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HIERARCHICAL OPTIMAL CONTROL FOR POLICY EVALUATION USING ECONOMETRIC MODELS FOR THE EUROPEAN COMMUNITY (*)

Yukio Ito
Meijo University, Nagoya, Japan
Joseph Plasmans
UFSIA (Univ. of Antwerp), Belgium, and, Tilburg University, The Netherlands
Aart de Zeeuw
Tilburg University and Free University, Amsterdam, The Netherlands
Alejandra Cervio Pinho, and, Anton Markink
UFSIA (**) Tilburg Univ.

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Universitaire Faculteiten St.-Ignatius
Prinsstraat 13 - 2000 Antwerpen
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A b s t r a c t

The purpose of this paper is to analyse the optimal coordination among interdependent economies with an (independently) acting coordinator, using aspects of hierarchical control theory in a linear(ized)-quadratic framework. It is argued that such a decision model could describe a simplified structure of the European Community. In the hierarchical control problem, the coordinator (i.e., the European Commission, Council of Government Leaders) at the upper level adjusts the actions of the subsystems (i.e., the countries of the European Community) at the lower level in order to achieve an overall objective, whereas the subsystems aim at their own objectives. According to the underlying econometric model, the coordinator's target variables influence the dynamic development of the target variables in the subsystems. The coordinator's policies influence the subsystems' targets, and vice versa. The direction of the information transmission can lead to "Top-Down" or to "Bottom-Up" policies, or to constrained policies (i.e., "Constrained Top-Down" or "Constrained Bottom-Up").

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1 - Introduction

The economic relationships in the society can be represented by a complex system consisting of small subsystems with different functions, showing own objectives and constraints. We shall consider an independent policy maker over the subsystems, who will try to coordinate the individual policies in order to steer the economy of the system towards a more desirable state. This hierarchical economic structure can be seen as a pyramid, with a coordinator in the vertex (upper level), and the subsystems in the base of it (lower level). The subsystems may have common objectives in favour or against the coordinator, or may have competing objectives. We shall assume that Hierarchical Optimal Control Theory applies to this macroeconomic framework since, in this paper, we would focus our attention on the hierarchical relationships. This type of control policies for hierarchical structures has been investigated for (artificially) simple model structures by Ito (1988 and 1989) and Ito and de Zeeuw (1989).

This paper is organized as follows. A brief exposition about the econometric model is given in section 2. In section 3, a theoretical formulation for the Hierarchical Control Policy Problem is presented. In section 4, Hierarchical Control Theory is applied on an (interdependent) econometric model for the European Community, given in section 2, under different information structures. Finally, some conclusions and remarks are addressed. In appendices A and B, the complete specification of the model can be found, and in appendices C and D, some explanatory tables of the results and graphics are shown.

2 - An Interrelated Kernal Model for the EC

To analyse the optimal coordination in the European Community, we have to find a proper model which allows the application of the theory being exposed below. We have built an annual interconnected econometric model, based on the COMET-V model (1988) for the Common Market. The countries under study are the EC-countries less Luxembourg (left out because its Gross Domestic Product represents less than 0.2% of the EC's GDP), and an aggregate of these countries (table 1 gives a complete list of the countries). The set of country models must have a similar structure to facilitate a comparison among them.

We want to remark that over the sample period, the values for the EC were obtained as an aggregation of the values of each country expressed in dollars, when the countries' variables were measured in their national currency. In the case of price indices or interest rates, the EC's values were calculated as a weighted sum of the values of each country. The population variables are, obviously, a simple sum of the variables.

The model was estimated and tested on a yearly basis for the sample period 1960-1986. Hierarchical Control Policy was analysed for the period 1987-1992. Coherence of the available data and the availability itself are important constraints when the specification of the structural equations starts. Throughout the sample period, we have used the same data sources [2] to avoid any difference in the definition of the variables.

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[2] EC, "ESA, European System of Integrated Economic Accounts", and, IMF, "International Financial Statistics", several years in both cases.

Table 1
Decision Units and Coordinator

DB	Federal Republic of Germany, in billions of Deutsche Marks
FR	France, in billions of French Francs
IT	Italy, in billions of Italian Liras
NL	The Netherlands, in billions of Dutch Guilders
BE	Belgium, in billions of Belgian Francs
UK	United Kingdom, in millions of Pounds Sterling
IR	Ireland, in millions of Irish Pounds
DK	Denmark, in billions of Danish Krones
HE	Greece, in billions of Greek Drachmas
PO	Portugal, in billