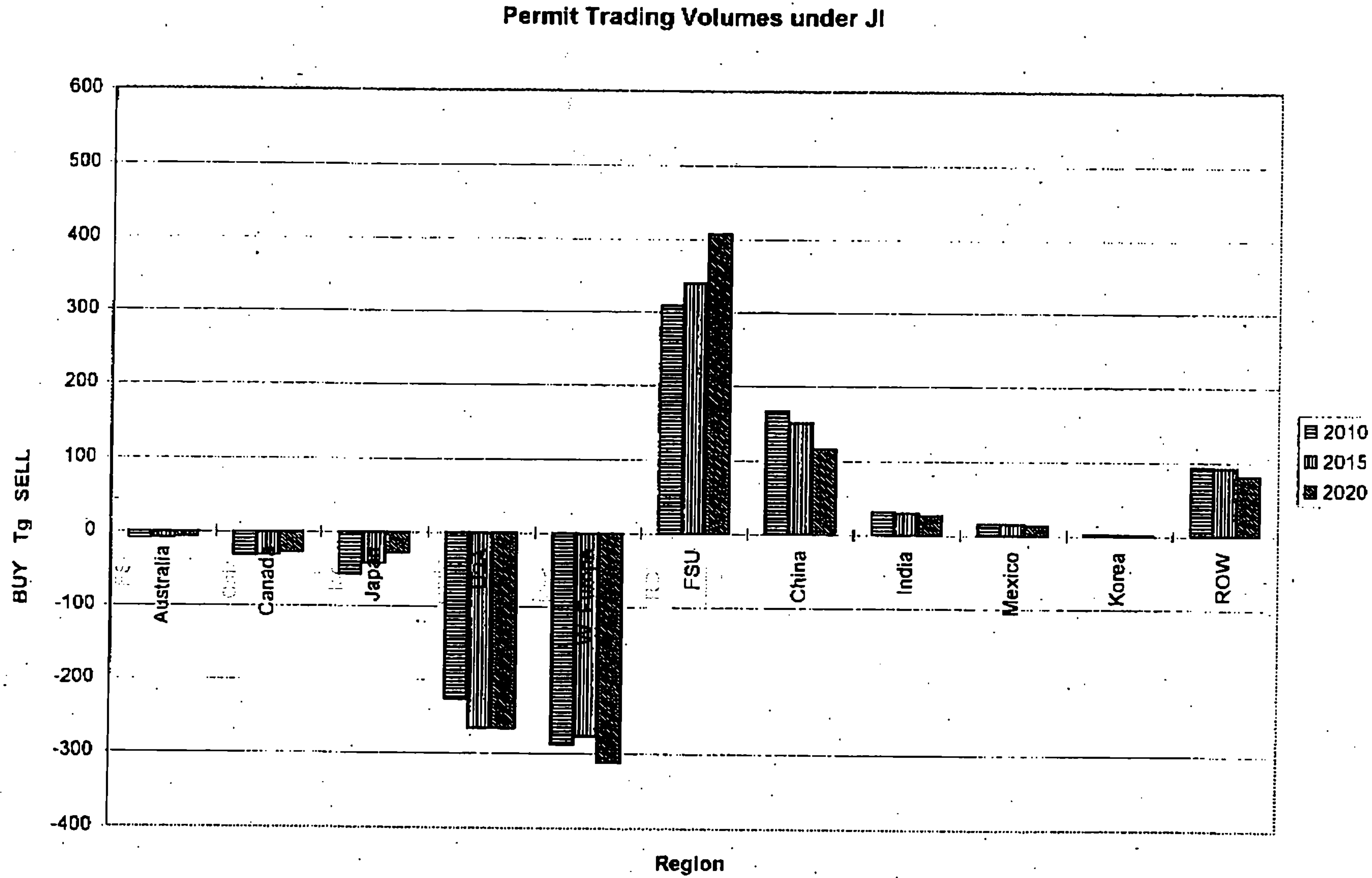

0.75%/yr. additional reduction in C/GDP in Annex I

FSU carbon emission projections from World Bank, others (Planecon, Hughes, PNL)

March 20, 1997

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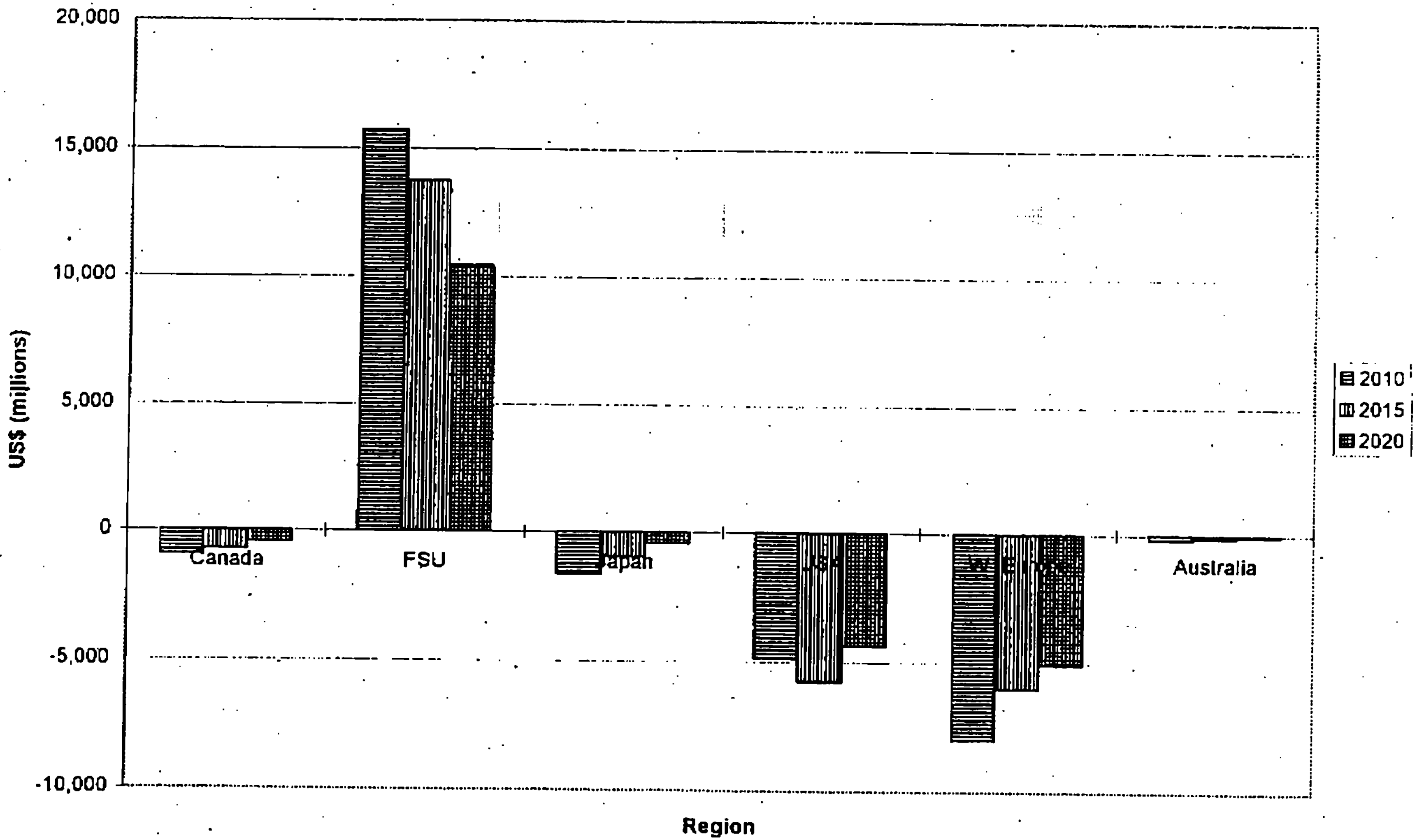
Value of Internationally Traded Permits Under Annex I Trading



.75%/yr. additional reduction in C/GDP

FSU carbon emission projections from World Bank, others (Planecon, Hughes, PNL)

March 20, 1997

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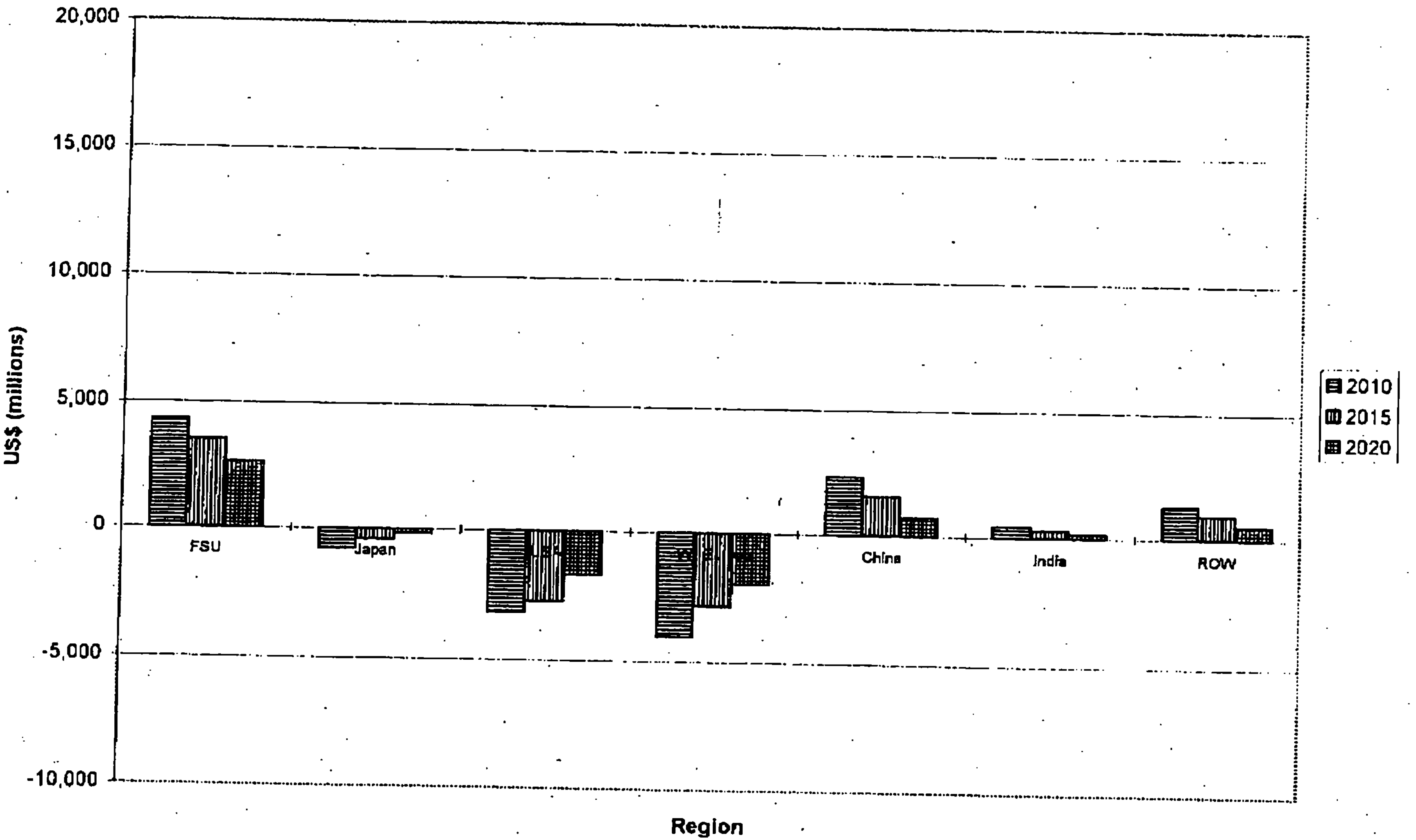
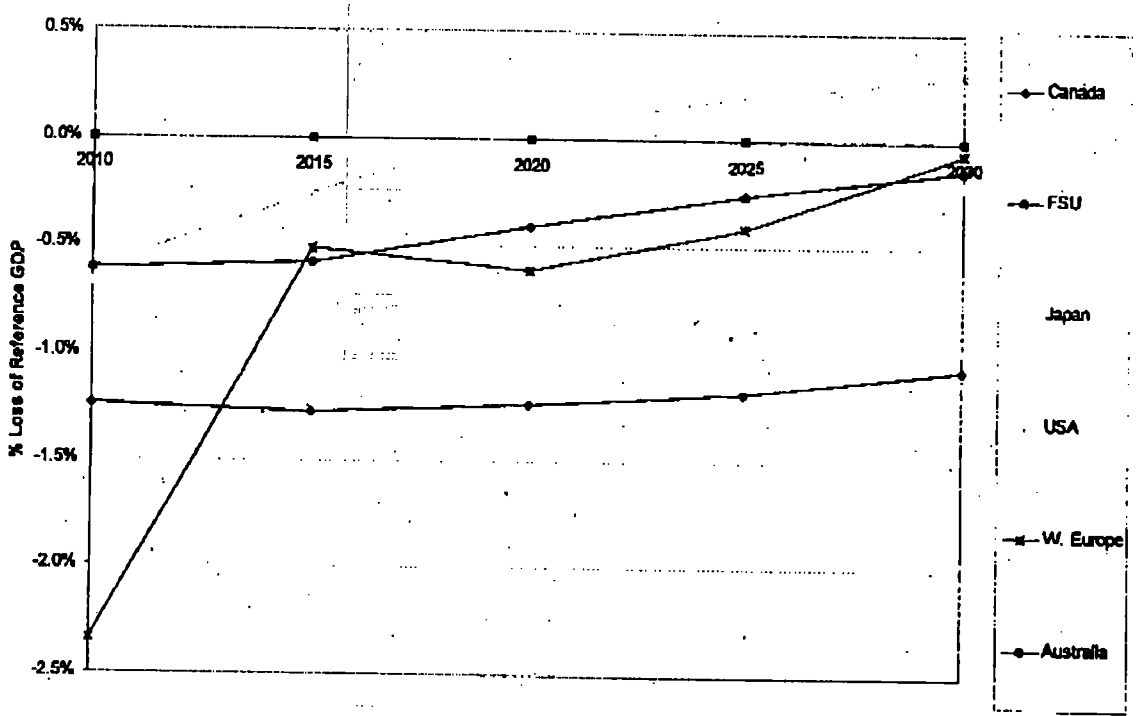
Value of Traded Carbon Permits Under JI



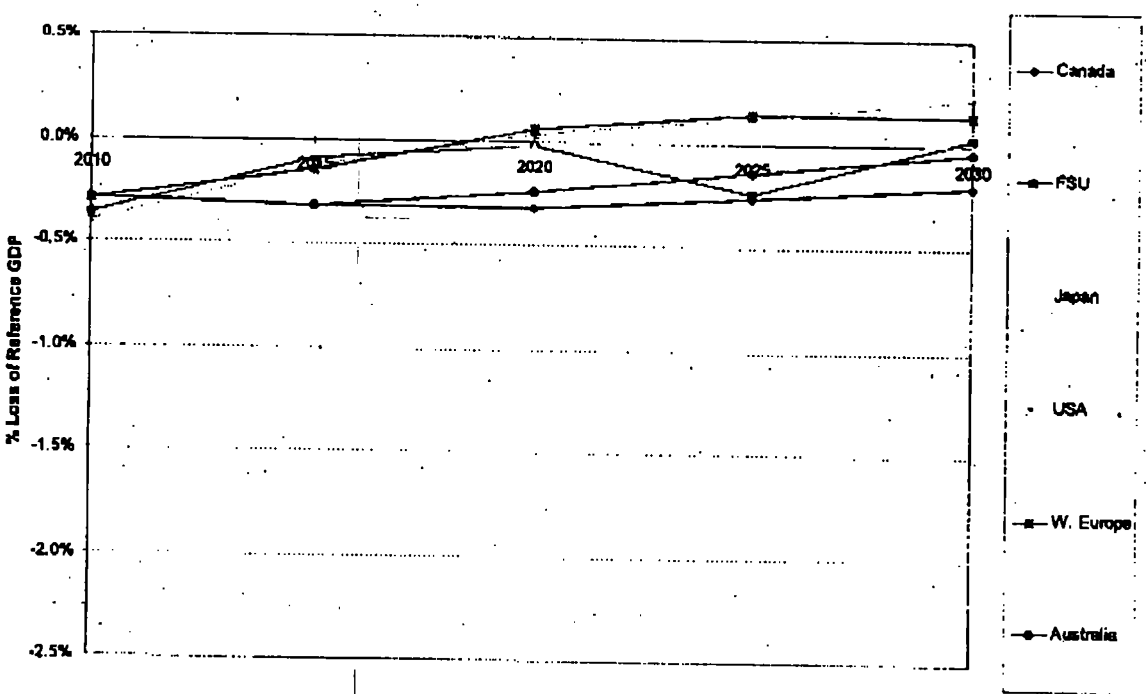
75%/yr. improvement in Annex I C/GDP
orea, Australia, Canada and Mexico not shown

FSU carbon emission projections from World Bank, others (Planecon, Hughes, PNL)

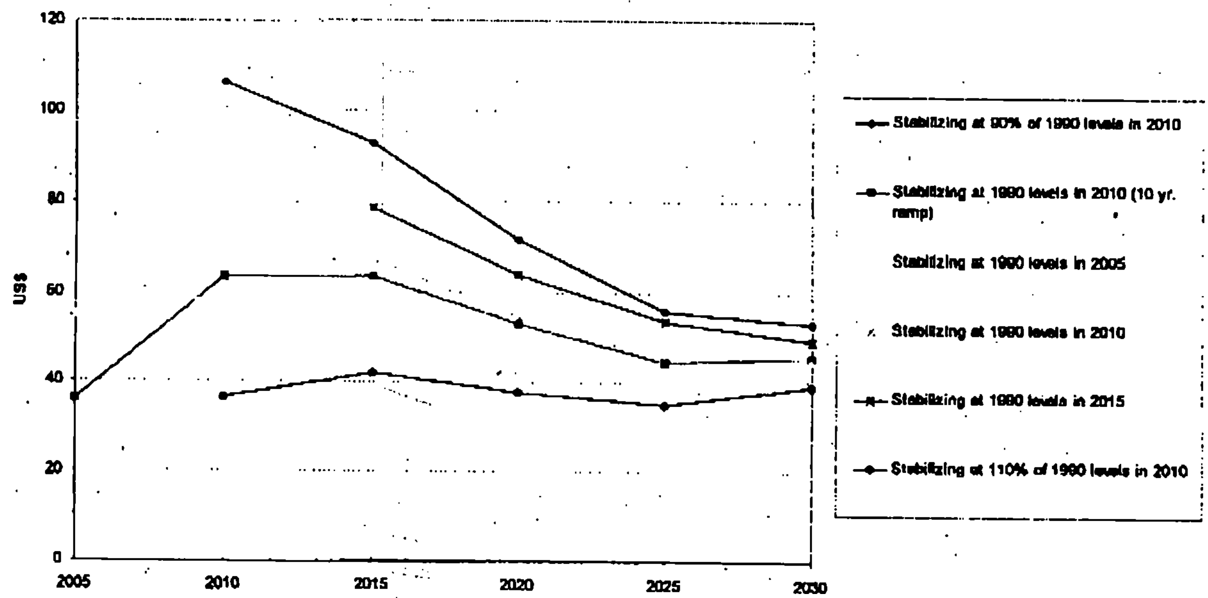
GDP Impacts of Stabilizing at 10% Below 1990 Levels in 2010
(no trading)



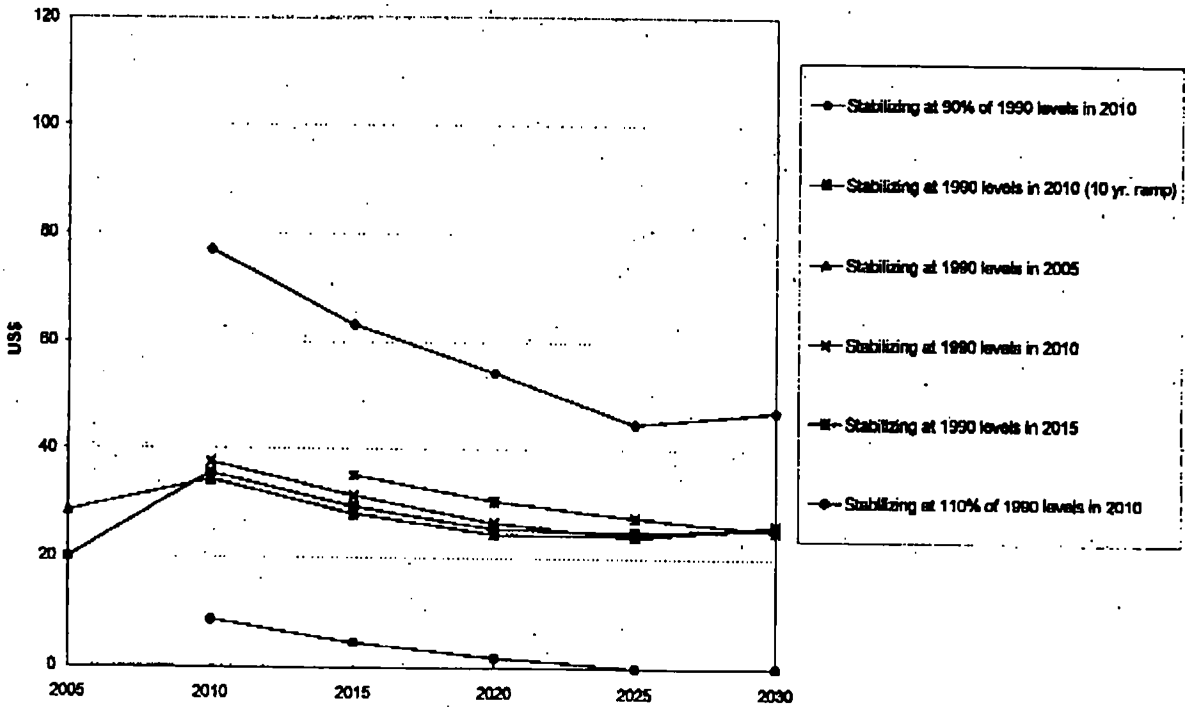
GDP Impacts of Stabilizing at 10% Below 1990 Levels in 2010
(with Annex I trading)



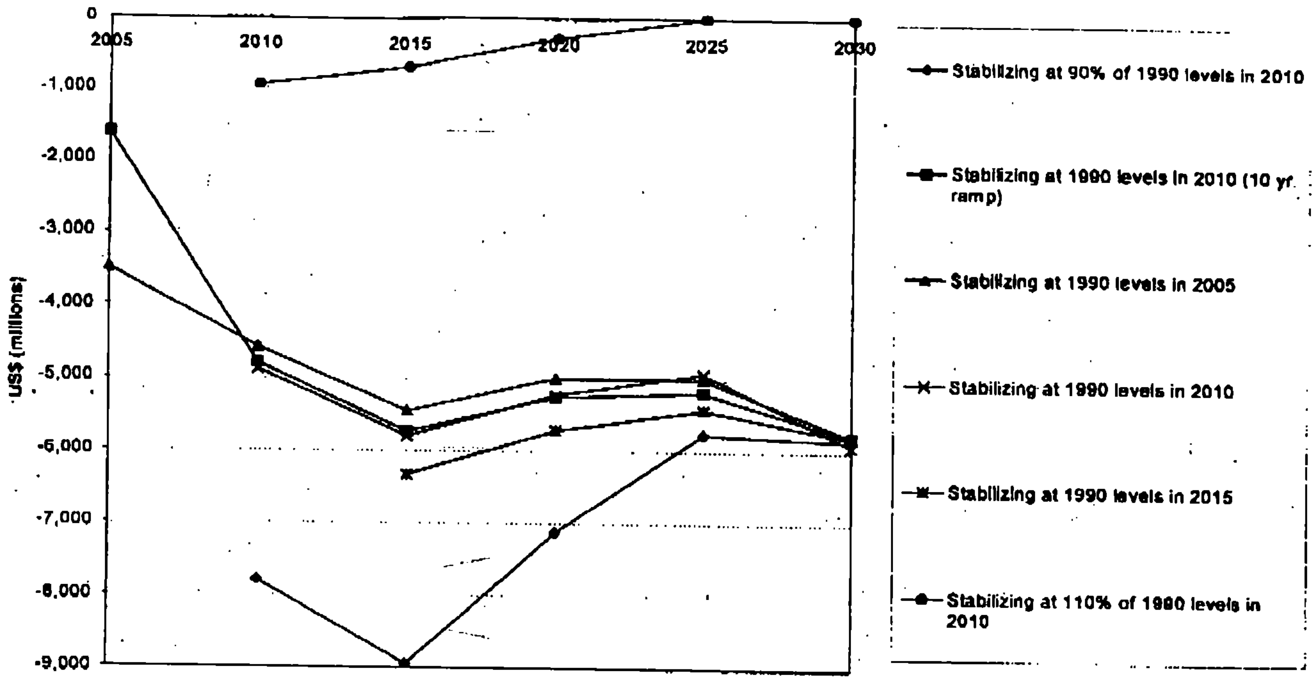
US Permit Prices for Various Targets and Timetables (no international trading)



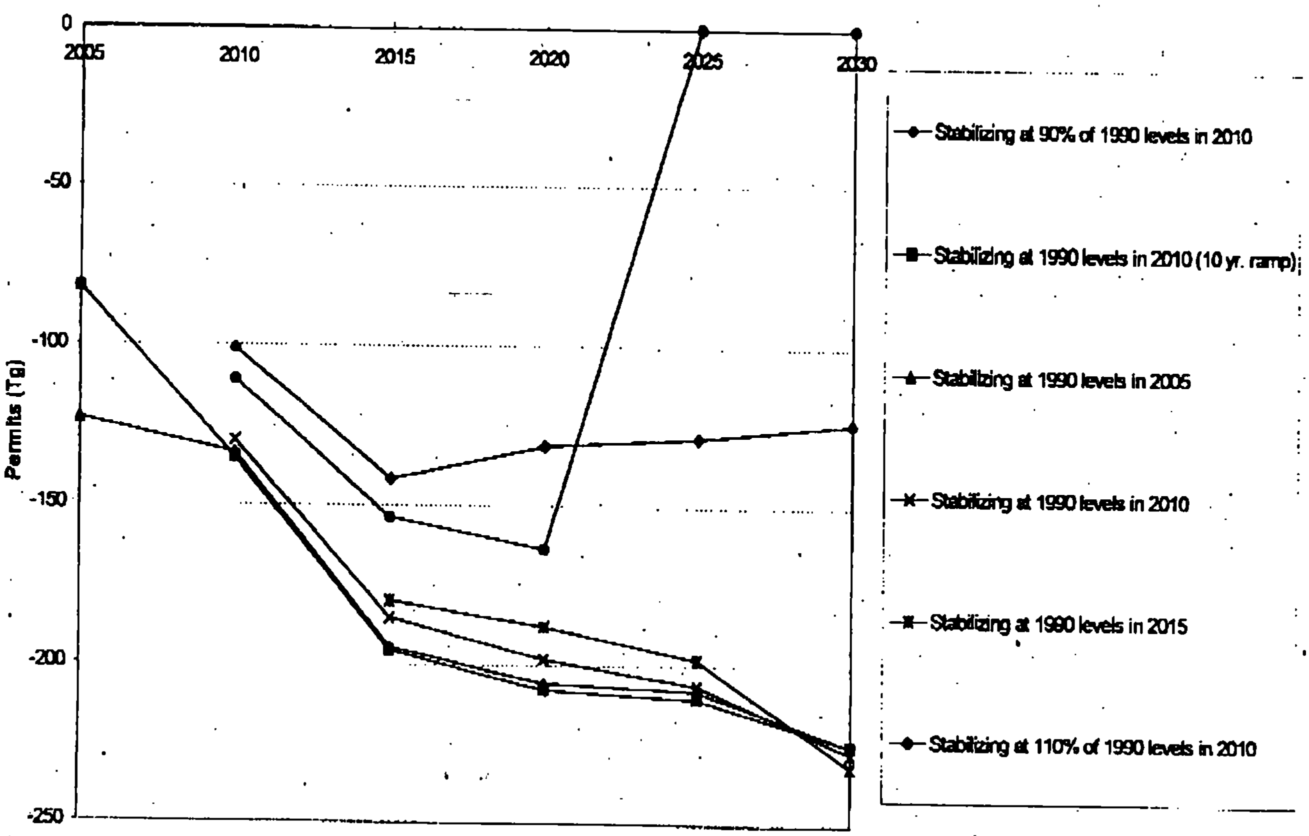
Annex I Trading Permit Prices for Various Targets and Timetables



US Expenditures on Permits under Various Targets and Timetables



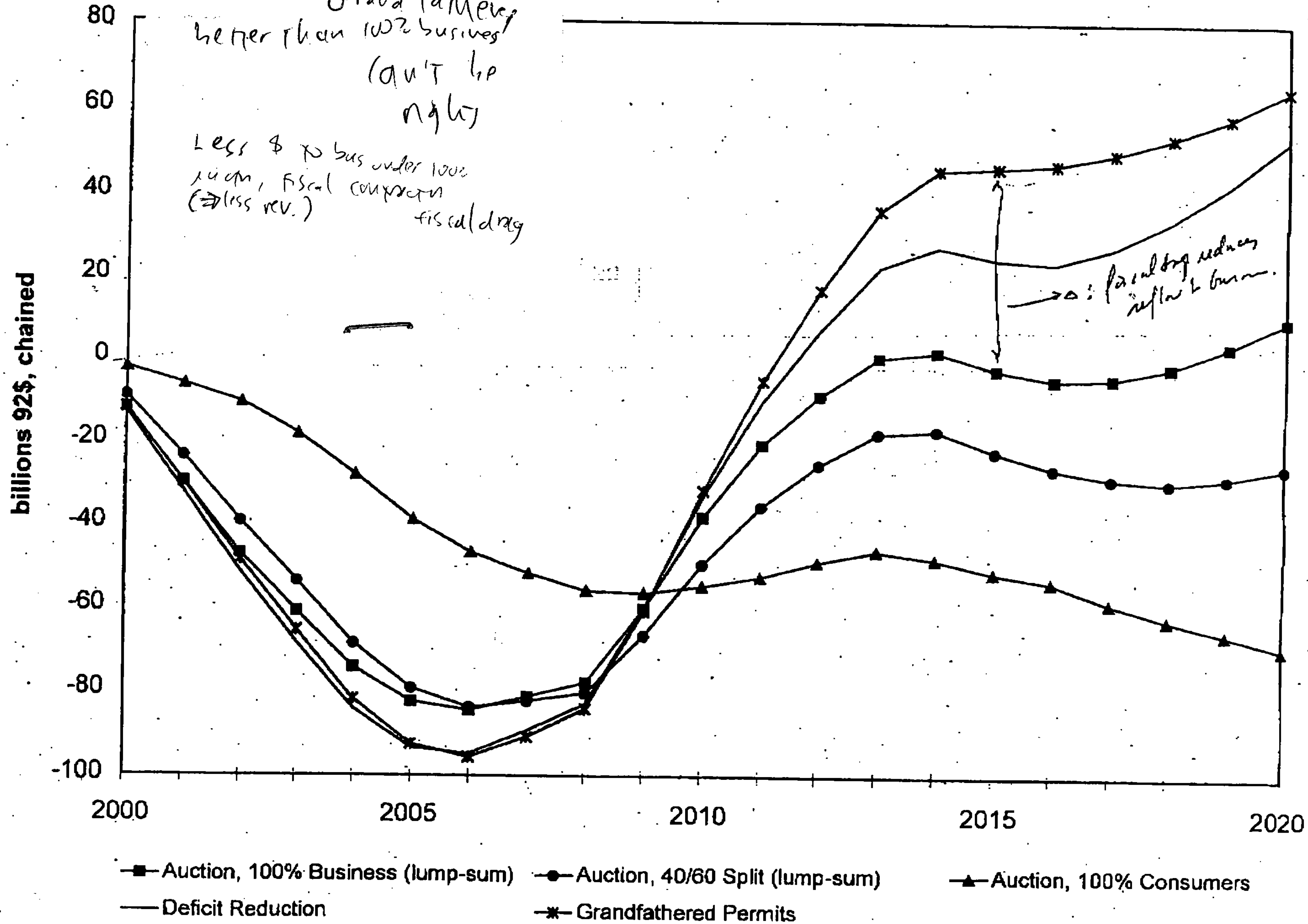
US "Imports" of Permits under Various Targets and Timetables



3 2nd DRI comfort

GDP, Change from Base

(billions 92$, chained)



Grandfathering better than 100% business can't be right

Less $ to bus under 100% auction, fiscal contraction (⇒ less rev.) fiscal drag

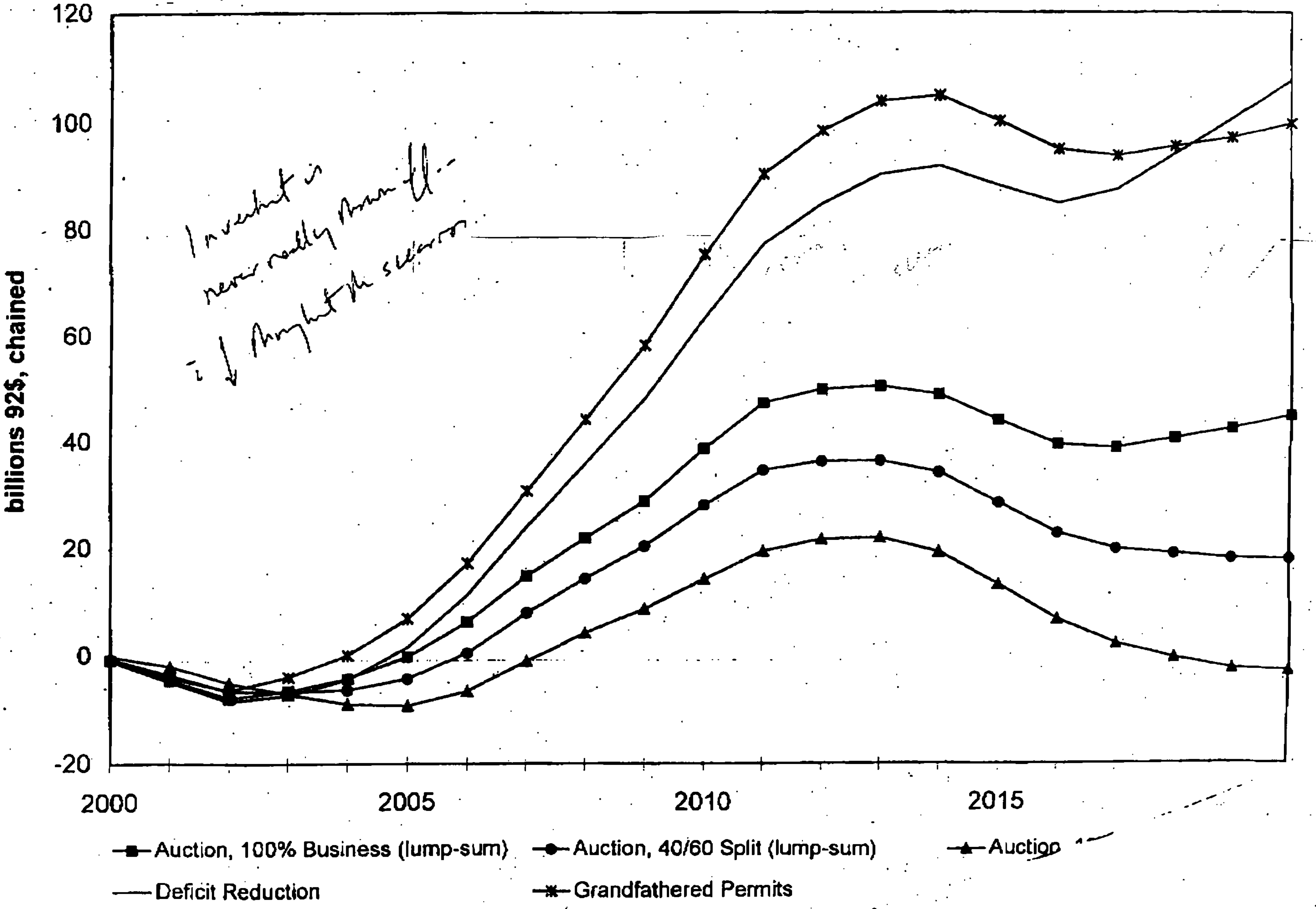
→ Δ: fiscal drag reduces inflow to bus.

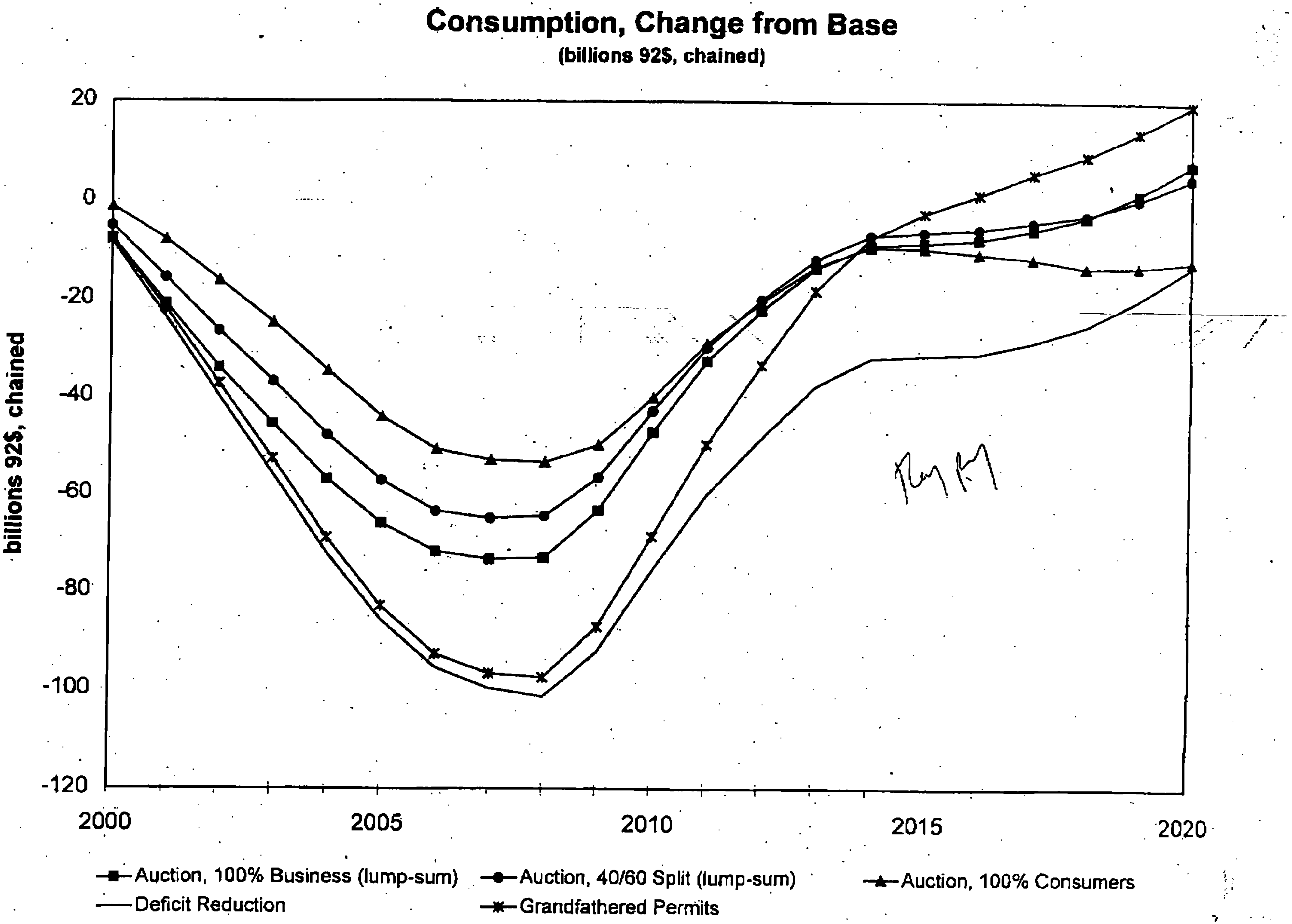
03/25/97 TUE 15:56 FAX 202 482 0432 ESA

1.25

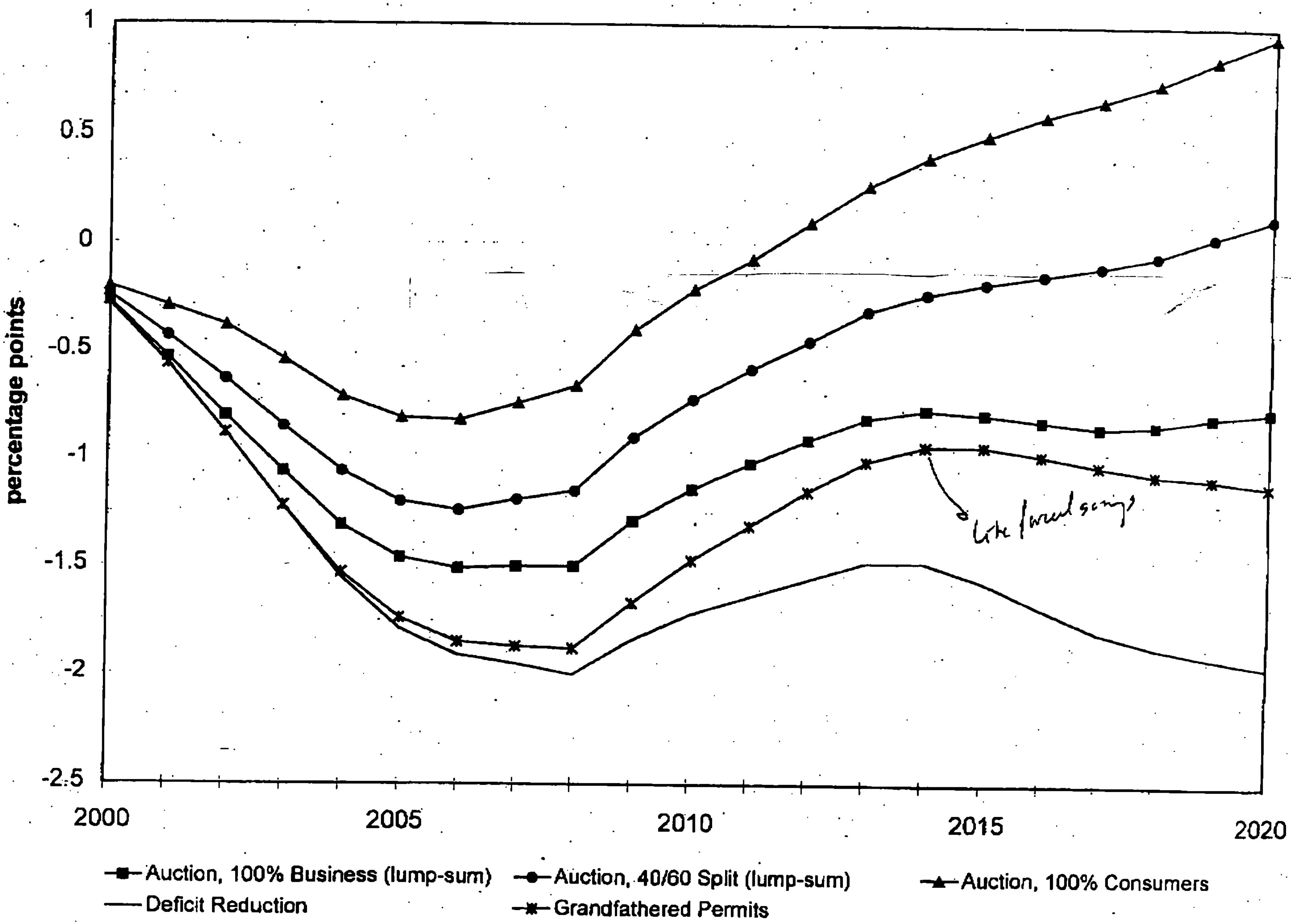
Investment, Change from Base

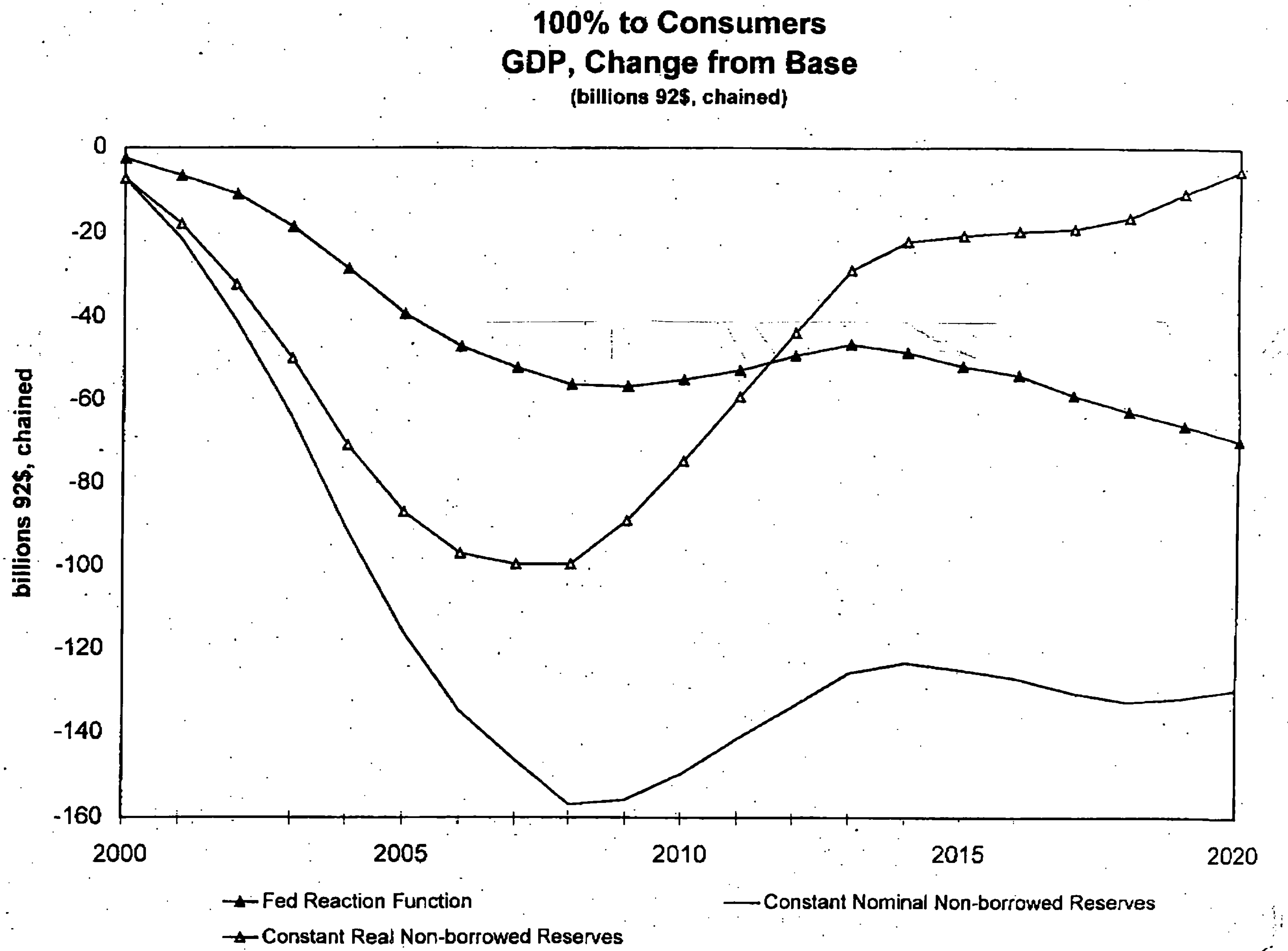
(billions 92$, chained)



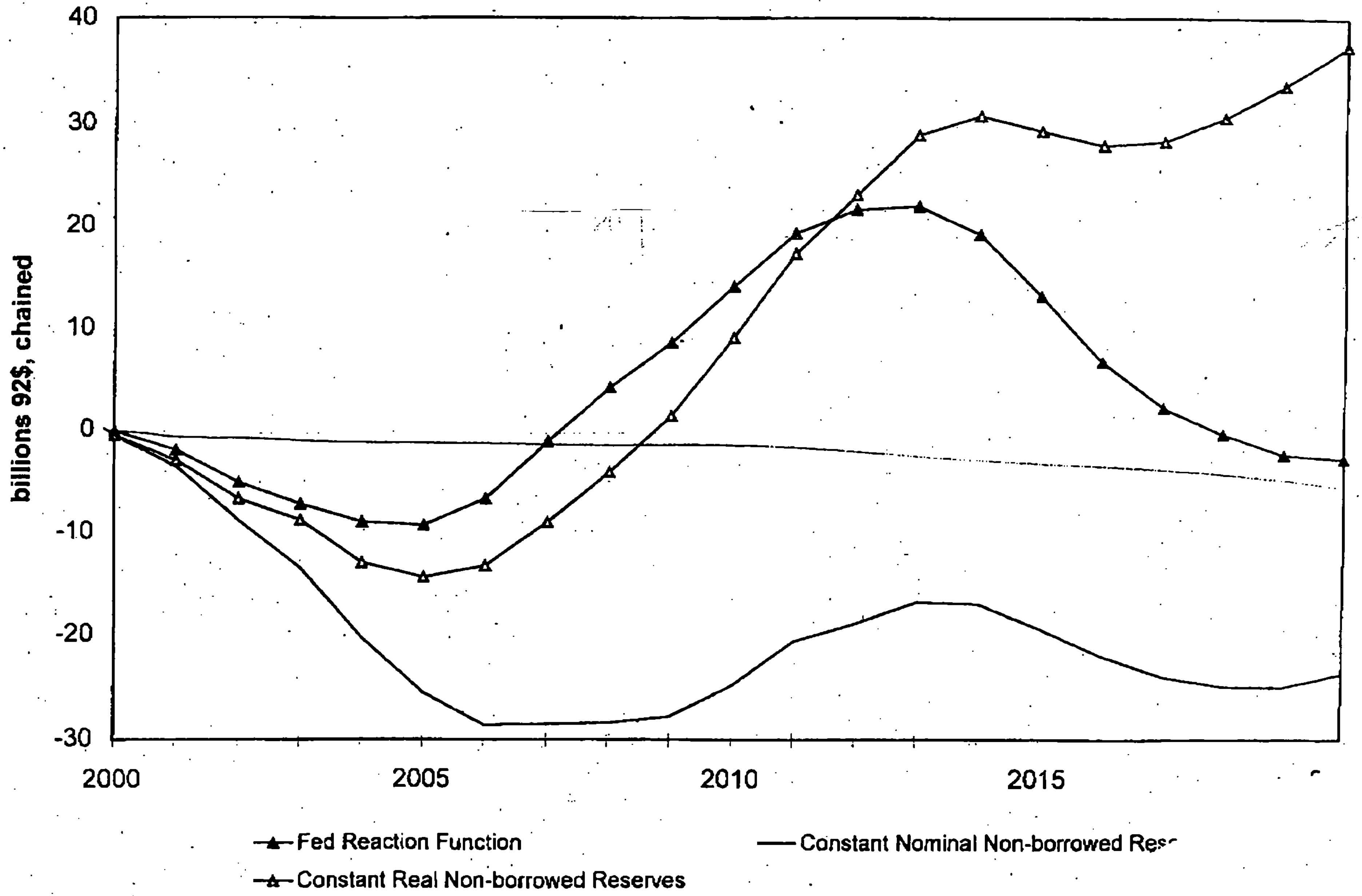

Consumption, Change from Base
(billions 92$, chained)
billions 92$, chained
20
0
-20
-40
-60
-80
-100
-120
2000
2005
2010
2015
2020
Auction, 100% Business (lump-sum)
Auction, 40/60 Split (lump-sum)
Auction, 100% Consumers
Deficit Reduction
Grandfathered Permits

Real Federal Funds Rate, Change from Base

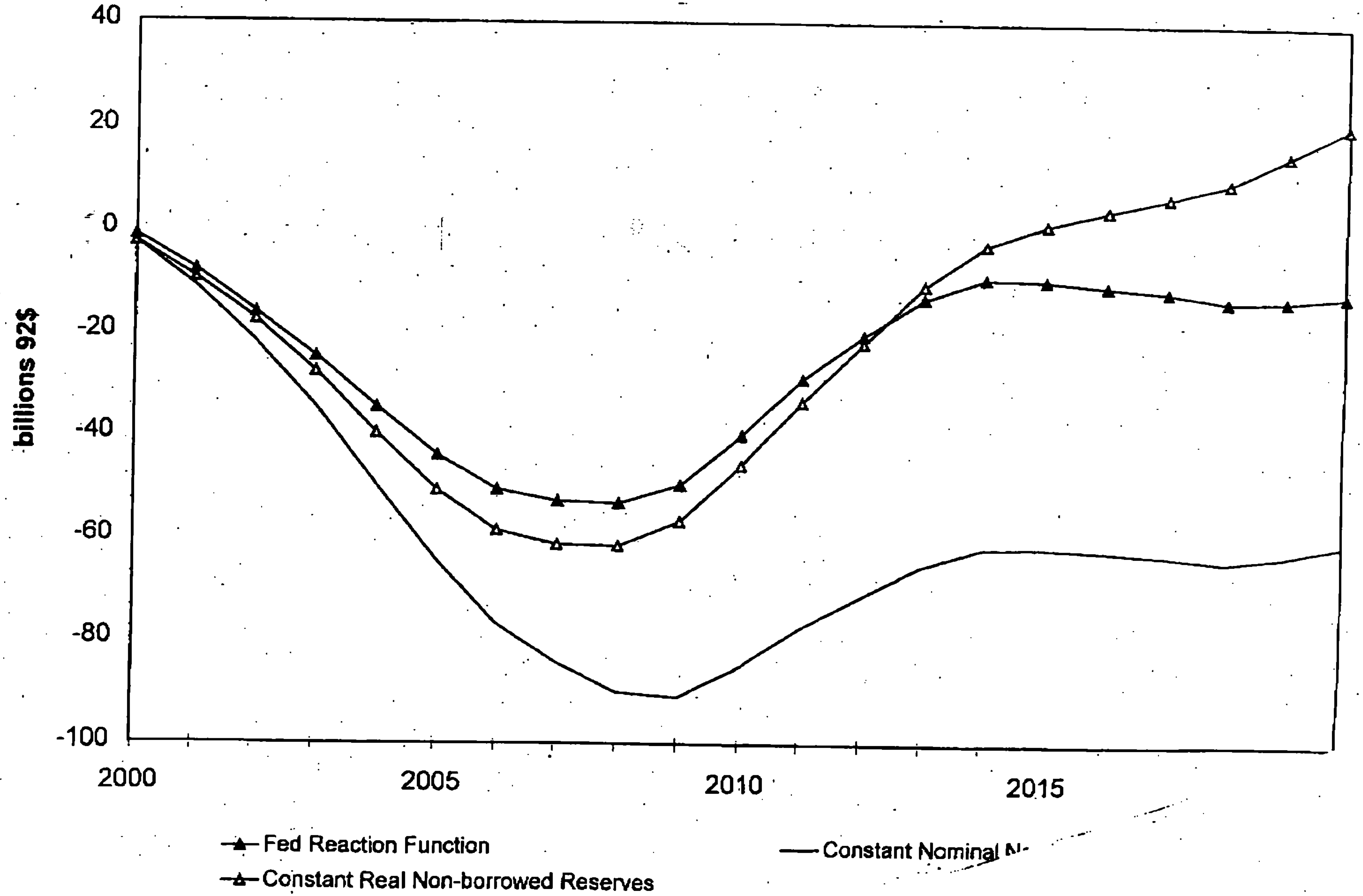



100% to Consumers
GDP, Change from Base
(billions 92$, chained)
billions 92$, chained
0
-20
-40
-60
-80
-100
-120
-140
-160
2000
2005
2010
2015
2020
Fed Reaction Function
Constant Nominal Non-borrowed Reserves
Constant Real Non-borrowed Reserves

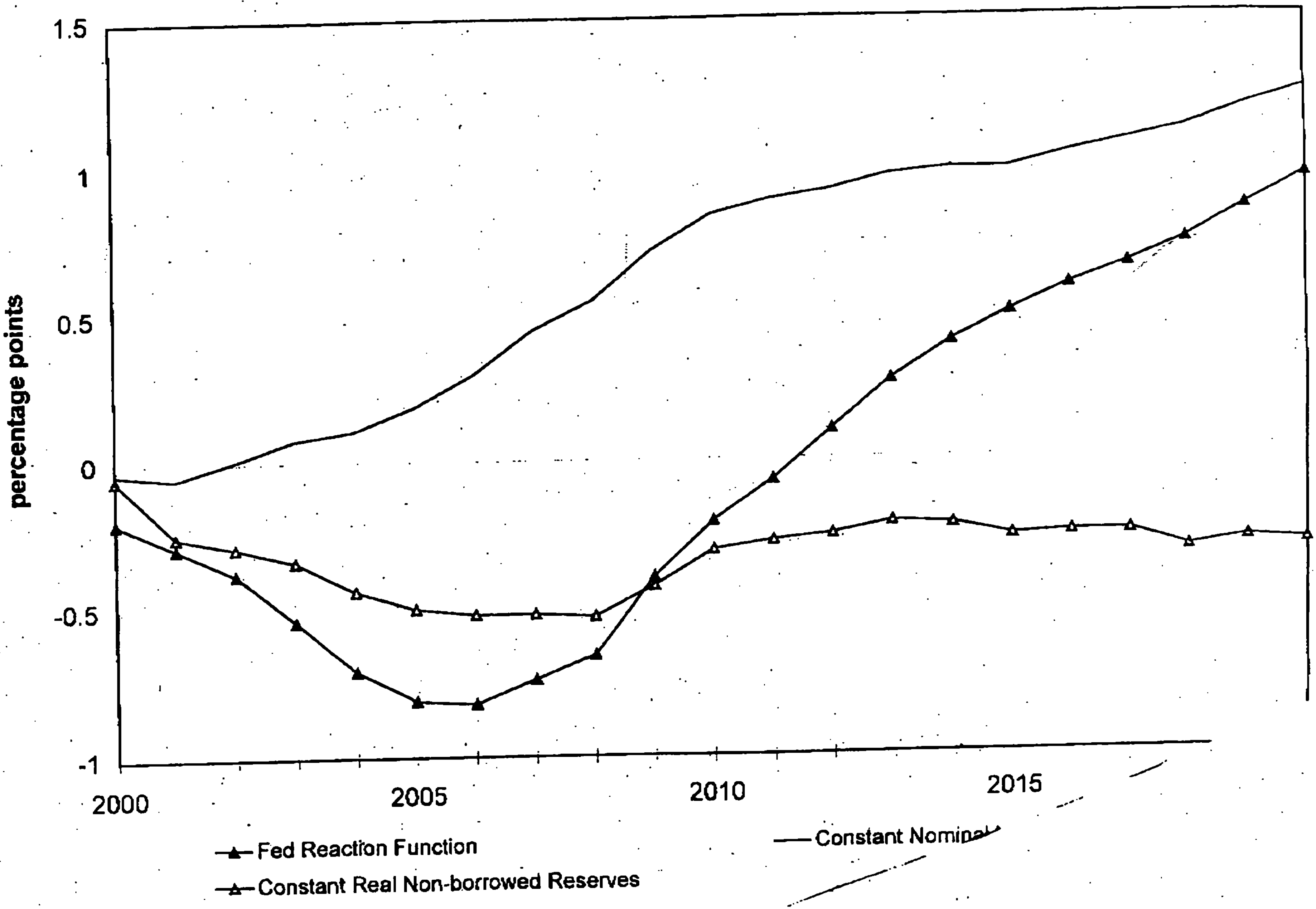
100% to Consumers
Investment, Change from Base
(billions 92$, chained)



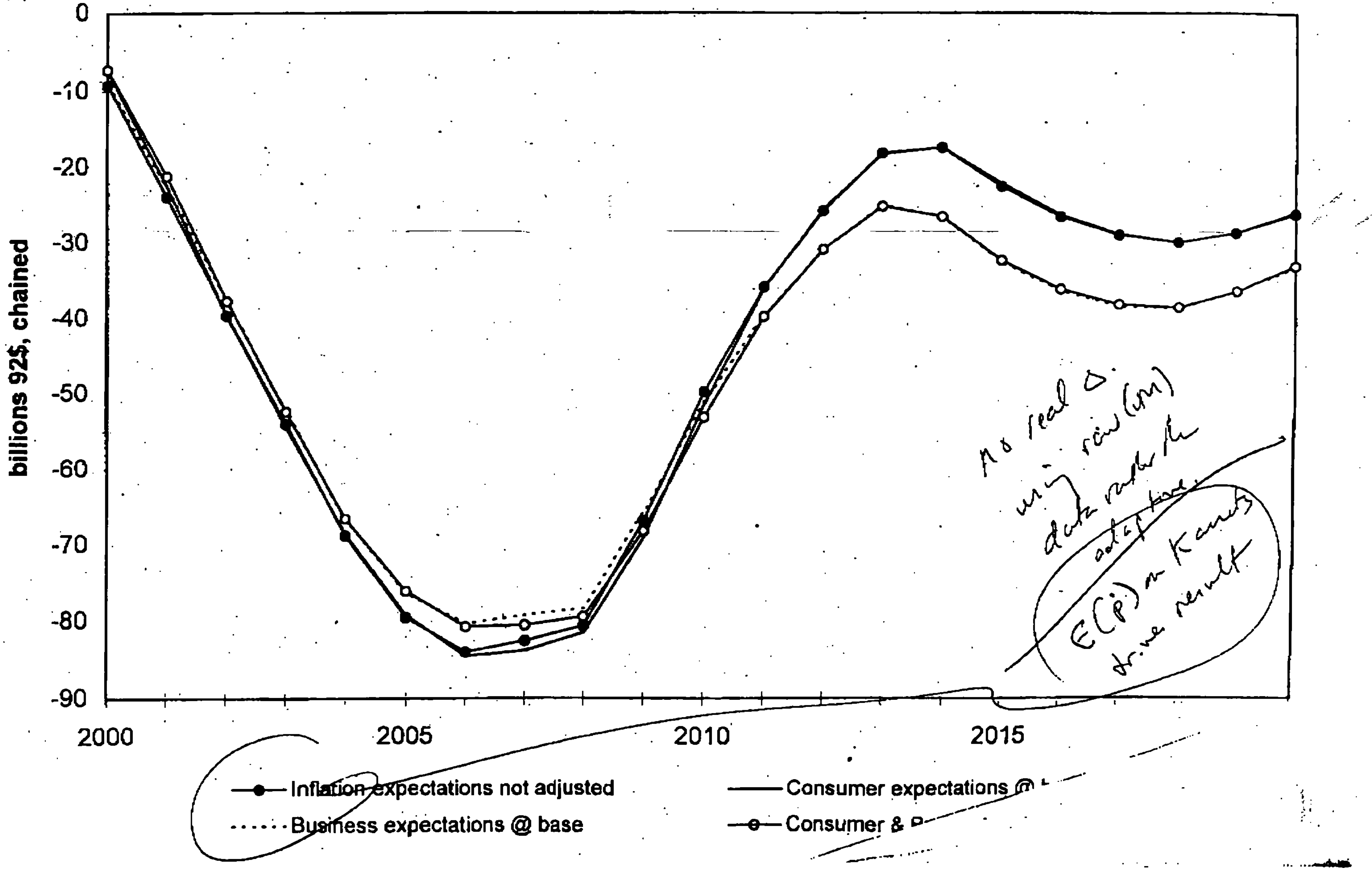
100% to Consumers
Consumption, Change from Base
(billions 92$, chained)

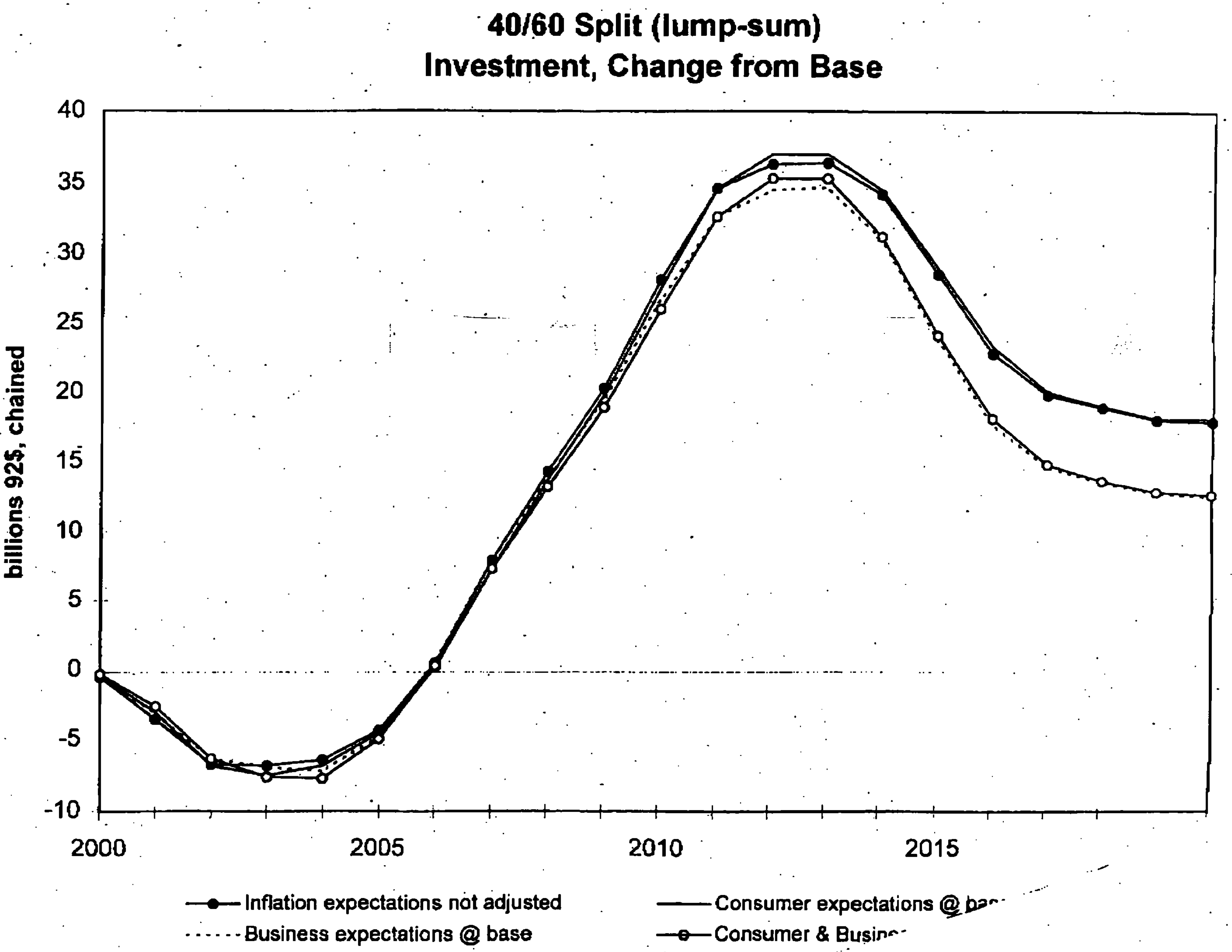


100% to Consumers
Real Federal Funds Rate, Change from Base

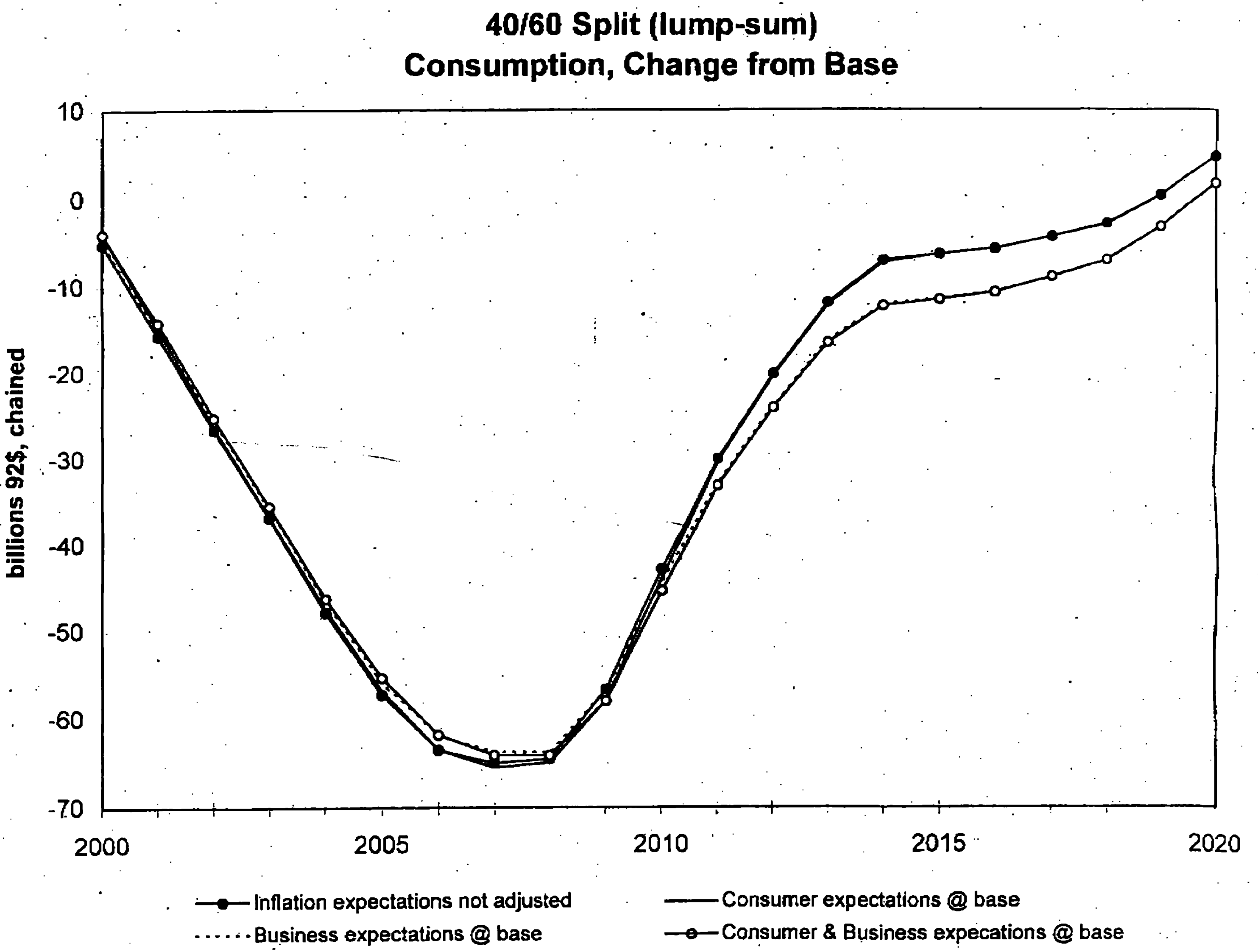


40/60 Split (lump-sum)
GDP, Change from Base
(billions 92$, chained)

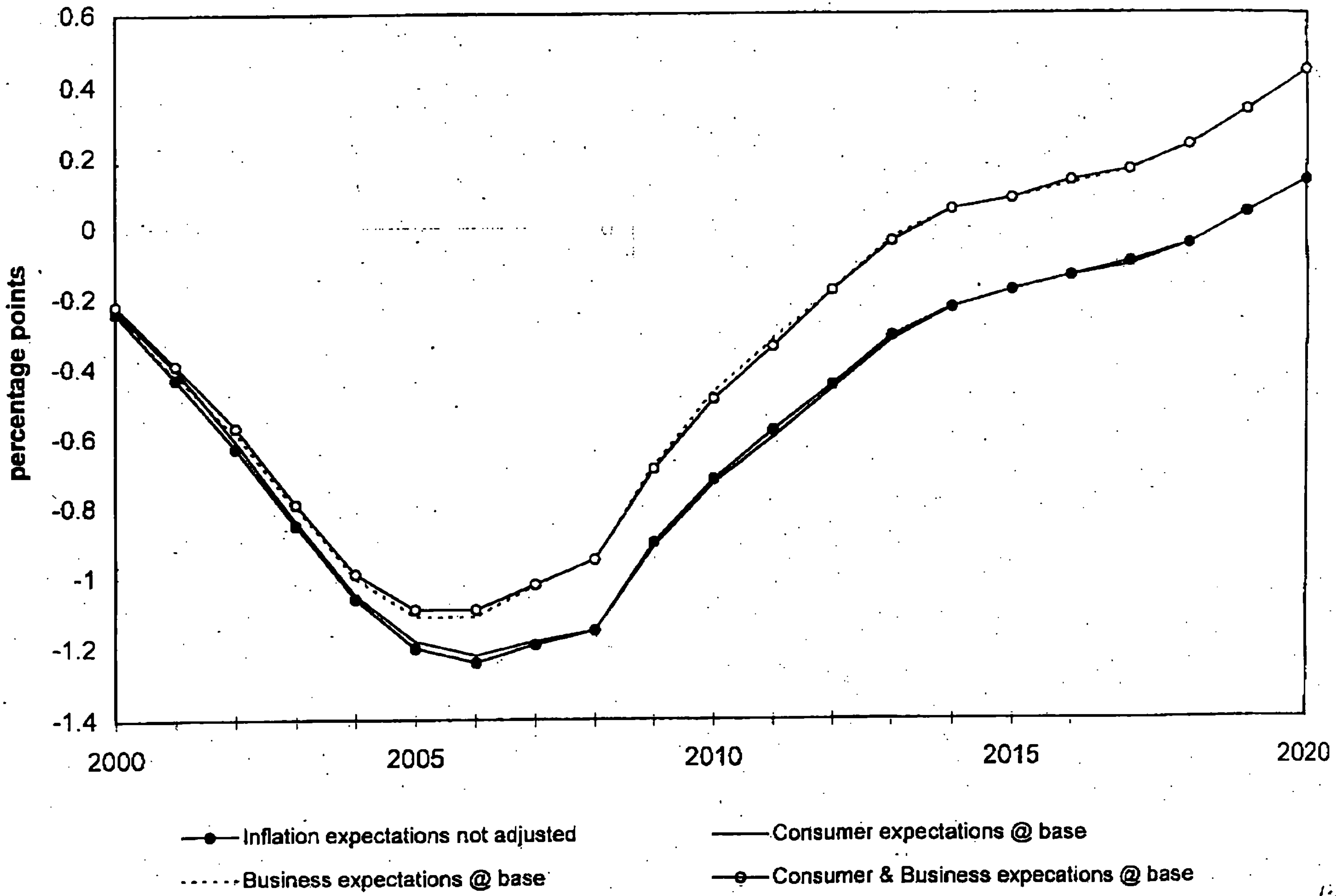




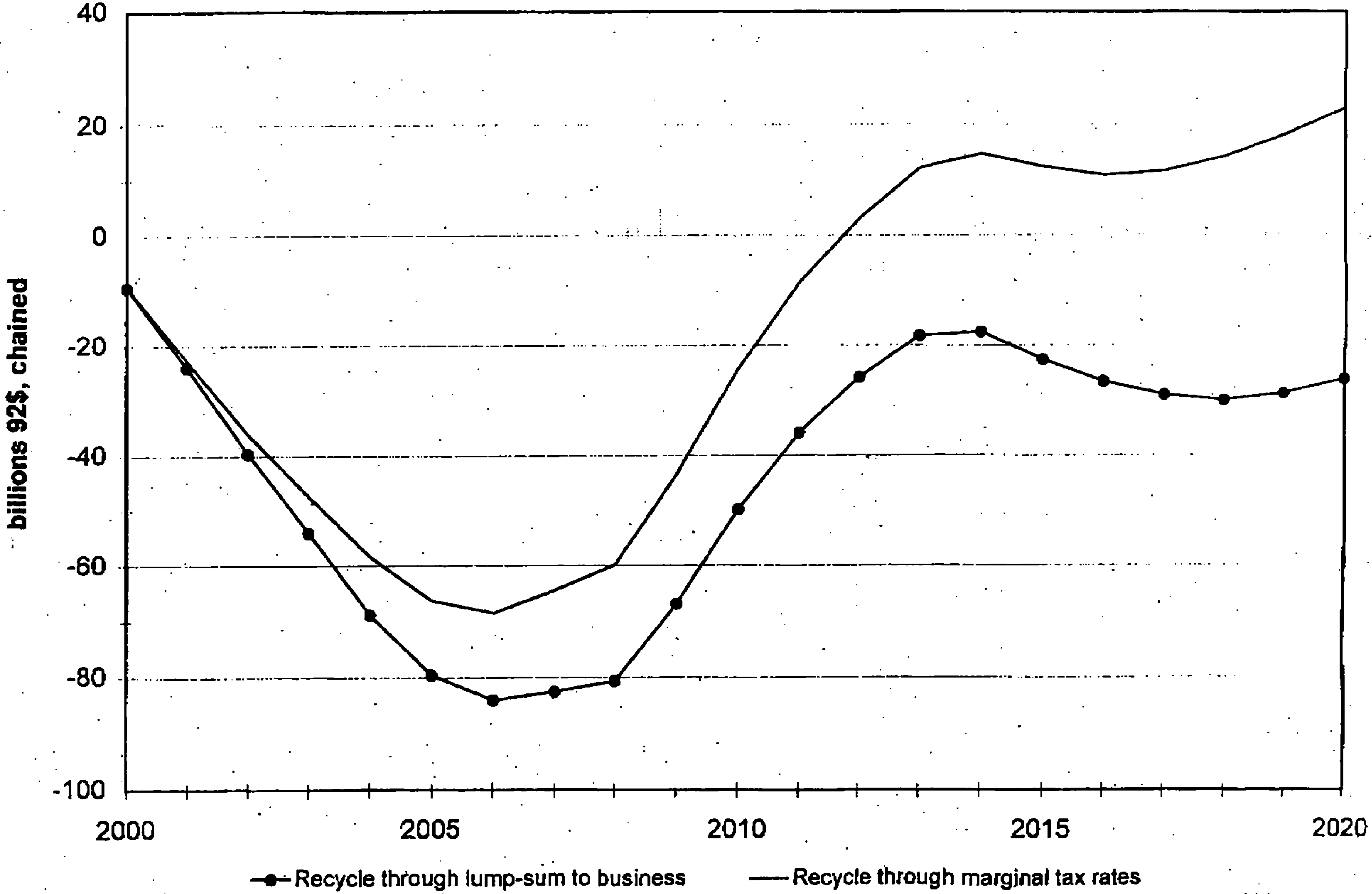
40/60 Split (lump-sum)
Investment, Change from Base
billions 92$, chained
40
35
30
25
20
15
10
5
0
-5
-10
2000
2005
2010
2015
Inflation expectations not adjusted
Consumer expectations @ ba
Business expectations @ base
Consumer & Busin


40/60 Split (lump-sum)
Consumption, Change from Base
billions 92$, chained
10
0
-10
-20
-30
-40
-50
-60
-70
2000
2005
2010
2015
2020
Inflation expectations not adjusted
Consumer expectations @ base
Business expectations @ base
Consumer & Business expecations @ base

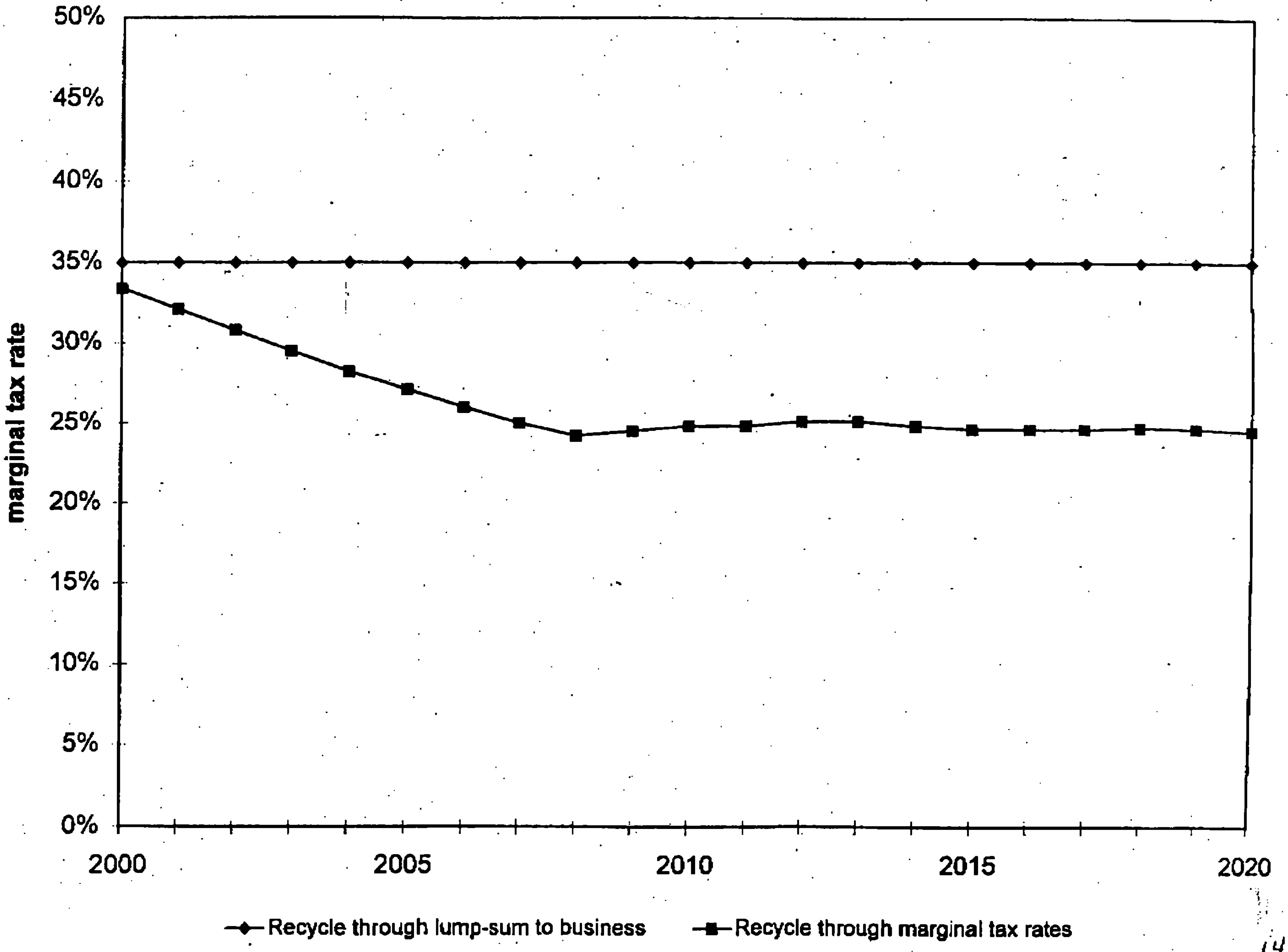
40/60 Split (lump-sum)
Real Federal Funds Rate



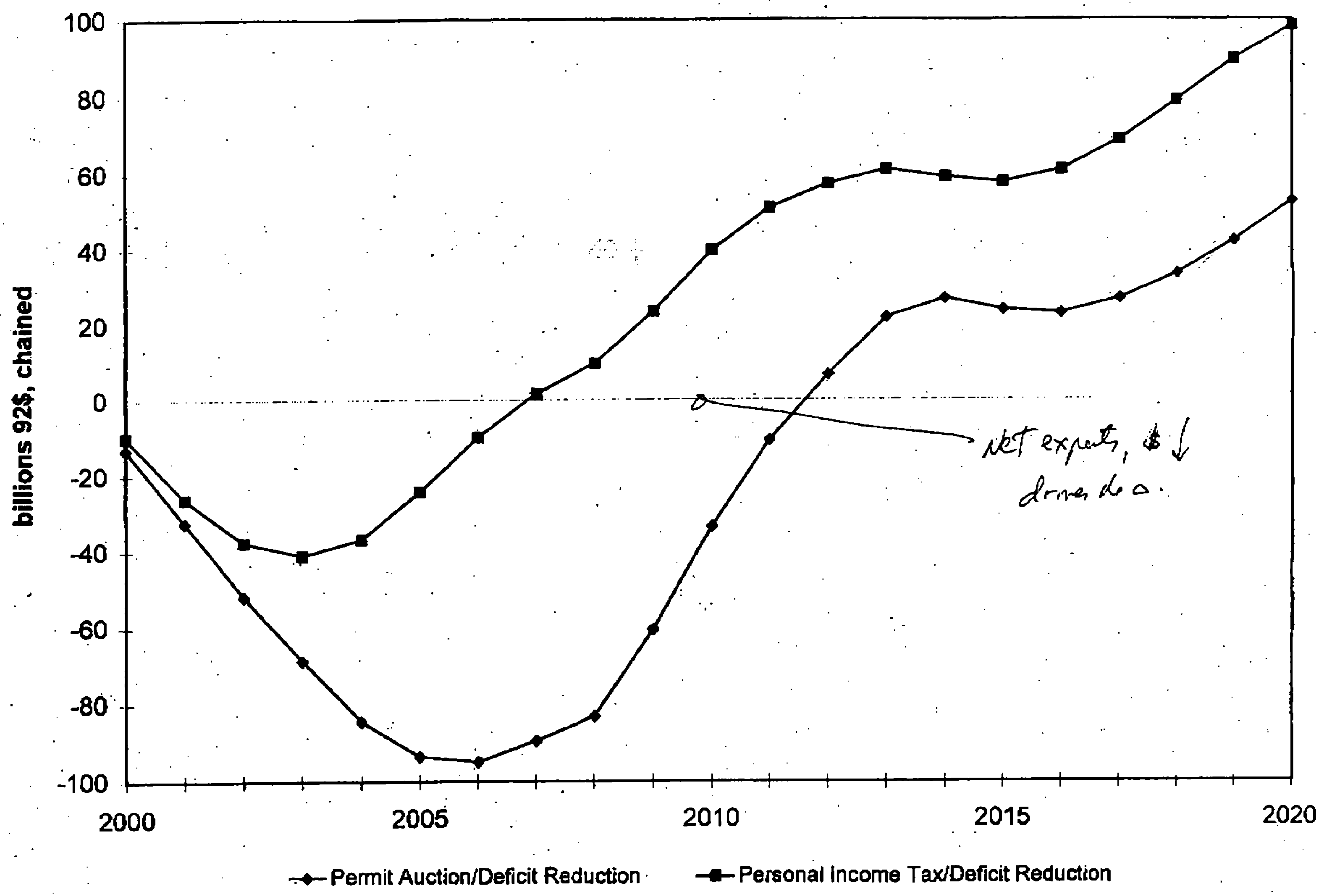
40/60 Split
GDP, Change from Base
(billions 92$, chained)



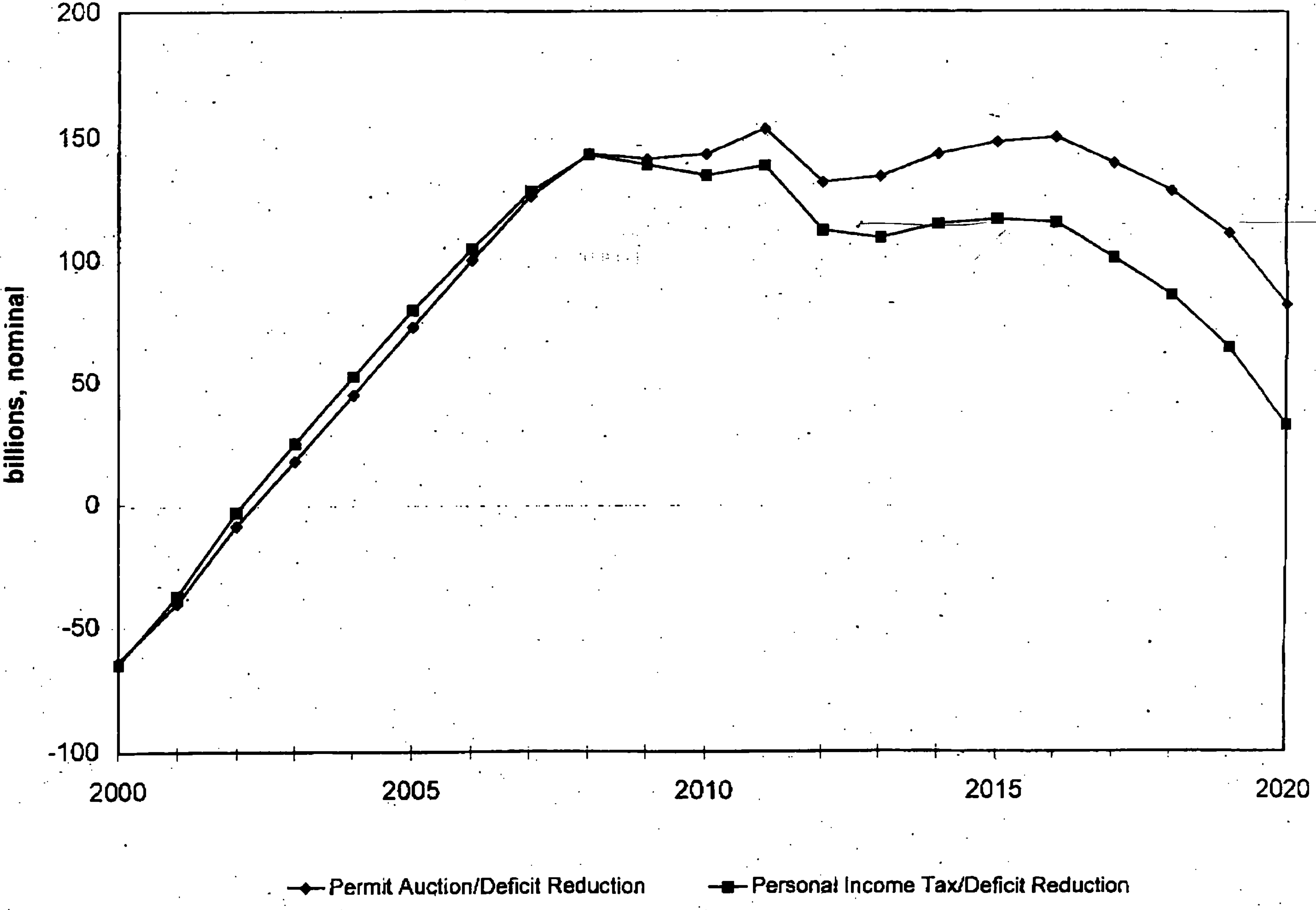
Corporate Tax Rates



GDP, Change from Base
(billions 92$, chained)



Federal Surplus/Deficit
(billions, nominal)



Perspectives on the Choice of Models for Global Climate Change Analysis

Presented by

Roger Brinner
Executive Director and Chief Economist
DRI/McGraw-Hill

Perspectives on the Choice of Models for Global Climate Change Analysis

- Key Aspects of the Policy Environment
  - Huge Scale of Economic Intervention
  - Long Time Horizon
  - Short-run Impacts Politically, Environmentally and Economically important
  - Speeds of Adjustment
  - Emphasis on Price Incentives in US Discussion
  - Command/Control Policies Often Favored in Europe
  - New Technologies
  - Regime-shifts and Forward-Looking Expectations
  - Industry-Specific Responses
  - International and Regional Complexity
  - Uncertainty about the Costs of Non-Intervention
  - Economic Welfare beyond Official GDP

The Truth about Modern Macro/Energy Model Systems such as DRI's System

The serious "macro" modelers have listened to and learned from the debates of the past three decades. On the other hand, most of the academic model builders and GEQ promoters have not had access to this work and thus compare their "GEQ" models to macro models as they existed in the 1960s and 1970s.

With extensive testing, innovative structures, and appropriately constrained core coefficients, DRI's modern systems centered on macro-econometric models are, in fact, genuine general equilibrium models.

- A robust long-run growth model is at the core, reliably regulating long-run answers.
- Most key expectation structures are "rational" and "forward-looking" in a realistic, tested manner.
- An extremely detailed, forward-looking energy model is fully integrated into macroeconomic cyclical and growth scenarios.
- Microeconomic fundamentals are fully respected in constrained long-run price elasticities in both macro and energy models.
- Technological change is endogenous, driven by R&D activities with literature-benchmarked rates of return.
- International feedback loops are built in, combining good microeconomics, historical testing, and user options for sensitive parameters.
- Continuous testing against actual experience has allowed identification of robust, sustained behavior and of structural shifts that need to be endogenized or specifically managed by the analyst.
- The models have been tested in a wide range of policy applications to reduce the risk of blind spots and short circuits in any specific policy situation.
- Well-documented model allows user to anticipate basic results and to understand valuable, initially paradoxical results.
- Sophisticated software implementation allows for constraining results further on a scientific basis to match other model insights, bridge to additional resource supply and industrial or regional models, or implement command/control changes as desired.

Specific Examples of Key Lessons Embodied in DRI Macro/Energy Model System:
Tied to the Key Aspects of the Environmental Policy Environment

– *Long Time Horizon*

Production function with diverse capital inputs (each with appropriate rate of return and depreciation).

Careful re-specification of the role of energy inputs in intermediate and final production as substitute for capital or labor.

– *New Technologies*

Factor-augmenting technical progress driven by R&D. First implemented in 1976, and continuously tested, validated since then.

– *Emphasis on Price Incentives in US Discussion*

Neoclassical investment/cost-of-capital functions in business fixed investment, housing, and consumer durable spending models with appropriate short- and long-run elasticities.

Accelerationist wage-price models with no long-run inflation/unemployment trade-off.

Stage-of-processing price model with appropriate long-run elasticities and import price sensitivity.

– *Command/Control Policies Often Favored in Europe*

Software environment of model greatly facilitates matching adjustments to durable goods spending(on new technology or higher-efficiency models)and related energy consumption.

– *Huge Scale of Economic Intervention &..*

– *..Short-run Impacts Politically, Environmentally and Economically important*

Reliable financial-real-price sector interactions, including multiple options to invoke alternative, endogenous central bank reactions.

Detailed government sector to track endogenous inflation, growth, finance budget repercussions on a short-and long-run basis.

– *Speeds of Adjustment*

Great care is taken during estimation to estimate the time profile of demand responses.

Specific Examples of Key Lessons Embodied in DRI Macro/Energy Model System:
Tied to the Key Aspects of the Environmental Policy Environment
(continued)

– *Regime-shifts and forward-looking expectations*

Linked energy model has detailed capital stock choice models for transportation, residential, commercial, and utility sectors with explicit forward-looking life-cycle costs and probabilistic selection of least cost options.

Financial market expectations based on the accelerationist model, structural deficits, and global conditions.

– *Industry-Specific Responses*

Detailed energy prices now feed relative prices of final demand elements driving industrial and service sector outputs by industry.

Full linkage between energy and macro model simulations.

– *International Complexity*

Automated, tested feedback loops involving world bond yields, oil prices, import prices, export demands.

The OECD and developing nation trade variables are entered as separate, distinct price, exchange rate, and volume inputs to U.S. export and import model equations. This will facilitate handling of differential policies and production responses,

– *Uncertainty about the Costs of Non-Intervention & Economic Welfare beyond Official GDP*

The GDP, Consumption, Income and price answers can be exported to other models to estimate broadly defined consumer welfare measures.

These features and improvements combine to give answers that should be respected by Keynesians, Monetarists and Neoclassical economists.

Integration of the DRI Macro, Energy, I-O and Regional Models

- The DRI Macro and I-O Models take key inputs from the Energy Model
  - fuel price by type
  - non-utility final demand for fuel use by type
  - consumer usage of energy by type
  - utility use of fuel use by type
  - energy production by type
  - energy imports and exports
  - light vehicle miles per gallon, new and weighted-average stock
- The DRI Energy Model takes key inputs from the Macro and I-O Models
  - Residential: housing starts and stock
  - Commercial: building square footage by type of construction, discount rates
  - Industrial: real output/production by 2-4 digit SIC codes
  - Utility: capital costs, wage rates, construction costs
  - Transportation: vehicle sales and stocks, prices, foreign trade (for bunker fuels)
  - All Sectors: real income, inflation components, capital costs
- DRIs U.S. Regional Model is also fully integrated into this system
  - The DRI Energy Model starts at Census and NERC regions and sums to national totals
  - For example, housing starts and stocks are distributed regionally, with differentiated energy requirements
  - National production and employment are distributed on a consistent basis across regions, states, and metro/non-metro areas---a potentially valuable political input

Problems Specific to Many "General Equilibrium" Models

- Only rough calibration to starting points and realistic base lines.
- No testing of historical validity and little testing of applicability to a broad range of policy situations, thus leaving severe blind spots and short-circuits even in their own principal policy area.
- Transition periods are ignored or handled roughly. Long- versus short-run elasticity demand and supply differences are paid scant attention.
- A central price is often set as numeraire, thus no policy guidance on inflation impact in all its dimensions.
- Simplistic, counter-factual expectation formation, not even recognizing Lucas/Sargent concept of the richness of expectation formation.
- No central bank, hence real cost of capital invariant in many circumstances where it should be expected to change substantially for a prolonged period of time.
- Full employment assumed, hence no policy guidance on job losses or gains.
- No business cycle, hence no capital formation losses or gains in very important transition periods.
- High degree of aggregation.
- Limited international feedback.
- Limited software environment to facilitate linkages to other models on a simultaneous basis.

In short and to be blunt, in contrast to their names, as a class the so-called GEQ models actually tend to be Very Partial Equilibrium Models with a penchant for elegant math and little resemblance to real world economies.

Expectations and “Regime Shift” Changes

- The phrases “rational expectations” and “perfect foresight” try to bring powerful, positive images in support of some “general equilibrium” models and, by contrast to criticize other models with different approaches. However, consider a few recent examples to see what the most reasonable and realistic interpretations of expectations should be.
- I. New monetary policy regimes:
  - Thatcher: monetarist/rational expectation promise of painless end of inflation thoroughly refuted
  - Volcker : bond markets expected sustained inflation and real credit scarcity, not immediate transition.
  - In both cases, no labor or financial market moderation occurred only after traditional information (i.e.. higher unemployment and lower inflation) confirmed policy.
  - France and the EMS/EMU: French yields remain far higher than German in spite of policy change and, indeed, years of delivery on the new policy.
- II New fiscal policy regimes
  - Some evidence exists of temporary 3-6 month benefit from balanced budget announcements, followed y relapse until actual deficit reduction produced.
  - No evidence of capital spending acceleration or deceleration in response to policy changes until the change takes place.
- III New energy policy regimes
  - Capital spending decisions made with great skepticism about endurance of long-run policy, given quick changes in official preferences for nuclear, then coal, and now natural gas.
  - Consumers behave in extremely short-sighted manner with regard to auto and appliance efficiency choices.
  - Phase I of Clean Air Act: Utilities behaved as if past coal prices would persist, and thus installed scrubbers. Perfect foresight would have foreseen price reductions for low sulfur coal and avoided heavy investment in scrubbers.
  - Government efficiency standards and programs: CAFE standards, electric vehicle requirements, Montreal protocol on CFCs, etc. presumed not to be binding or to be evaded, thus technology development did not accelerate to match desired norms.
- IV. Surveys of expectations confirm backward-looking expectations with significant lags.

Therefore, the DRI model system uses appropriate, not fanciful or untested, representations of rational or forward-looking expectations.

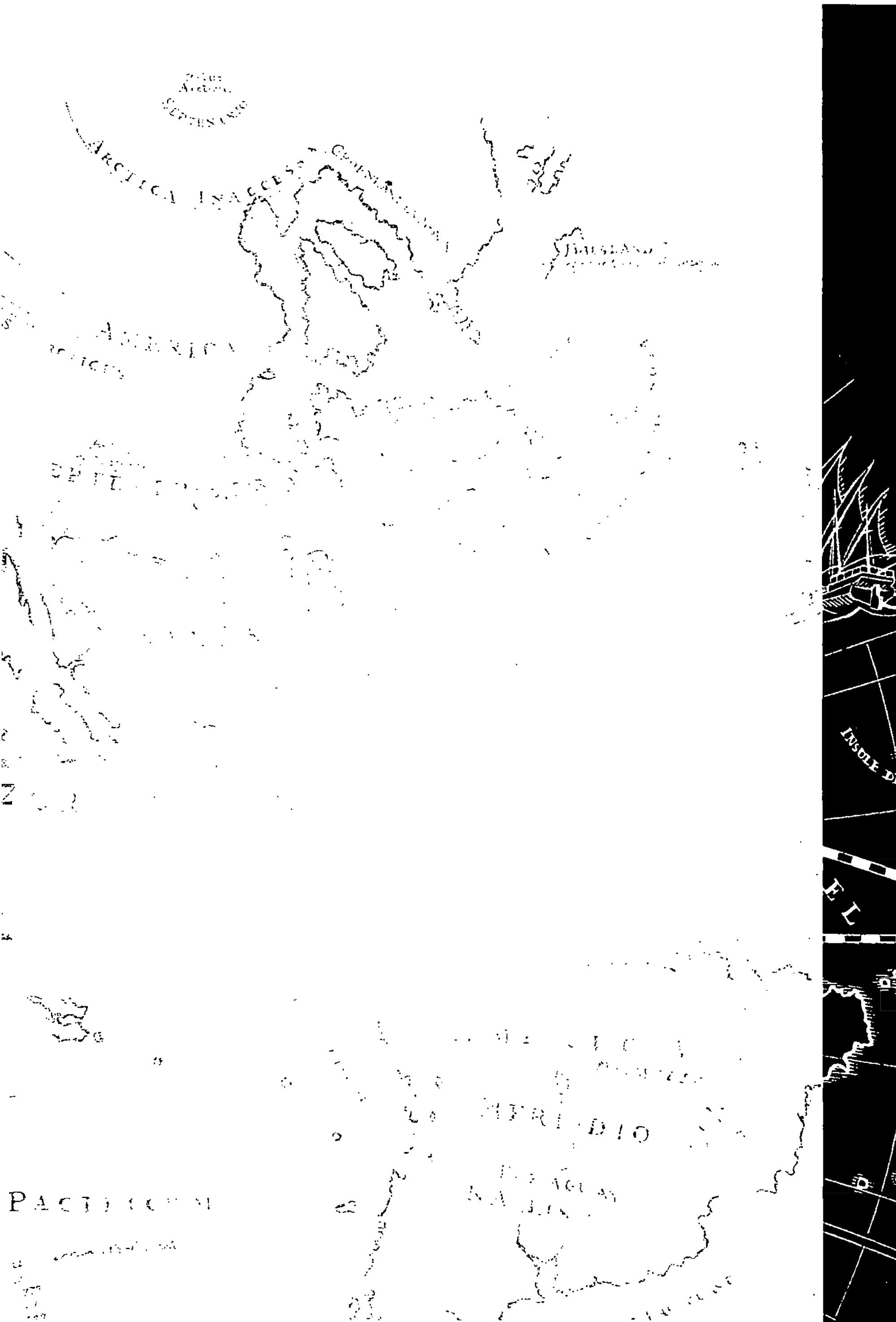
A Set of Policy Experiments to Highlight the Theoretical Integrity and Flexibility of the DRI Macro/Energy System and the Potential Blind Spots of New "GEQ" Models

- The Fiscal Policy Experiment:
  - Substitute payroll taxes for personal and corporate income taxes
  - Target the original full-employment federal deficit
- The Monetary Policy Alternative Assumptions, highlighting the role of the central bank as a major participant in the capital markets and the financial / real / price interations---economic elements ignored or handled poorly by newer GEQ models
  - Constant nominal reserves
  - Constant real interest rate (a la many GEQ models)
- The Labor and Goods Markets Alternative Assumptions
  - Normal reactions of individual agents as historically observed
  - "Perfect foresight" assumption such that nominal base wages are adjusted to keep price level unchanged if nonborrowed reserves are unchanged
    - Or, think of this option as the equivalent of assuming a fixed price numeraire
- Comparison of results for output, employment, capital formation, prices, wages, capital costs
  - Short-run
  - Medium- and long-run
  - Note: think of "the long-run" in many climate change scenarios as the integration of a sequence of overlapping, ever-increasing fiscal initiatives

Perspectives on the Choice of Models for Global Climate Change Analysis

- A modern macro and energy model system is calibrated to perform with robust general equilibrium properties.
- Because these models have been developed and maintained over decades with policy analysis as the key focus, they avoid the short-circuits and blind spots of recent alternatives.
- However, the best insights from new models can be incorporated into the simulations of the macro/energy system. The software environment greatly helps the user to input alternative theoretical or empirical assumptions about key parameters and then to observe the sensitivity of the key results to such assumptions.

DRI/McGraw-Hill



Exhibits for Perspectives on the Choice of Models for Global Climate change Analysis

Presented by:
Roger E. Brinner, Ph.D.
Executive Director and
Chief Economist
DRI/McGraw-Hill
24 Hartwell Avenue
Lexington, Massachusetts 02173
(617)860-6661

THE DRI U.S. ENERGY MODEL

U.S. Energy/Economic Modeling System

The DRI U.S. Energy/Economic Modeling System was designed to analyze the impacts of major energy issues on the U.S. energy sector and the feedback effects from energy markets on the U.S. economy. The system is composed of:

- o DRI's Macroeconomic, Regional and I-O Models
- o DRI's U.S. Energy Model

In the Energy/Economic Modeling System, the simultaneity between energy and the economy is dealt with through iterative solutions of the DRI Models. The Macro, Regional and I-O Models define the economic environment in which the energy markets are operating. Projections of real GDP growth, inflation, industrial production, employment, income, housing, vehicle sales, etc., are provided to the Energy Model from the other models.

Also feeding into the Energy Model is a complete array of present and expected future energy regulations which impact the pricing and/or availability of domestic energy supplies, assumptions regarding the technical or efficiency characteristics of the energy-using capital stocks, and world oil prices. With these inputs, the Energy Model determines the prices, demands, and supplies of the major energy sources in the U.S. The major forecasts for prices and demands are given by consuming sector and by region of the country.

A key innovation is the set of detailed energy-using capital stock choice algorithms, presenting such decisions as choices among alternative life-cycle costs as fuel types or prices and equipment characteristics are varied. These can be combined appropriately with econometrics-based estimates of demand elasticitities to elaborate the development of technology options and other substitutions from energy to capital or labor. In the life-cycle choice models, a Weibull distribution guides the distribution among options, allowing relative costs to drive the probability of choice. The life-cycle costs are forward-looking, driven by the future prices of fuels by type within the full long-run simulation. This approach is implemented in the utility, residential, and commercial sectors. Appropriate capital data was not available to sustain this approach within the industrial sector; instead DRI built detailed links to our region-specific I-O model where fuel usage is driven by output and relative price factors.

Energy Model

The Energy Model develops the prices and the demands for the major fuels and for electricity in the residential, commercial, industrial, and transportation sectors on a regional basis for the total U.S. End-use demands and prices are projected for 11 census regions. The model also translates the electricity demands into the generation requirements and determines the electricity generation capacity requirements, fuel consumption, costs and electricity prices in a restructured electricity industry. Electric load, generating capacity, and generation are projected by both the 11 Census regions and the 10 North American Electric Reliability Council (NERC) regions. Pricing in the Energy Model and demands by sector are discussed below.

Energy Prices

<u>Oil</u>: The Energy Model determines the price of petroleum products to end-users by tracking oil prices from the wellhead or their point of U.S. entry, to the refiner, to the wholesaler, and finally to the end-users. The taxes, transportation costs, refiner markups, and retailer markups applicable at each phase of petroleum supply are entered into the price calculations.

Crude oil prices are projected for imported and domestic oils. Imported oil prices are based upon a comprehensive analysis of world oil demands and supplies within the World Oil Model. The World Oil Model compiles oil demand and supply projections from DRI's individual country models, defines the call on OPEC's marginal suppliers, and determines a market clearing price. (DRI's global energy models include 43 individual country models, plus additional regional models which provide a complete analysis of world energy demand and supply.) Domestic wellhead prices by supply source reflect the world oil price and the quality of the source. Average domestic and acquisition crude oil prices are calculated as supply-weighted averages of these prices.

<u>Natural Gas</u>: Natural gas prices within the model reflect (1) policy assumptions regarding the pricing of spot versus contract gas, of Canadian and Mexican imports, and of LNG and SNG supplies, (2) the regional transportation and distribution markups to each consuming sector, and (3) a market demand/supply balance for the long-term.

Spot and contract natural gas prices are computed based upon competing oil prices and resource supply costs. Regional average pipeline acquisition costs are calculated as volume weighted averages of all gas sources, domestic and supplemental. Retail industrial, residential, commercial, and electric utility prices are developed by adding regional transportation and distribution markups to pipeline acquisition costs.

Coal: Delivered coal prices are determined by projecting new mine-mouth prices by supply basin, monitoring the expiration of old contracts and the terms associated with new contracts, tracking the flow of coal by type between supply basin and demand regions, and estimating the transportation costs associated with the delivery to the demand regions.

Electricity: Regional electricity prices to residential, commercial, and industrial customers reflect the transition from cost of service pricing in the very near-term to a deregulated electricity generation market over the next 10 years. Near-term prices reflect utilities' generating, purchase power, transmission and distribution costs, and an allowable rate of return on the utility capital; mid-term prices reflect the rise of competition, stranded costs, and partial cost recovery; long-term prices reflect the long-run marginal cost of providing electricity in a deregulated environment. Long-run marginal generating costs are defined by the levelized cost associated with the minimum cost technology in new base load and peak load generation

Energy Demands

The consumption of electricity, natural gas, and oil in the residential and commercial sectors and the consumption of coal, natural gas, and oil in the electricity industry is determined through a two-step decision process. The first step is the stock decision. This entails a) the decision to purchase the capital which provides an energy service: given demographic (production) trends and existing stocks, how many furnaces (boilers) are required for new homes (plants) or to replace exhausted or inefficient units, and b) the decision as to the characteristics of the capital stock being chosen: what types of equipment are to be installed, (electric, natural gas, oil, coal) and what are the structure thermal integrities or new equipment efficiencies which characterizes the stock. Decisions at this stage determine the size and the fuel efficiency characteristics of the energy service capital stock, and limit the flexibility in the sectors' fuel mix and conservation potentials. The second step in the process is the utilization decision for the selected energy-service capital stocks. Utilization varies as a function of economic factors and climate.

The final BTUs of energy consumed by energy type are therefore based upon the capital stocks, their efficiencies, and the utilization of these stocks.

Residential

The economic forecasts from the DRI Macroeconomic Model drive the energy service demands in the residential model. Housing stocks, real disposable income, and population define the demand for such energy services as heating, cooling, and refrigeration.

The model determines the levels and the energy use characteristics for 11 residential stocks providing energy services. Stocks are defined based upon existing stock characteristics and new investment decisions. New investment decisions for space conditioning and water heating, for example, are based upon detailed life cycle cost analyses, where life cycle costs are defined as the sum of equipment and installation costs plus the present discounted value of the energy costs associated with the service equipment. Costs are evaluated for competing space conditioning systems in both the new housing and the replacement market. In analyzing the replacement market, the model keeps track of the space conditioning system vintages. Life cycle costs in the replacement market include conversion costs when evaluating the decision to switch to an alternative system.

The model acknowledges four caveats which preclude a determination of new and replacement systems based solely upon average life cycle cost calculations.
These include:

- Housing access to natural gas main extensions.

- The inherent bias toward the existing system when replacing a retired system.

- Market imperfections due to first-cost bias in the investment decision.

- Variations in energy costs, household size, thermal integrity, preference, etc., within any given region.

After the stock decision is made, the utilization of the stock is determined. Utilization varies with the efficiency of the capital stock, economic factors and climate. Economic factors include real disposable income per capita and real energy service costs. The impact of climate on the utilization of space conditioning systems is accounted for by deviations in heating and cooling degree days from their norms.

Commercial

The structure of the Commercial Submodel parallels that of the Residential Submodel. Energy consumption by the sector is determined by analyzing the energy service requirements associated with the commercial square footage for eight building types. The model considers six energy services within the commercial sector. Energy service-per-square-foot coefficients translate square footage forecasts into energy service (stock) requirements. New energy service requirements (investments) are determined by the growth in square footage, and hence service stock. New investments are allocated across each equipment type in each energy service, and are rolled in with the existing stock to define the fuel and efficiency characteristics of the current stock of energy service equipment.

Stock utilization is defined as the commercial sector's electricity, gas and oil consumption relative to the levels of equipment or service stocks fueled by the respective energy types. Utilization is modeled as a function of equipment operating costs, heating and cooling degree days, and building utilization rates.

Industrial

The industrial model analyzes the energy requirements of output from 42 industrial sectors as forecast in DRI's Regional Input-Output Model. Energy intensity in total, and by fuel type, within each industry varies in response to explicit technology trends and relative price movements. The available detail allows the analyst to make explicit adjustments for industry-specific or fuel-specific technological changes or price sensitivities.

Transportation

The Transportation Submodel projects demands by automobiles and by trucks for fuel types; gasoline, diesel and alternative fuels. The model incorporates a detailed analysis of the vehicle stock, the economic and technical characteristics affecting the utilization of the vehicle stock, and the efficiency ratings of the stock. Stock efficiency ratings translate projected miles traveled into fuel demand. The six major outputs of the Transportation Submodel are:

- Vehicle (automobile or truck) sales by fuel type
- Vehicle stocks by fuel type
- Vehicle stock efficiencies
- New vehicle efficiencies
- Vehicle miles traveled
- Motor fuel demands by fuel type

Automobile and truck sales from the Macroeconomic Model are disaggregated by fuel type. Vehicle stocks and 'effective' vehicle stocks by fuel type are computed as the summation of current and lagged vehicle sales, adjusted by the survival rates associate with each vintage for the former and by the survival and typical usage rates for the latter. Stock fuel efficiencies are computed based upon the new efficiency associated with each vintage and the usage rate associated with each vintage. New vehicle efficiencies are positively related to the real price of gasoline and negatively related to exogenous projections of vehicle weight.

Miles traveled by automobiles (trucks) are functions of real income per capita (real GDP per truck), and real fuel costs per mile. Real fuel costs per mile reflect the gasoline price, price inflation, and the average efficiency of the automobile or the truck stock. Total fuel demand by vehicle type is derived by dividing the miles driven for each vehicle type by the vehicle's stock efficiency estimate. The total is then apportioned into gasoline and diesel fuel demand based upon the fuel composition of the "effective" vehicle stocks.

Electric Utility
Generating capacity currently under construction is an input to the model. The model determines additional capacity requirements in each utility planning region (NERC region), based upon the region's "expected" generation requirements for the year and the "optimal" capacity for the region. "Optimal" capacity is defined as that which would assure a desired reserve margin for the region while "expected" generation is calculated based upon the electricity demand projections, transmission losses, and inter-regional transfers of power. If the "optimal" capacity calculation implies an increase in generating capacity greater than a specified magnitude, capacity is added to the region.

Electricity is generated from 29 technology types using seven forms of energy.
Electricity Generation Technologies:

- Combined Cycle Coal Gasification Units
- Combined Cycle Dual Fuel Combustion Units
- Combined Cycle Dual Fuel Combustion Units - Existing Site
- Combined Cycle Dual Repower
- Combined Cycle Gas - Existing Site
- Combined Cycle Gas Repower Units
- Combined Cycle Gas Turbines
- Combined Cycle Oil Repower Units
- Combined Cycle Oil Turbines
- Integrated Gasifier Combined Cycle Biomass
- Combined Cycle Other Fuels
- Combined Cycle Other Fuels - Existing Site
- Conventional Coal Units (Small, Medium, Large, Scrubbed and Unscrubbed)
- Conventional Coal Units (Small, Medium, Large, Scrubbed and Unscrubbed) - Repowering
- Conventional Coal Units (Small, Medium, Large, Scrubbed and Unscrubbed) - Existing Site
- Conventional Hydroelectric Units
- Dual Combustion Turbine
- Fluidized Bed Coal Units
- Gas Combustion Turbines
- Nuclear Boiler Water Reactor (BWR)
- Nuclear Pressurized Water Reactor (PWR)
- Oil Combustion Turbines
- Pumped Storage Hydroelectric Units
- State of the Art Coal Fired Units
- Steam Dual Fuel Turbines
- Steam Dual Fuel Turbines - Existing Site
- Steam Gas Turbines
- Steam Gas Turbines - Existing Site
- Steam Oil Turbines

Electricity Generation Fuel Sources:

- Solar and Geothermal
- Hydropower
- Nuclear
- Coal
- Natural Gas
- Oil
- Biomass

The model is used to balance the demand and supply for electricity generation capacity by NERC region. The model compares existing generation resources to projected requirements for base, intermediate, and peaking capacity needs in designated planning periods. If new capacity is needed in a particular region, an array of generating technologies are analyzed to identify the lowest cost technologies. The variation in plant costs, plant efficiencies, and projected fuel prices in a region puts a range around each cost estimate, allowing for the possibility of a mix of systems being chosen in any particular region and planning period. After the technologies are selected, their capacity is added to a given NERC and Census region. The model also provides sufficient detail to evaluate the competitiveness of existing generating capacity with new plant.

The model dispatches capacity by technology groupings and associated fuel types based upon non-linear load duration curves. The model calculates dispatch costs by technology and NERC region, and dispatches generation resources from the lowest to the highest cost technology group in each year. Generation by NERC region is converted to Census region based upon the distribution of plants within Census sectors of the NERC regions and summed across fuel types.

Fuel demand for electricity generation is derived by multiplying average fuel heat rates by fuel generation. Average heat rates by fuel type reflect the variation in heat rates by technology type and by the age of the equipment.

Consumers form their Expectations in a manner consistent with the DLI above.

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LS

                    ORDINARY LEAST SQUARES
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QUARTERLY(1978:1 TO 1996:2)   74 OBSERVATIONS
DEPENDENT VARIABLE:    PCEXPMEAN

         COEFFICIENT    STD. ERROR     T-STAT    INDEPENDENT VARIABLE

            2.52558       0.2020       12.50     CONSTANT

 1)                                              PDL(RCPI,4,30,NONE)
  \0      0.176560       0.02804         .                      +   *   +
  \1      0.133573       0.01551         .                 + * +
  \2      0.0985488      0.006914        .            +*+
  \3      0.0705534      0.004830        .        +*+
  \4      0.0487052      0.007714        .     +*+
  \5      0.0321742      0.01004         .  + * +
  \6      0.0201825      0.01115         .+ * +
  \7      0.0120041      0.01123         + * +
  \8      0.00696466     0.01057       +.* +
  \9      0.00444206     0.009438      +*+
  \10     0.00386589     0.008092      +*+
  \11     0.00471766     0.006768      +*+
  \12     0.00653079     0.005661       +*+
  \13     0.00889060     0.004884       +*+
  \14     0.0114343      0.004414        .+*+
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  \25    -0.000259676    0.005180      +*+
  \26    -0.00491714     0.004234     +*+
  \27    -0.00938451     0.003901    +*+.
  \28    -0.0132981      0.007160    +*+.
  \29    -0.0162421      0.01390   + * +.
  SUM     0.734245       0.07566       9.704
  AVG        NM

 2)       0.0824205      0.03866       2.132     RCPI-RYACPI\1

 3)      -0.101790       0.04960      -2.052     RMGBS3NS

 4)      -0.282064       0.1448       -1.948     RUC-RUFE

R-BAR SQUARED:   0.9318
DURBIN-WATSON STATISTIC:   1.7038
STANDARD ERROR OF THE REGRESSION:   0.5170    NORMALIZED:   0.09486

?
```

PCEXPMEAN = U of Mich Survey of Expected Inflation

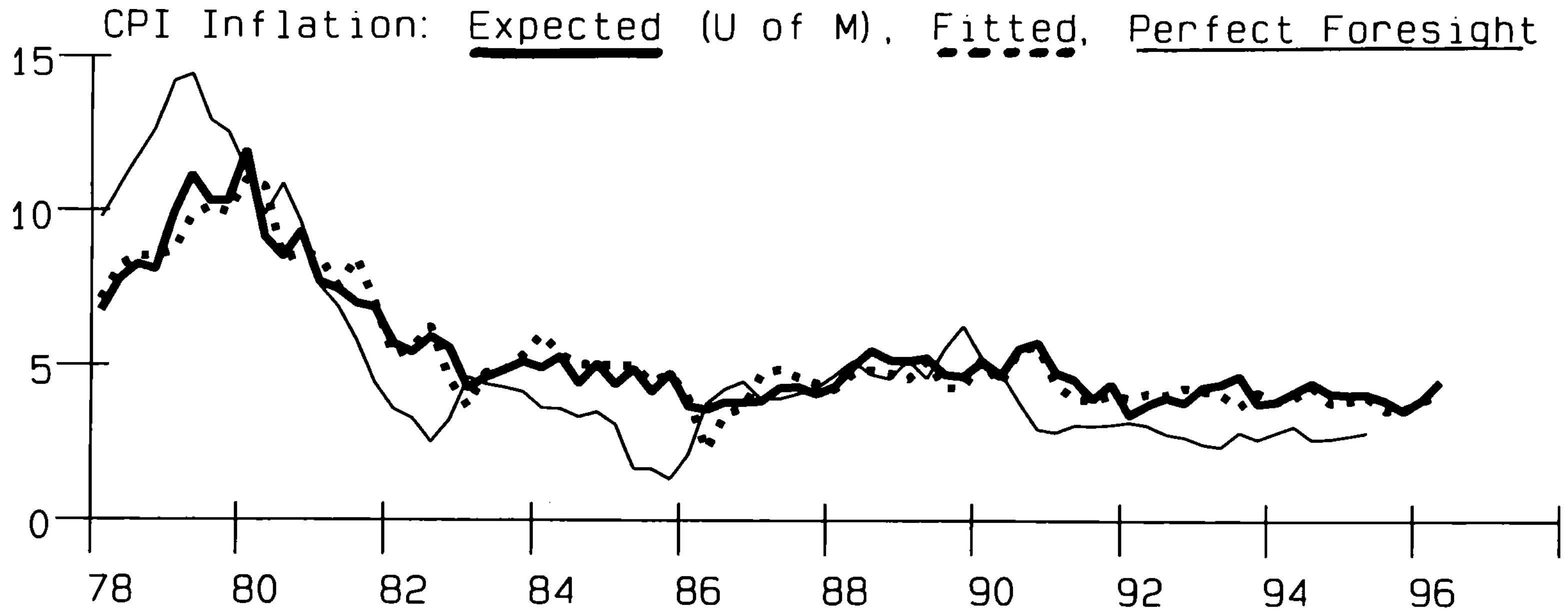
Distributed lag on current and past actual CPI inflation.

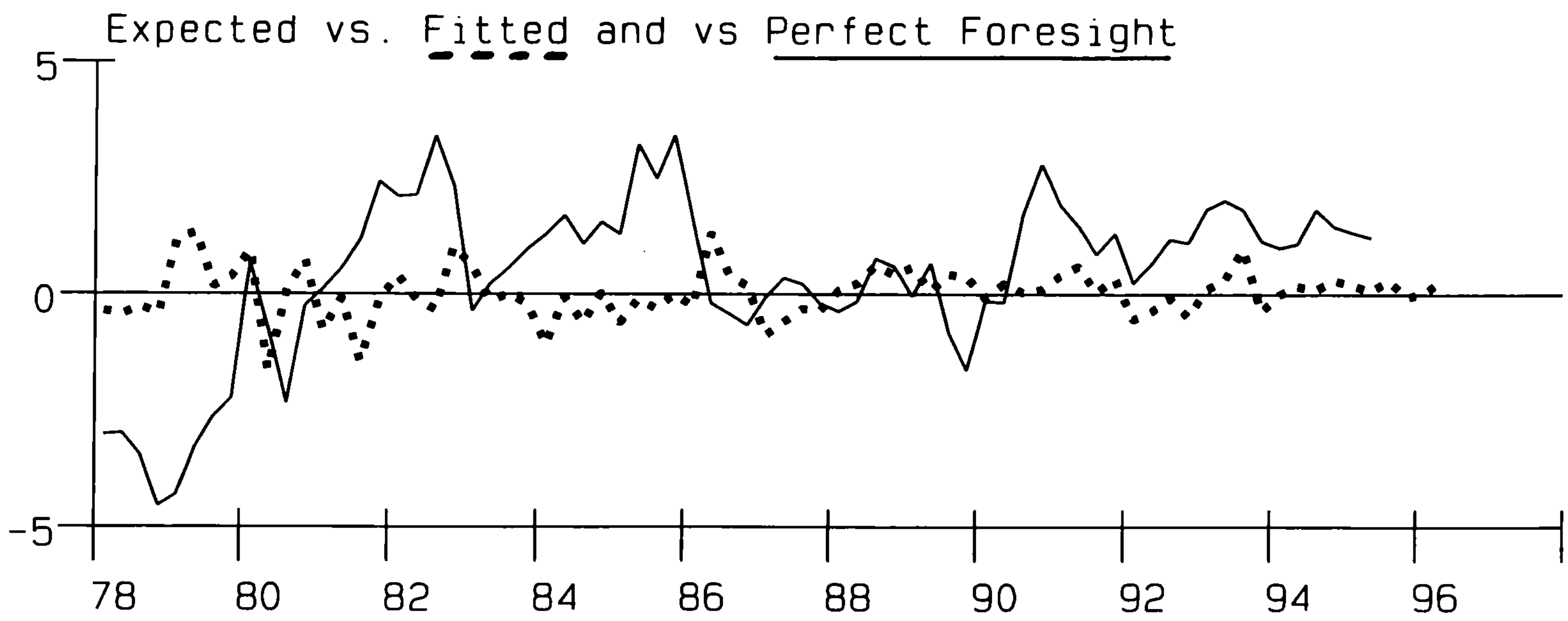
- $\Sigma \beta = 0.73$
- s.e. = 0.08
- mean lag is less than 1 year

RCPI-RYACPI\1: current quarter inflation minus prior year

RMGBS3NS – Treasury bill rate

RUC-RUFE – Actual unemployment minus demographically adjusted norm


CPI Inflation: Expected (U of M), Fitted, Perfect Foresight
15
10
5
0
78
80
82
84
86
88
90
92
94
96


Expected vs. Fitted and vs Perfect Foresight
5
0
-5
78
80
82
84
86
88
90
92
94
96

The Impact of Deficit Reduction on Interest Rates

Board of Governors
The Federal Reserve System
May 31, 1995

Presented by:
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Executive Director and
Chief Economist
DRI/McGraw-Hill
24 Hartwell Avenue
Lexington, Massachusetts 02173
(617)860-6661

The Core Relationships
Among the Treasury Yield Curve, the Business Cycle, and the Federal Deficit

Updated: May 1995 (DRI Model 1995A)

The pivotal rate at the beginning of the yield curve is the Federal Funds Rate,
This rate reflects the private demand and supply for short-term funds, plus the Federal Reserve's active participation as either a lender or borrower to the banking system, depending on the degree of restraint or ease it seeks.

Treasury securities of varying maturities change in relation to this pivot rate depending on:
the stage of the business cycle,
inflation experience and expectations,
the maturity structure of the federal debt (short vs. long), and
the extent of Federal government borrowing expected to persist.

As estimated (1976-1994), these are the relationships, qualitatively and quantitatively:

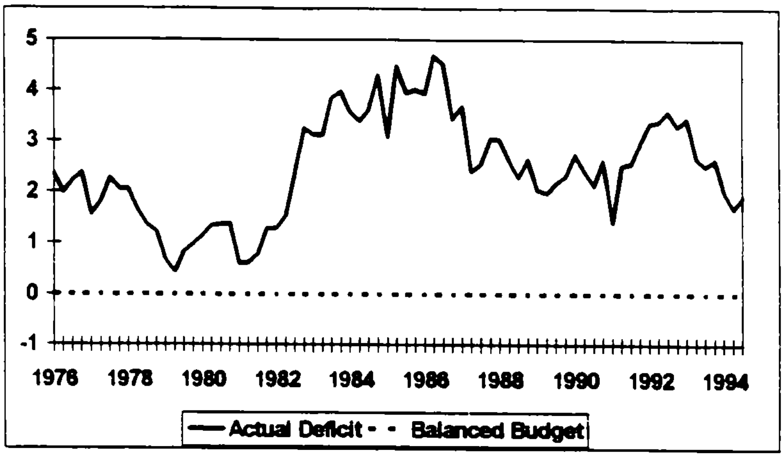
	Percentage Point Increase in Yield for Indicated Maturity for each Percentage Point Change in Factor Shown Below					
maturity of Treasury security	**fed funds rate**	**yield on next-earlier maturity**	**recent inflation experience**	**cyclically-adj. federal deficit/GDP**	**current business cycle GDP Gap**	**short-term share of federal debt**
3-month	0.86	0	0	0	0	0.030
6-month	0	0.96	0	0	0	0.010
1-year	-0.02	0.99	0.02	0.11	0	0.000
2-year	-0.05	1.00	0.05	0.24	-0.06	-0.008
3-year	-0.05	1.00	0.05	0.11	-0.05	-0.009
5-year	-0.08	1.00	0.08	0.12	-0.07	-0.016
10-year	-0.09	0.99	0.09	0.12	-0.04	-0.012
30-year	-0.06	0.94	0.06	0.08	-0.04	-0.004

	fed funds rate	**yield on next-earlier maturity**	**recent inflation experience**	**cyclically-adj. federal deficit/GDP**	**current business cycle GDP Gap**	**short-term share of federal debt**			
assumptions/forecasts for year 2002:									
baseline	5.25%	NM	3.8%	2.2%	0.0%	25%			
balanced budget	2.96%	NM	3.8%	-0.2%	0.0%	25%			
(approx. 10% phased-in federal spending cut across the board)									
change	-2.29%	NM	0.0%	-2.4%	0.0%	0.0%			
							APPROX. CUMULATIVE IMPACTS of:		
impacts on yield curve of changes of each type:							**FED FUNDS**	**DEFICIT**	**TOTAL**
3-month	-1.97%		0.00%	0.00%	0.00%	0.00%	-1.97%	0.00%	-1.97%
6-month	0.00%	-1.89%	0.00%	0.00%	0.00%	0.00%	-1.89%	0.00%	-1.89%
1-year	0.05%	-1.88%	0.00%	-0.26%	0.00%	0.00%	-1.83%	-0.26%	-2.09%
2-year	0.12%	-2.09%	0.00%	-0.58%	0.00%	0.00%	-1.71%	-0.84%	-2.54%
3-year	0.11%	-2.54%	0.00%	-0.26%	0.00%	0.00%	-1.59%	-1.10%	-2.69%
5-year	0.18%	-2.69%	0.00%	-0.28%	0.00%	0.00%	-1.41%	-1.38%	-2.79%
10-year	0.20%	-2.76%	0.00%	-0.29%	0.00%	0.00%	-1.20%	-1.65%	-2.85%
30-year	0.14%	-2.69%	0.00%	-0.18%	0.00%	0.00%	-0.99%	-1.74%	-2.72%

Effect on i rates
Term Structure debt mgmt.
BD

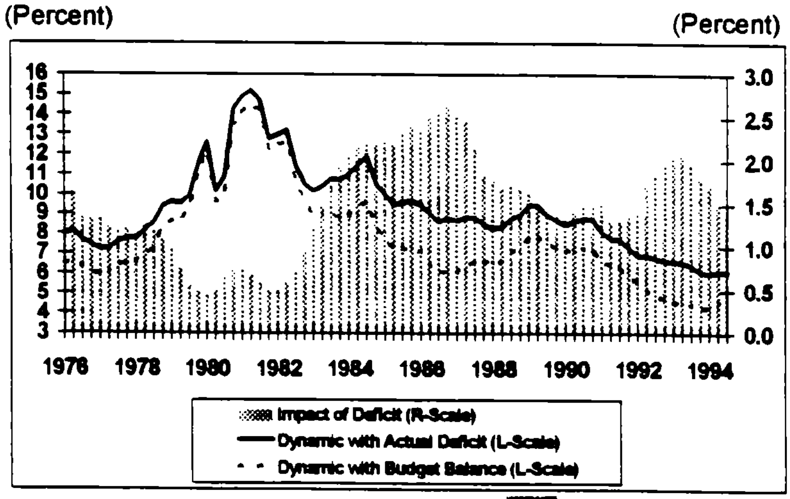
Full-Employment Federal Government Deficit

(Deficit as a Percent of GDP)

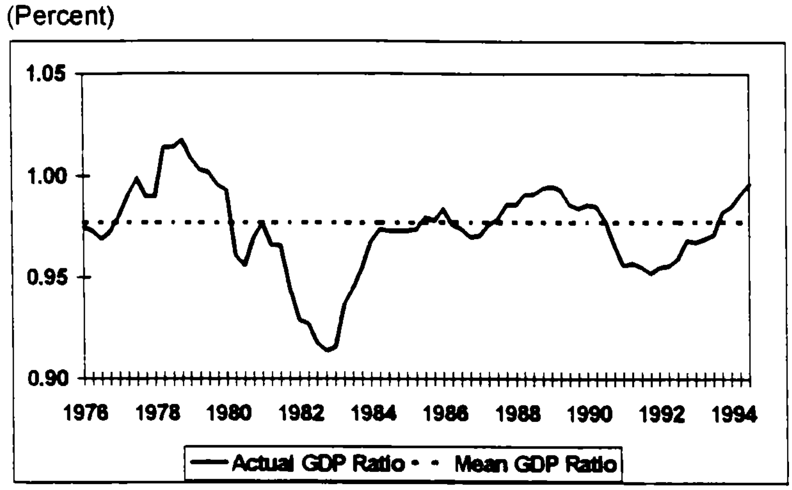


Impact of Structural Budget Deficits on 10 Year Note Yield

(Assuming Unchanged Federal Funds Rate)



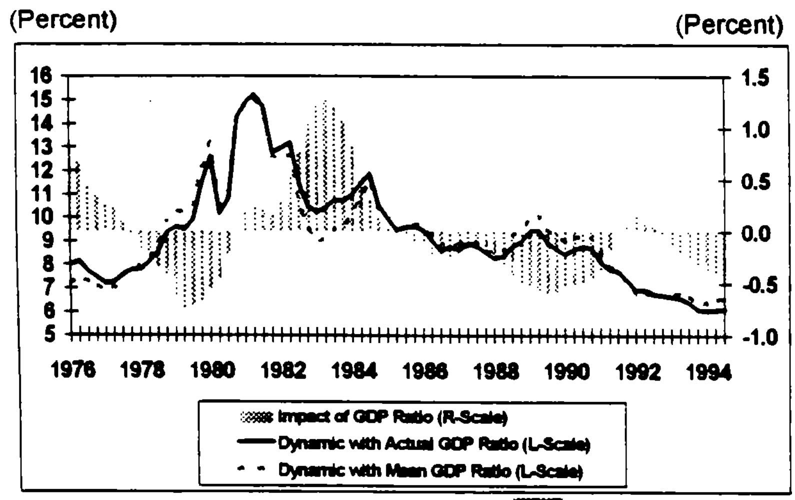
Real GDP as a Percent of Potential/Full-Employment GDP



DRI McGraw-Hill

Impact of GDP Cycle on 10 Year Note Yield

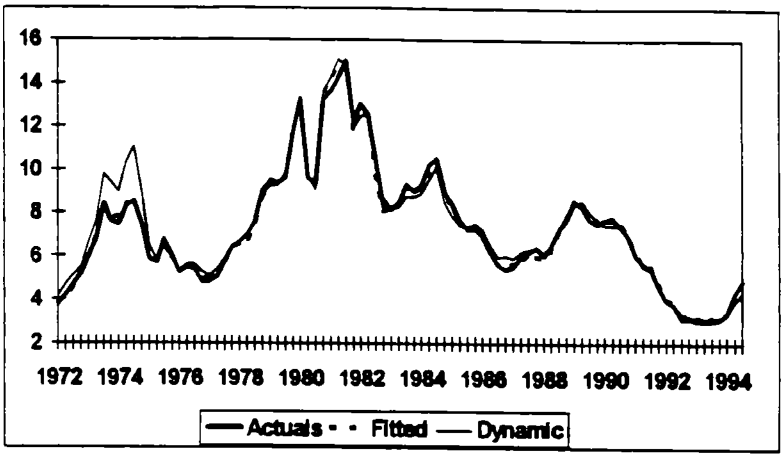
(Assuming Unchanged Federal Funds Rate)



DRI McGraw-Hill

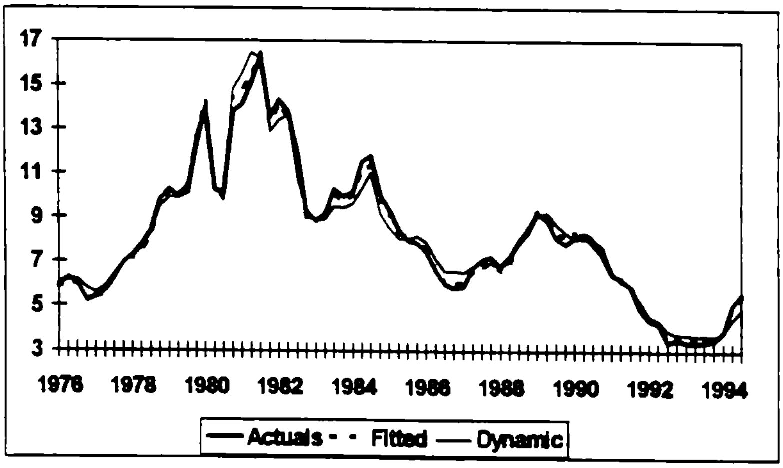
Fitted vs. Actuals – 6 Month T-Bill Rate

(Percent)

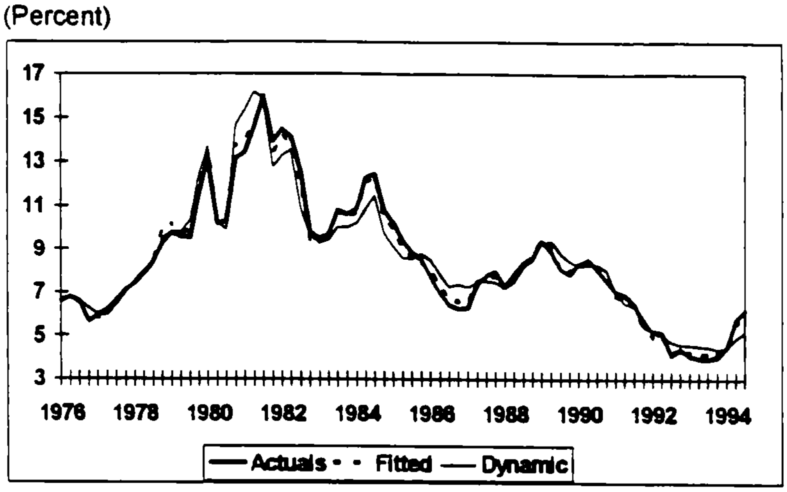


Fitted vs. Actuals – 1 Year Bill Yield

(Percent)



Fitted vs. Actuals -- 2 Year Note Yield



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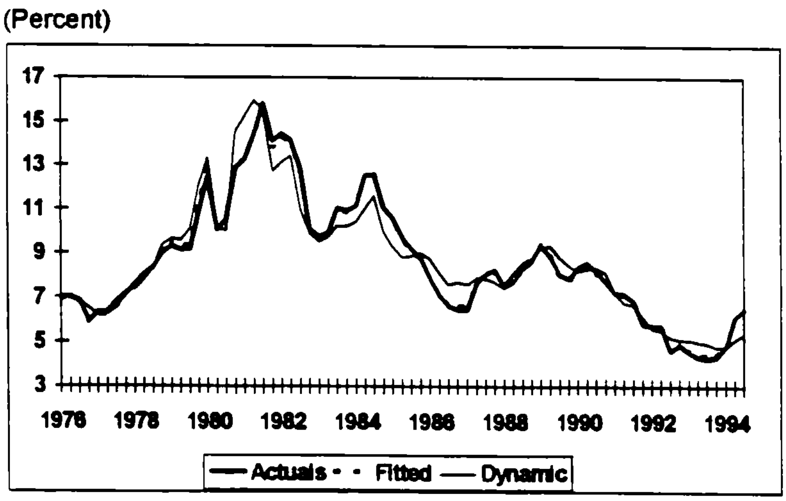
Fitted vs. Actuals -- 3 Year Note Yield



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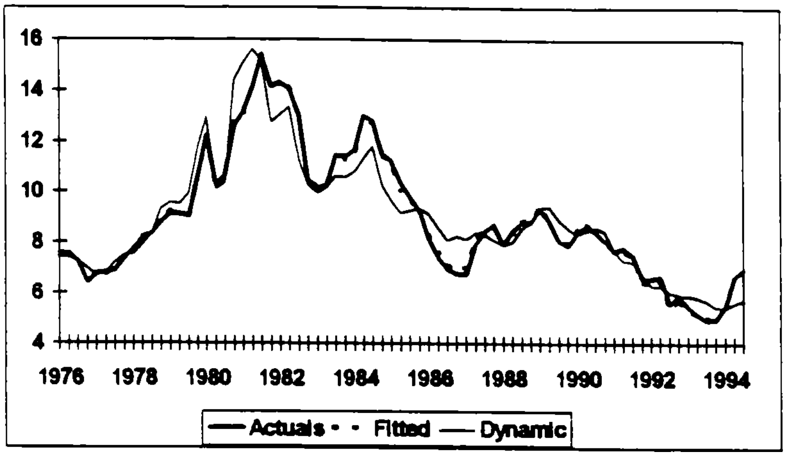
Fitted vs. Actuals -- 5 Year Note Yield

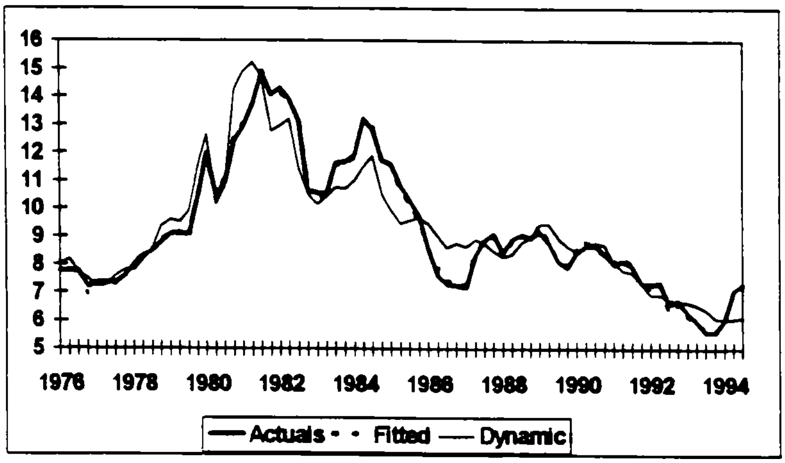
(Percent)



17

Fitted vs. Actuals -- 10 Year Note Yield

(Percent)



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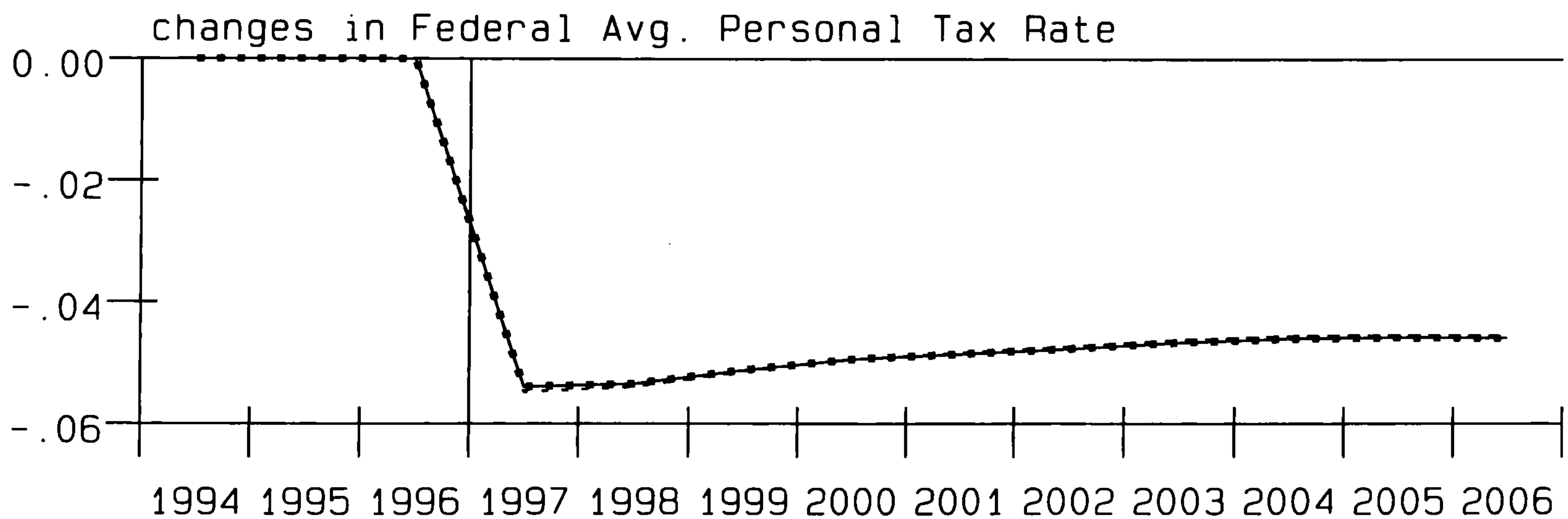

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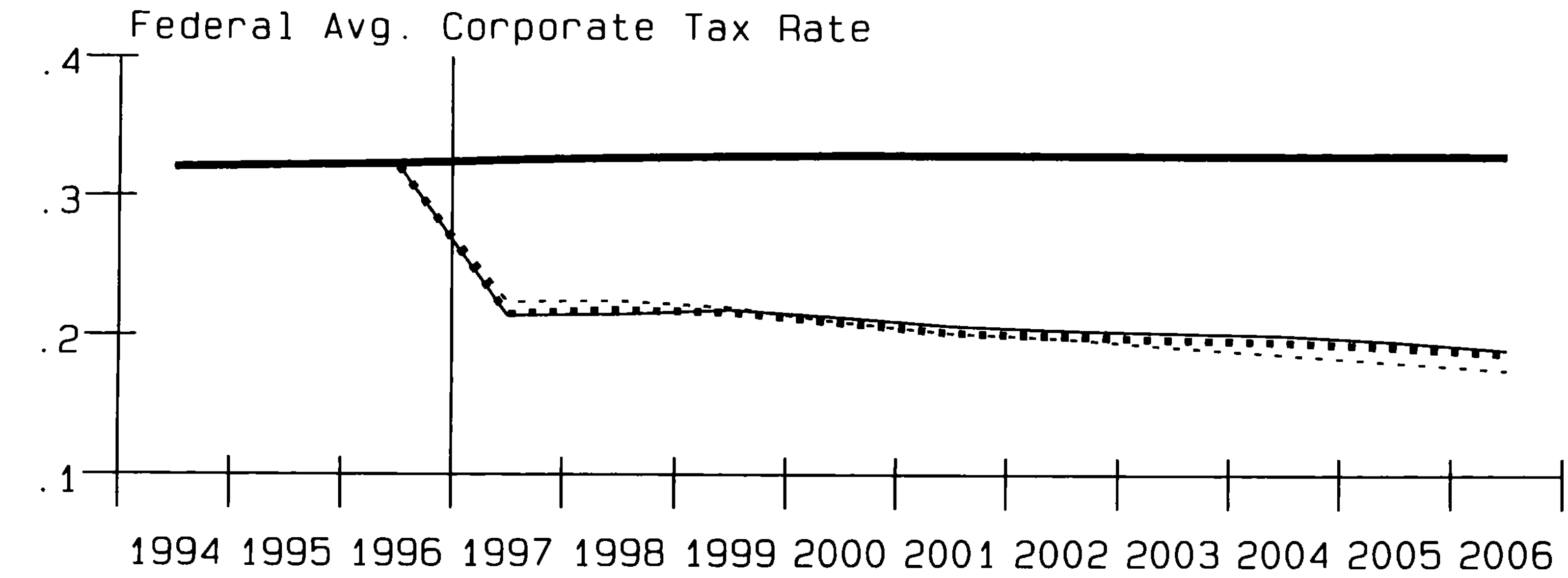

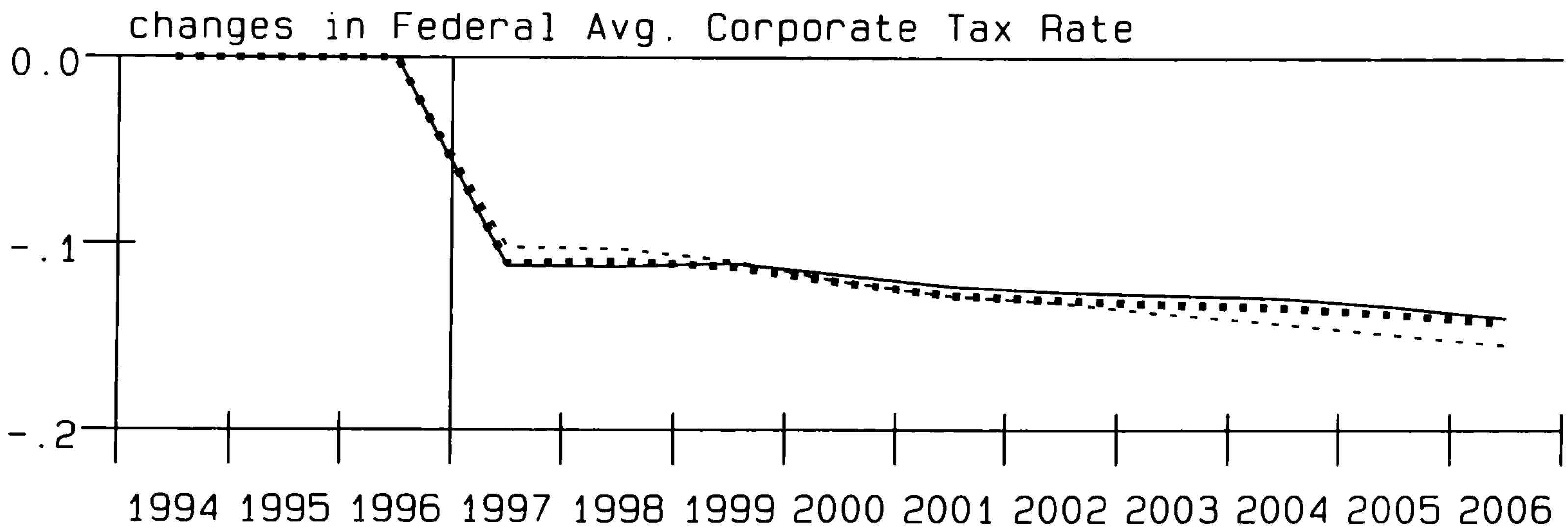

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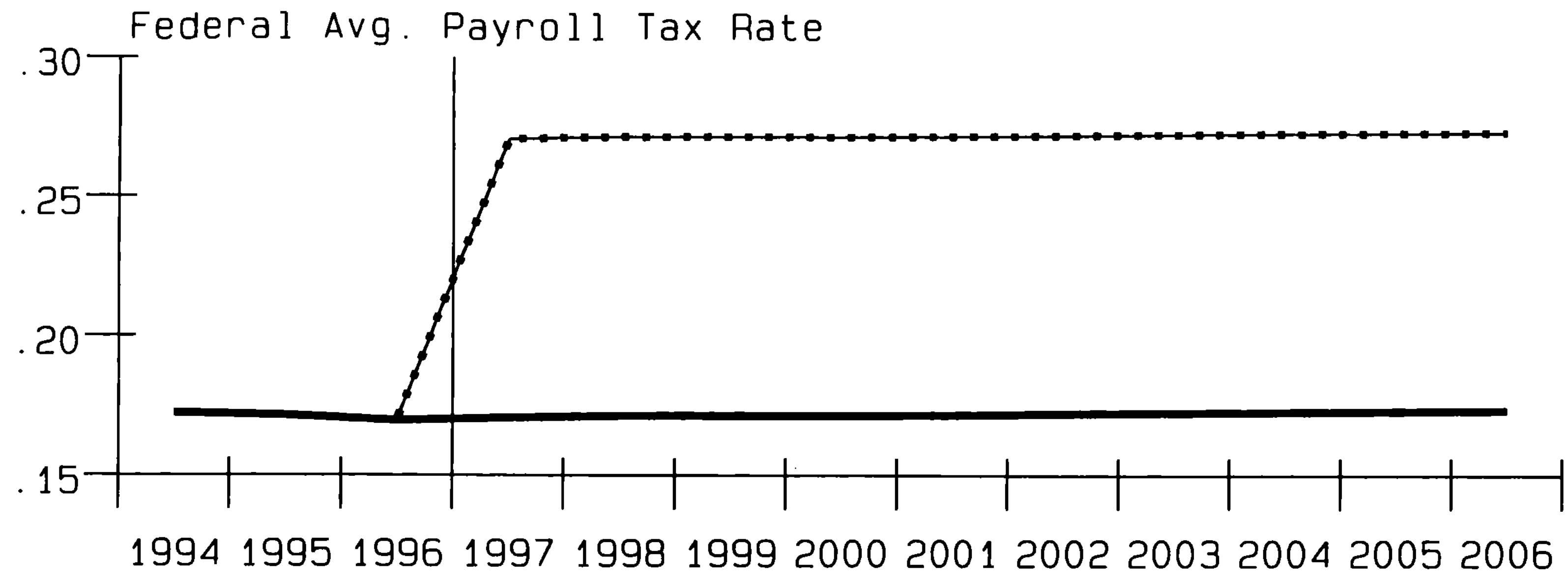

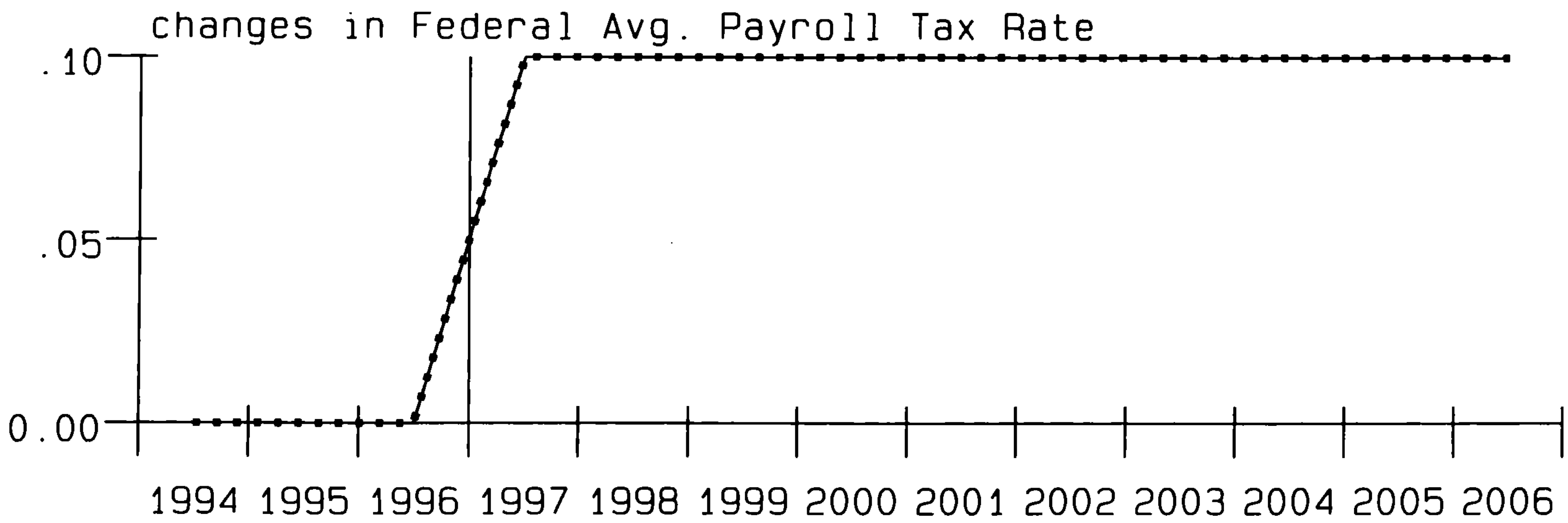

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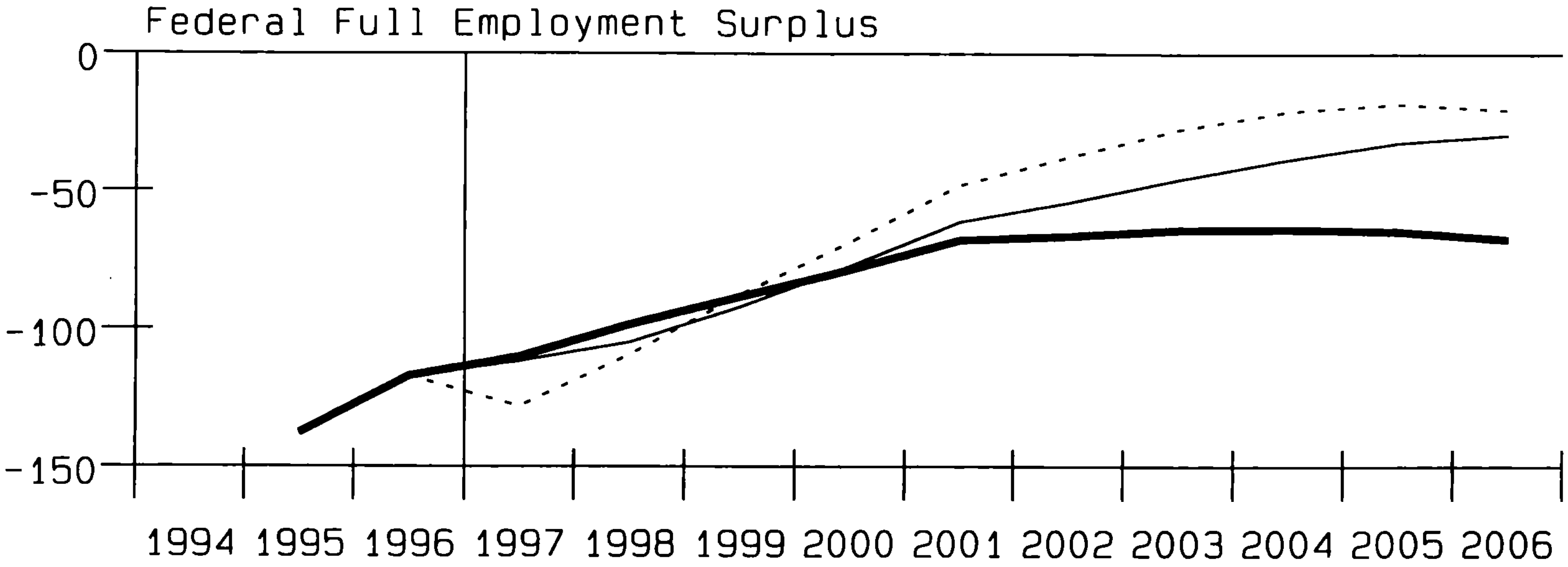

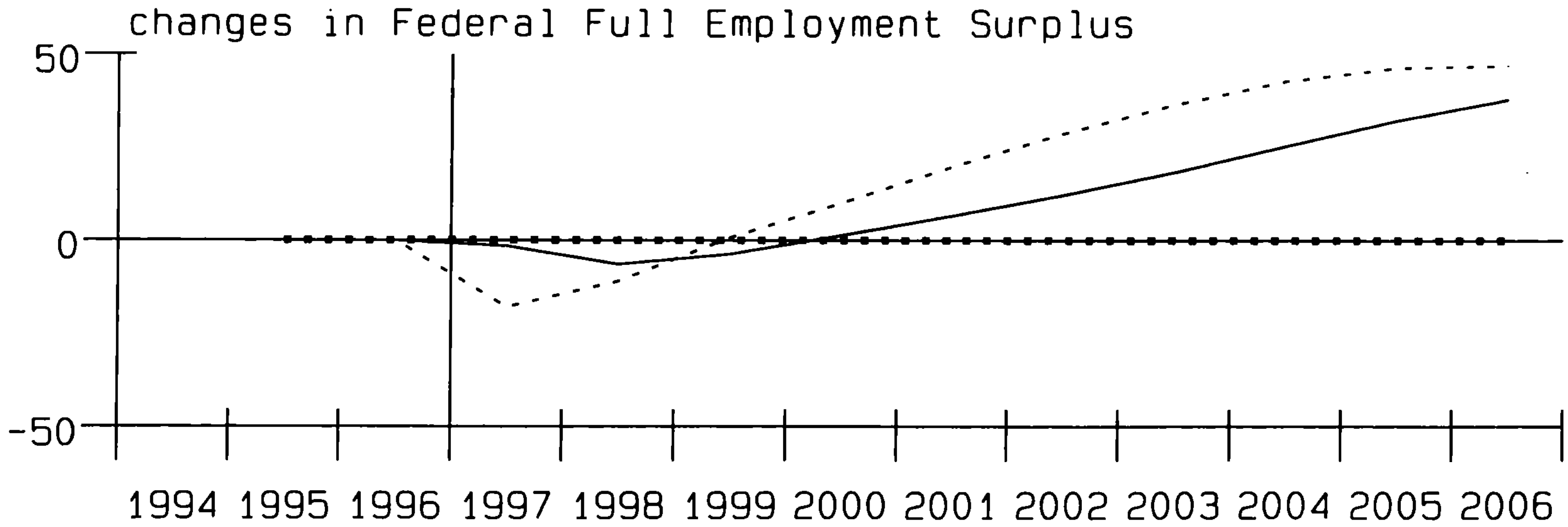

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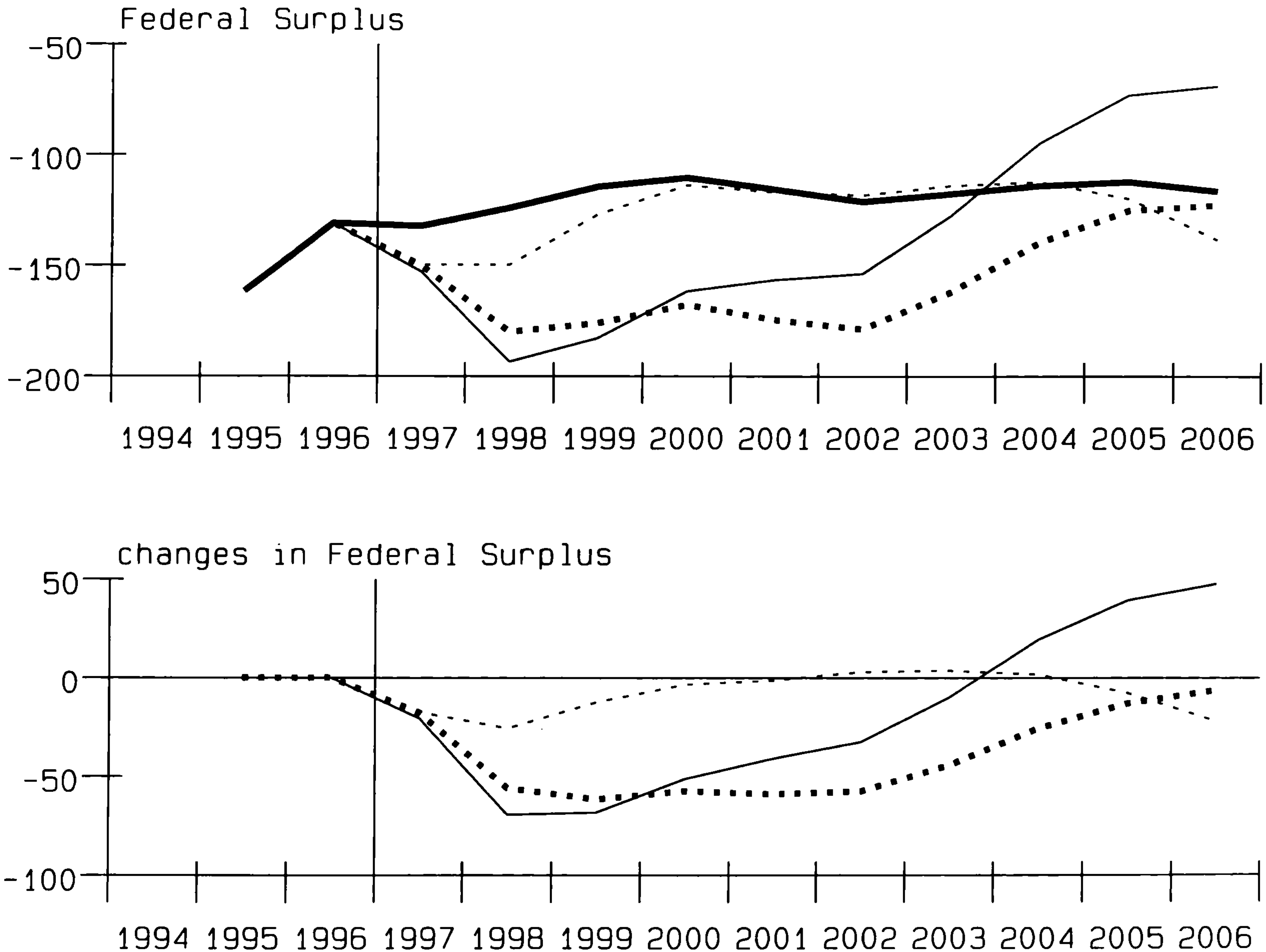

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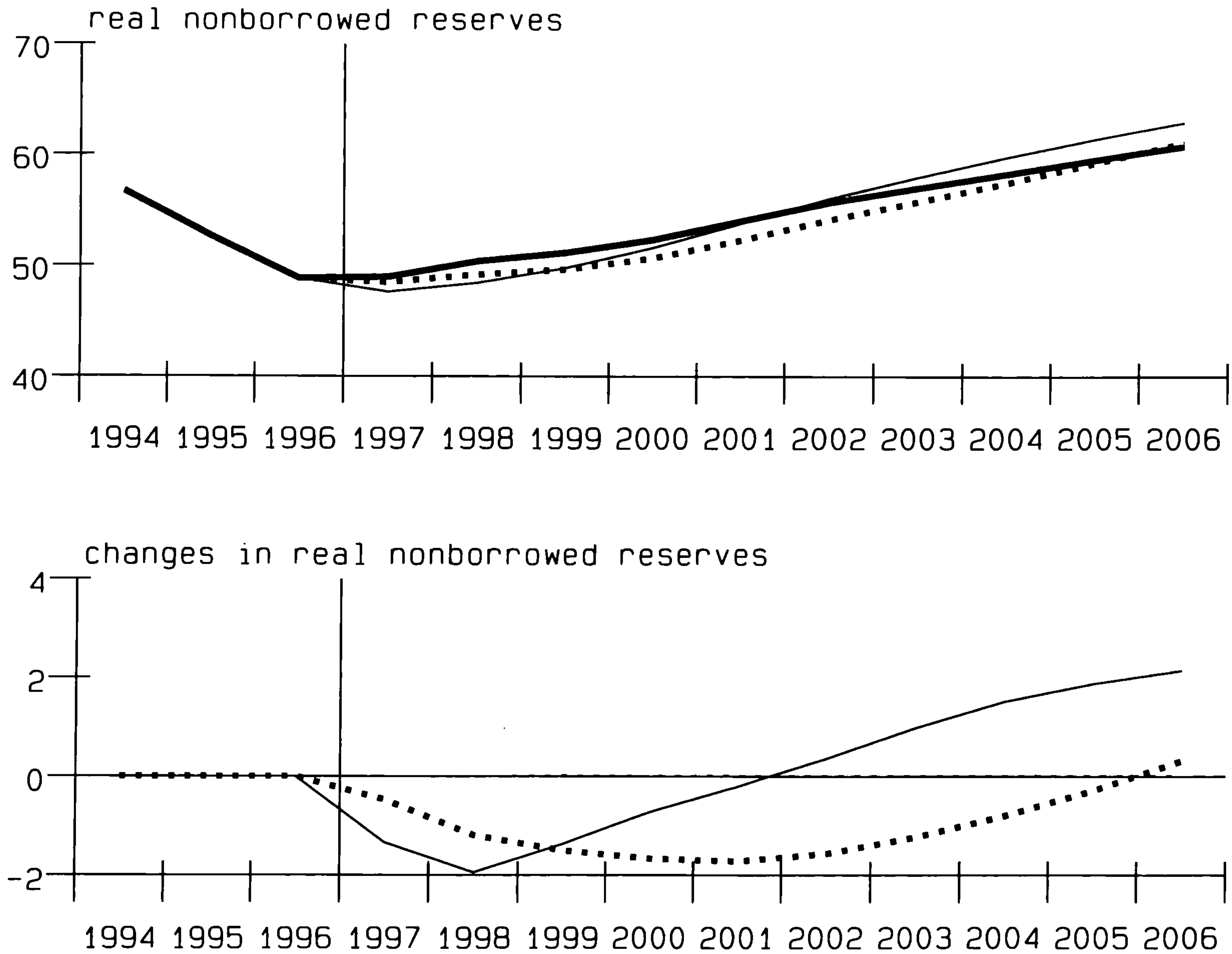

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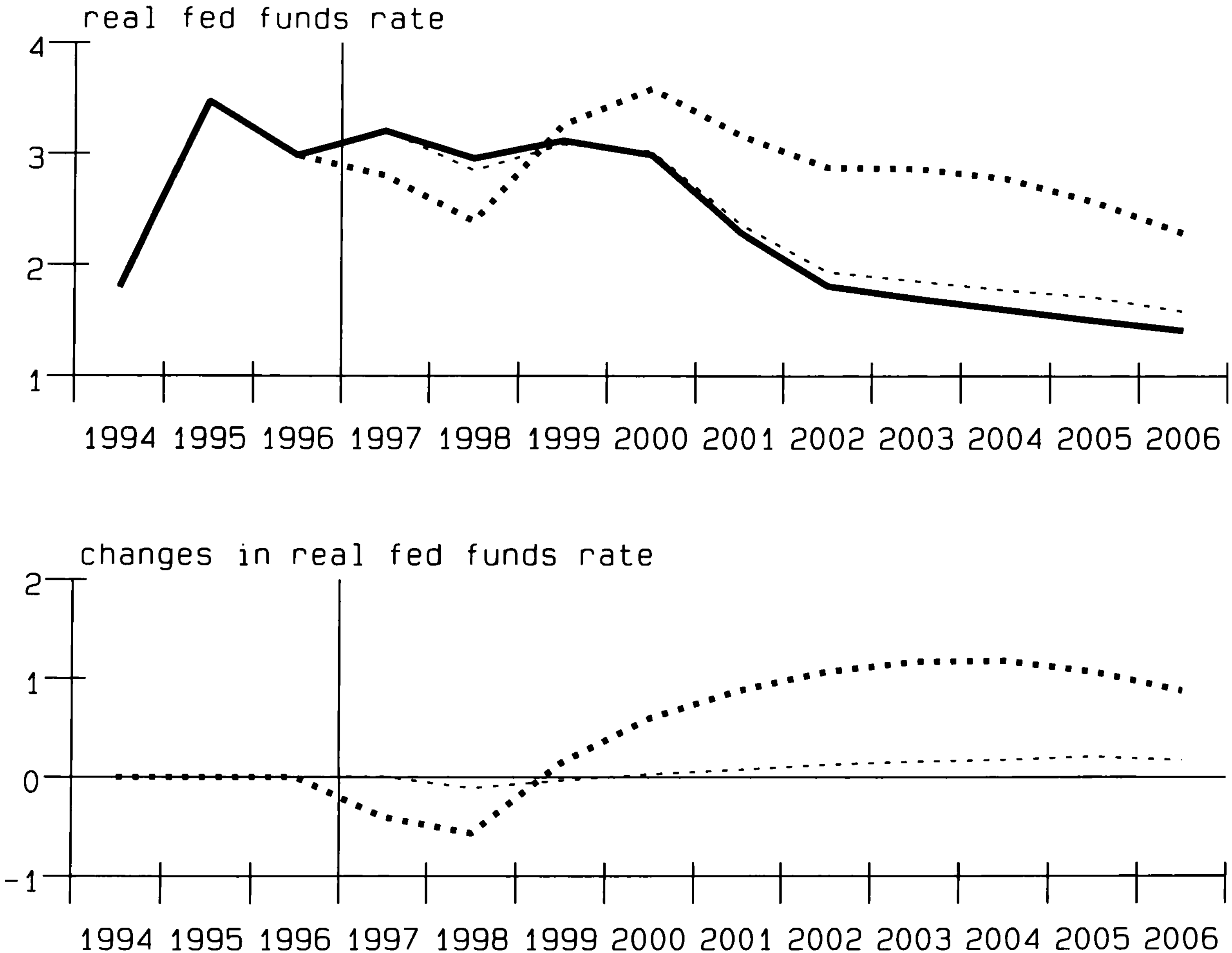

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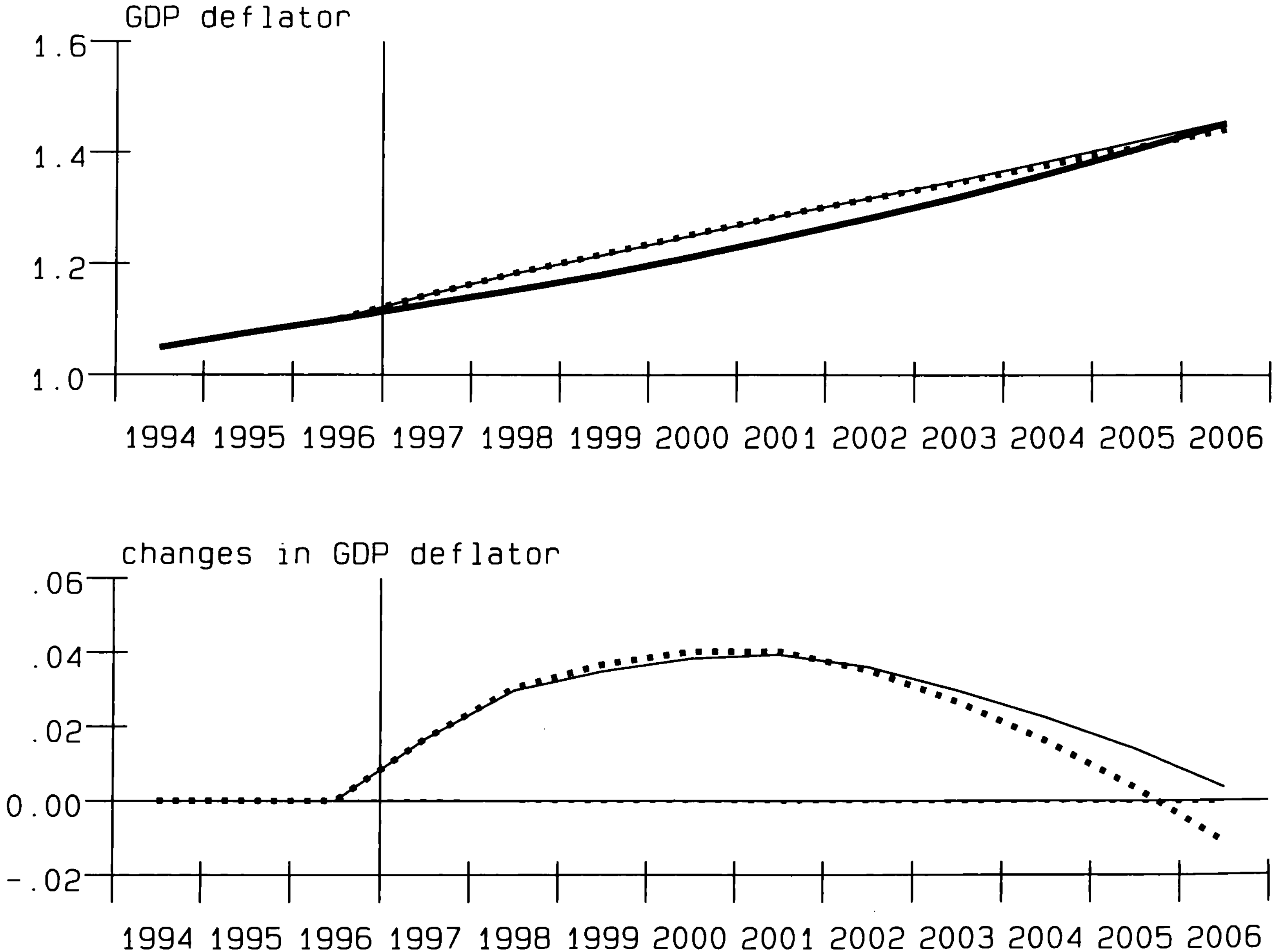

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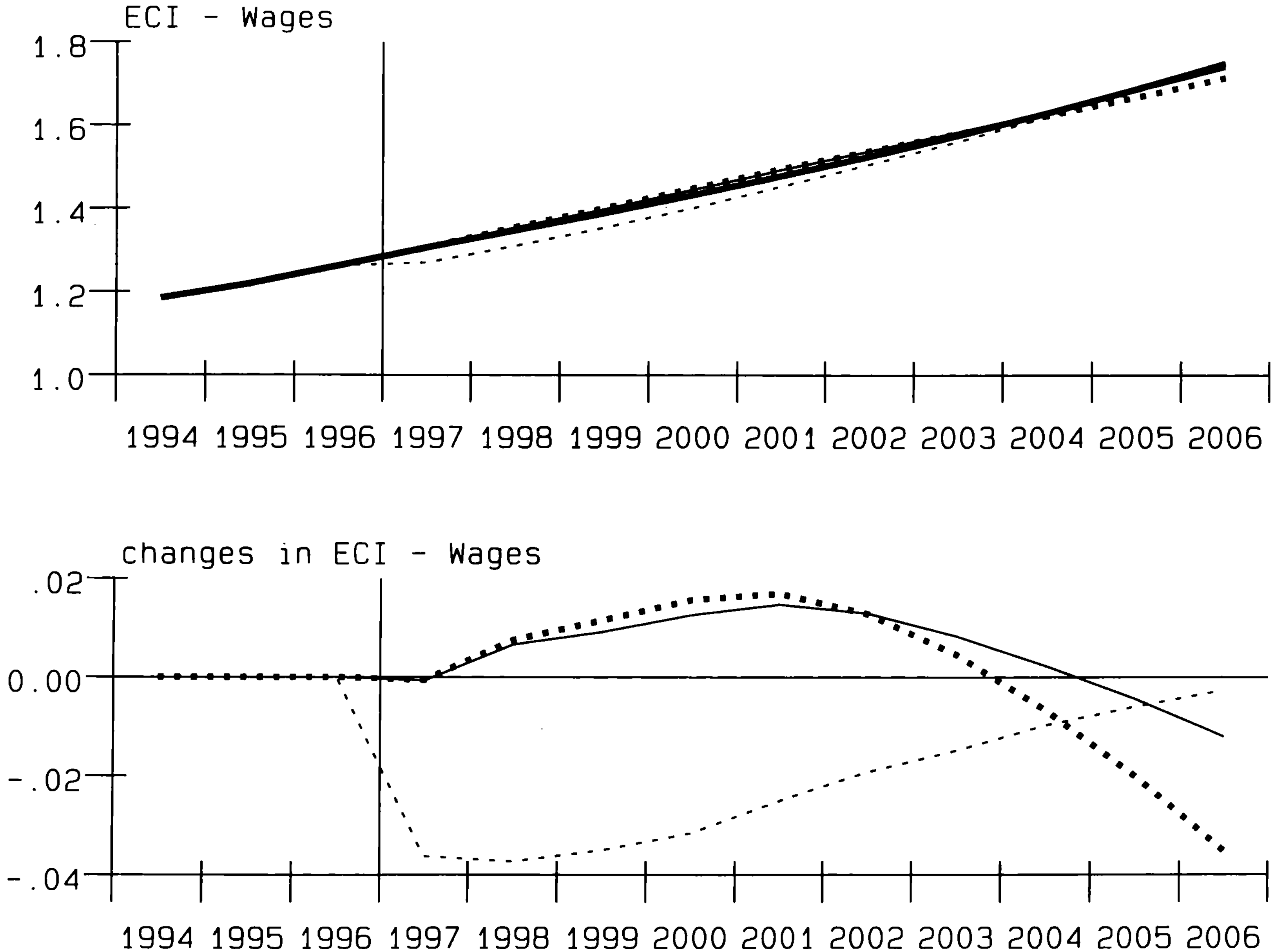

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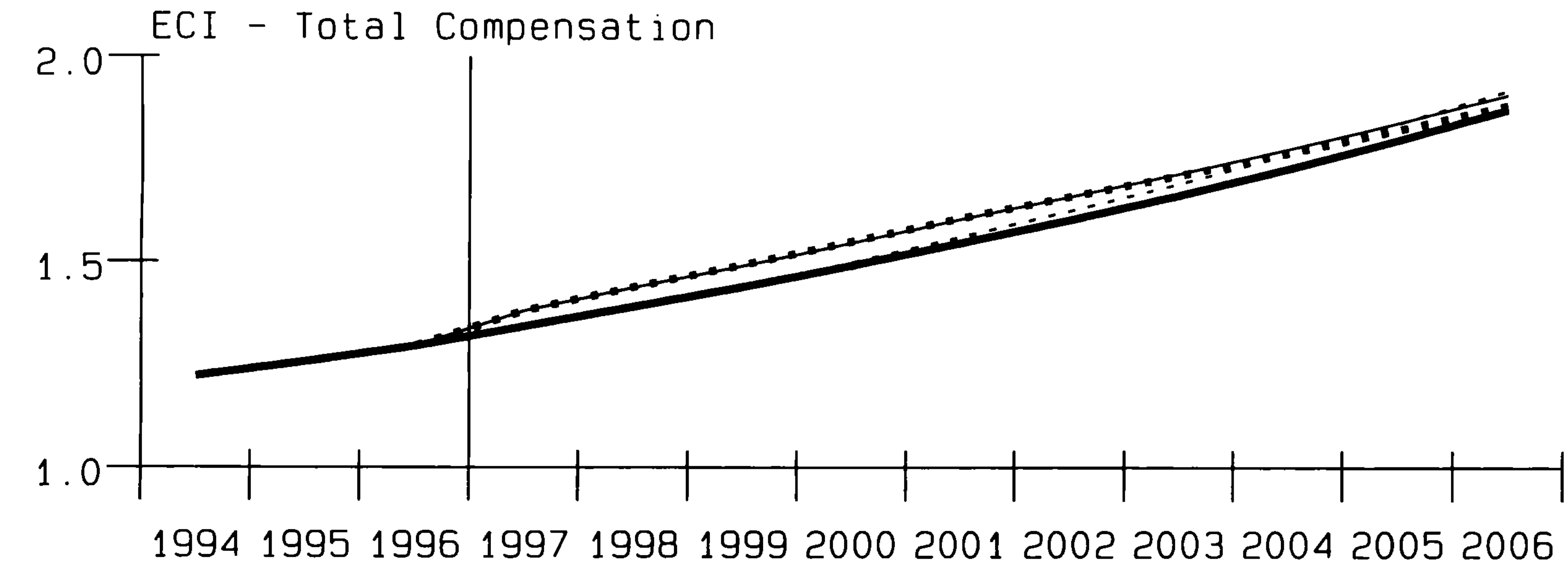

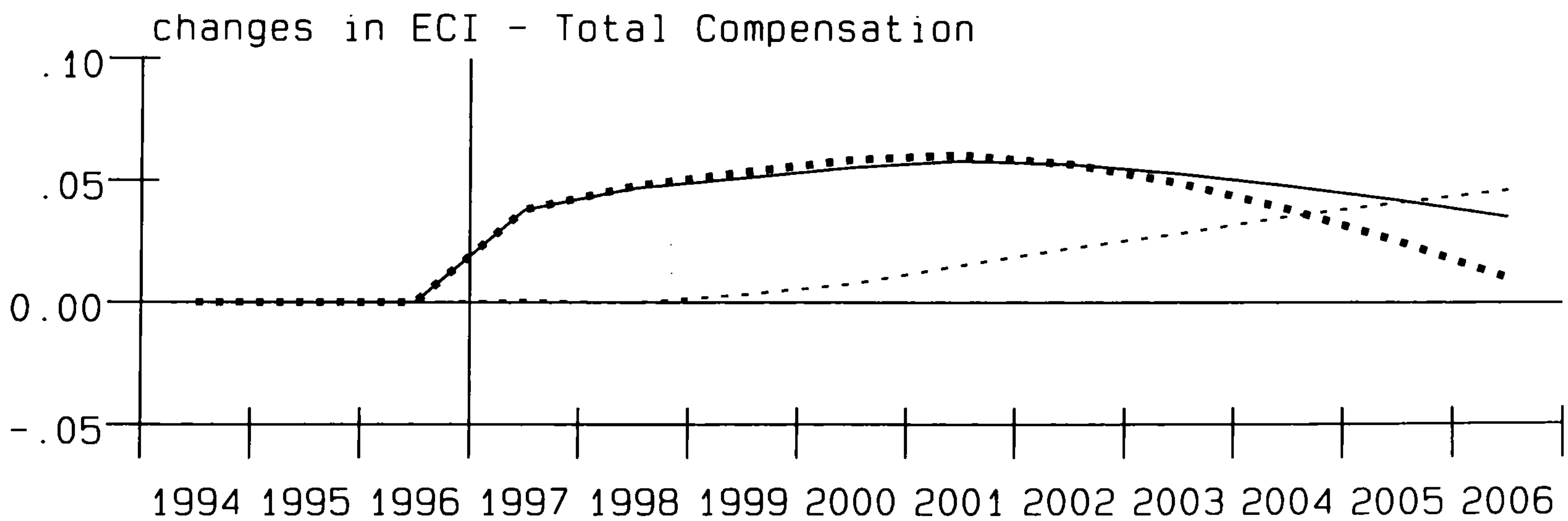

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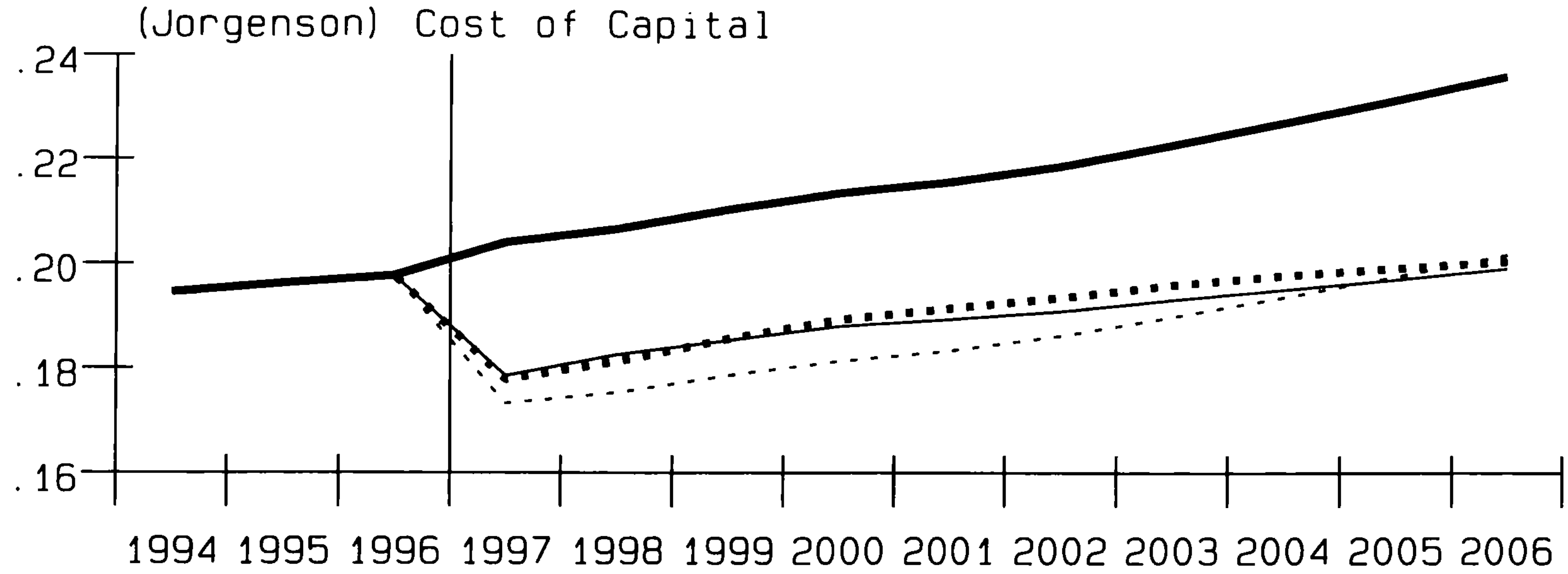

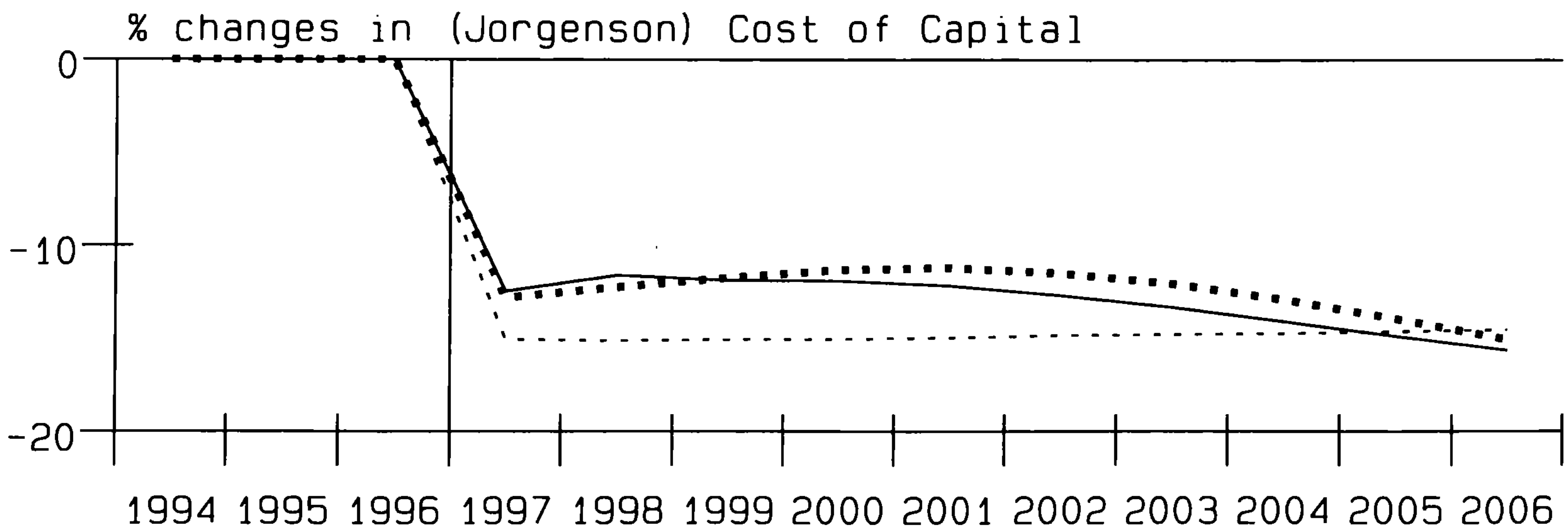

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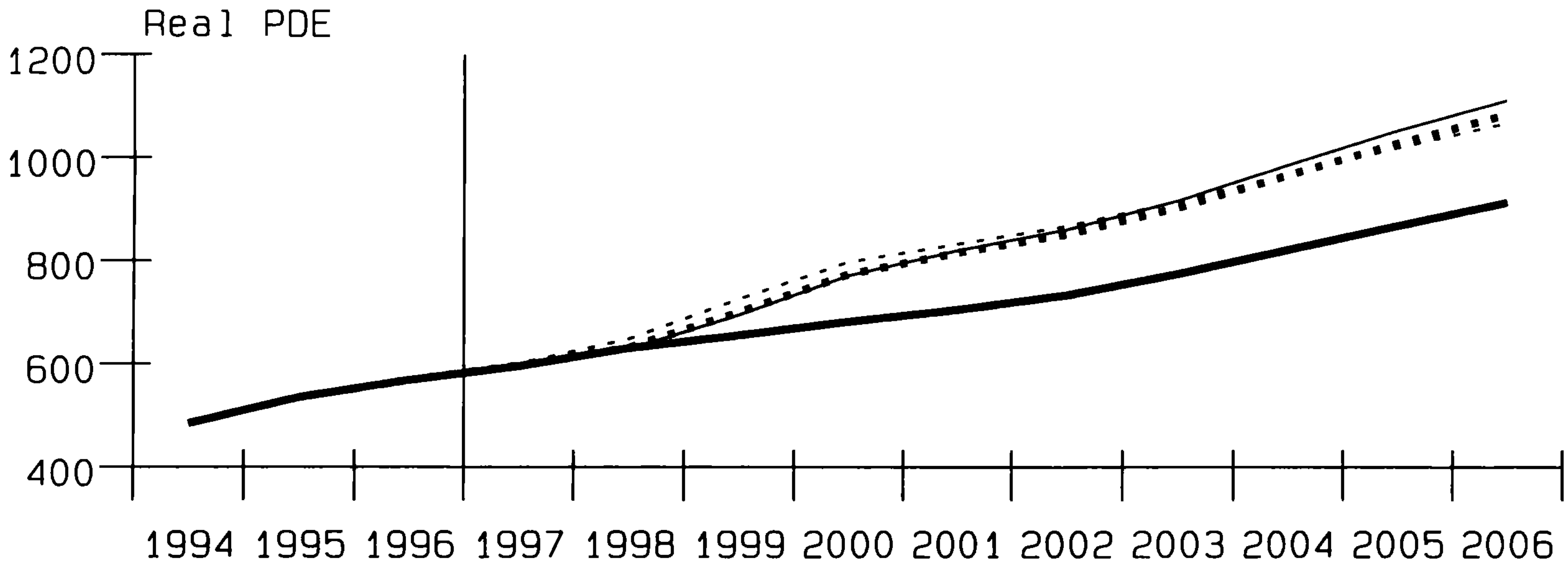

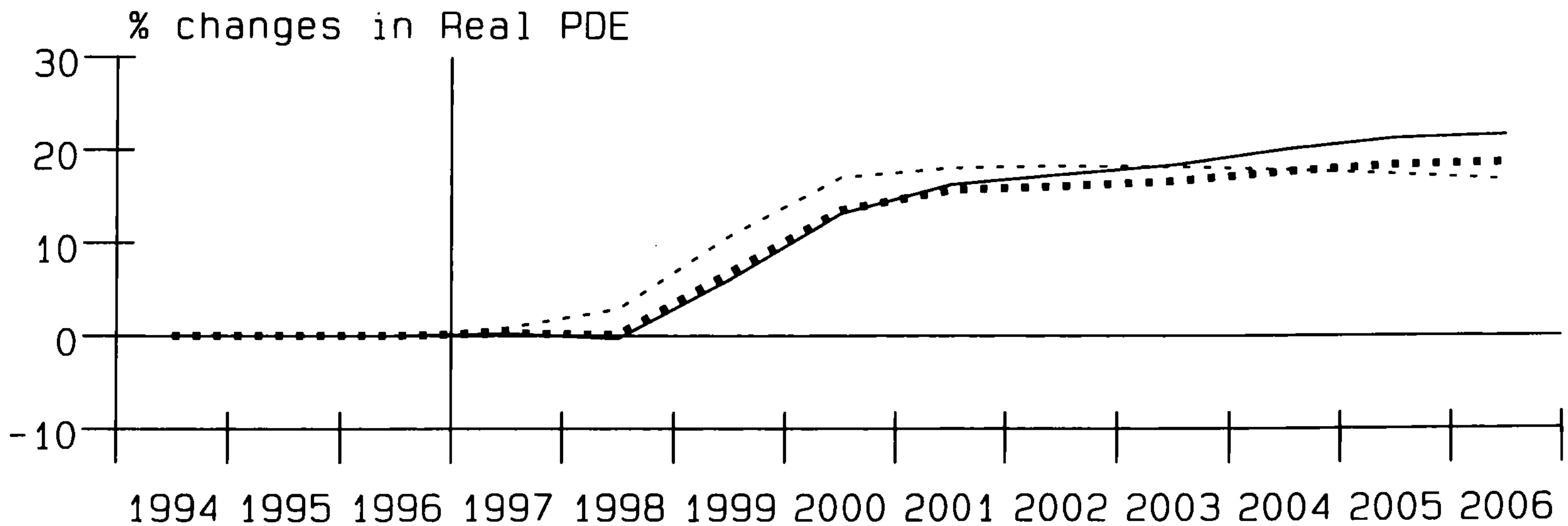

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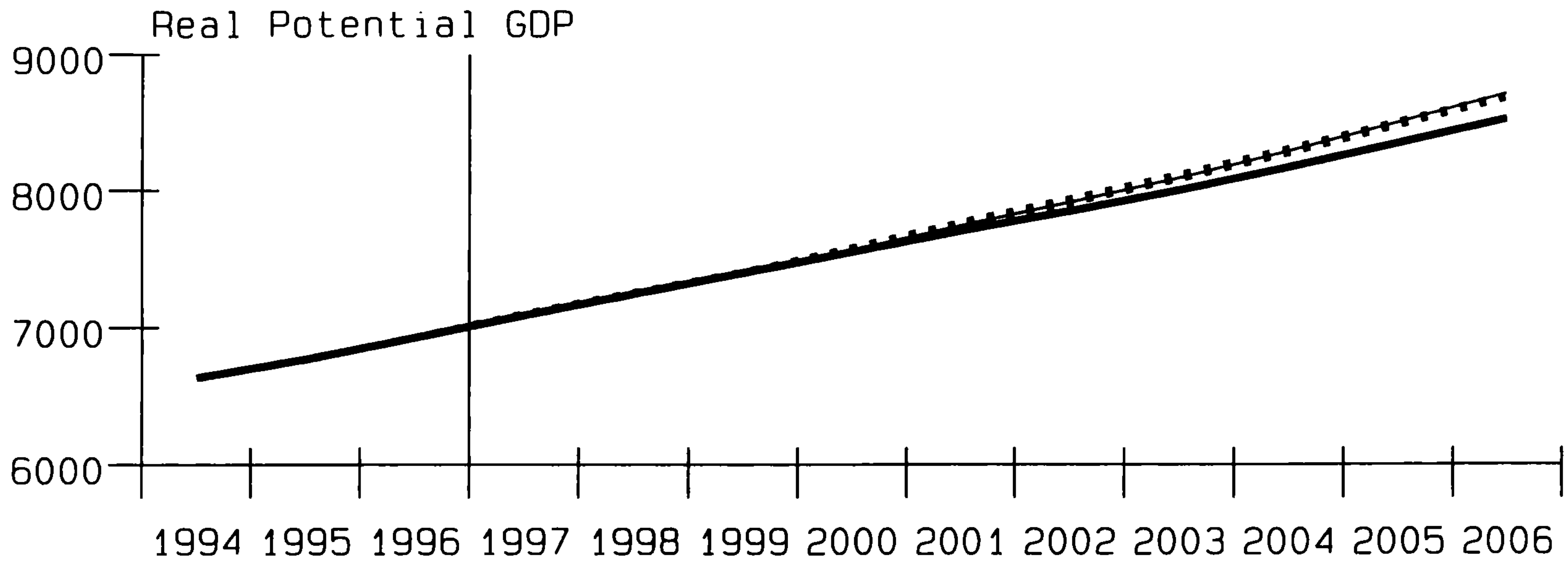

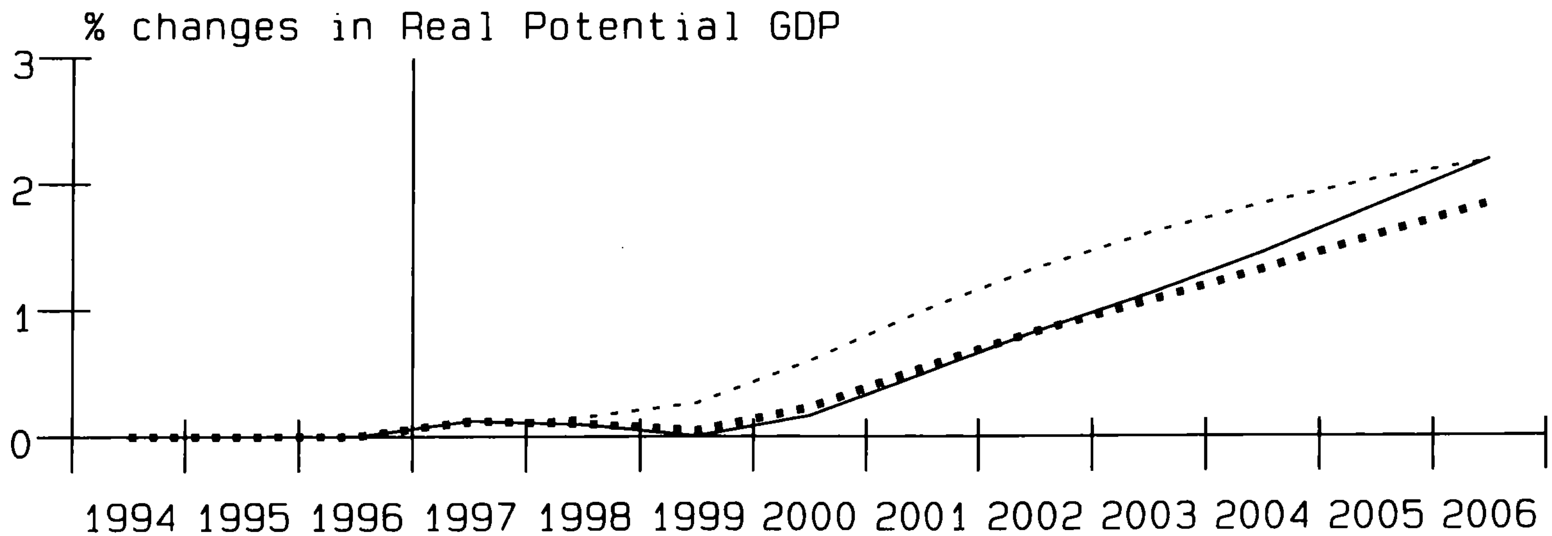

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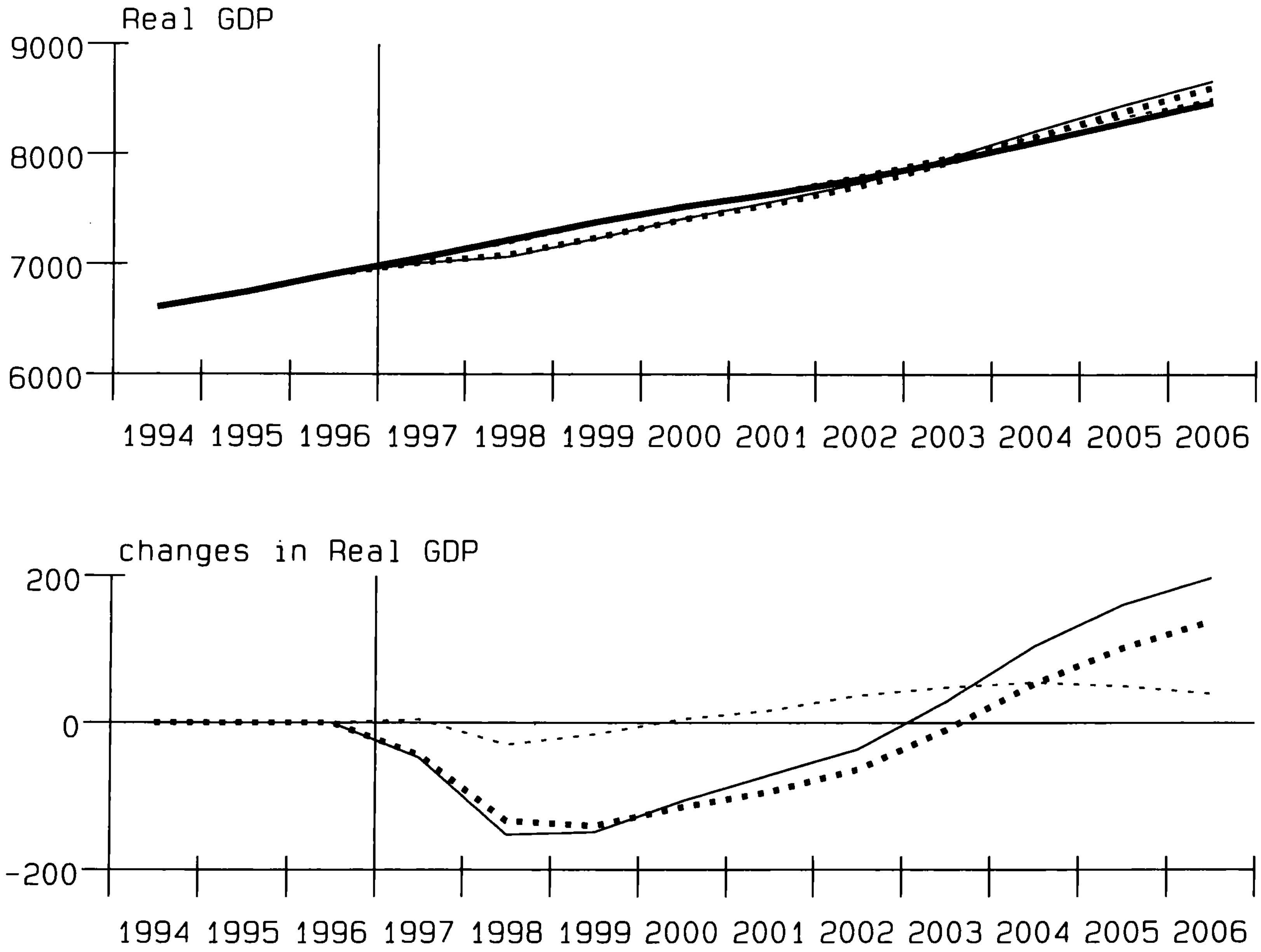

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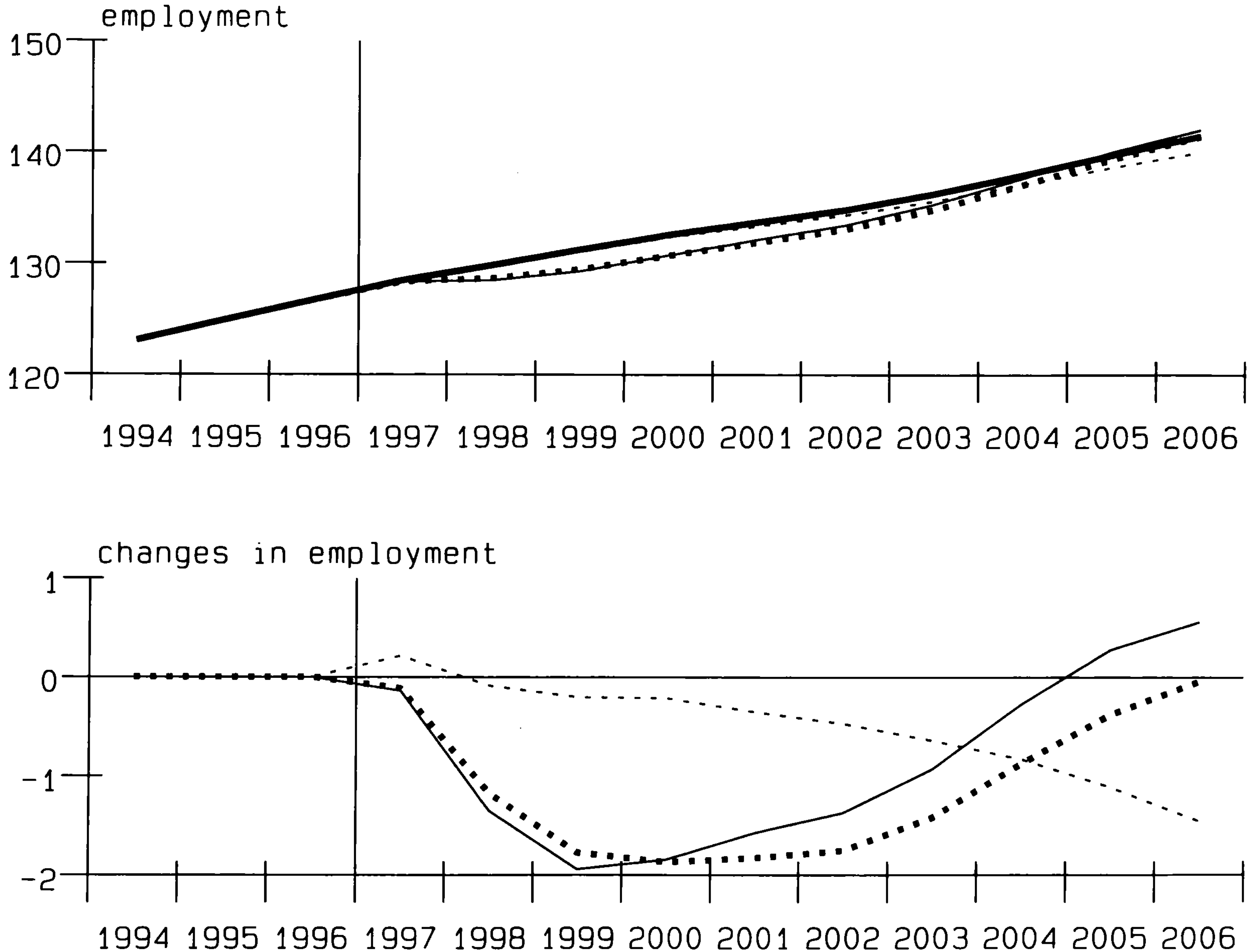

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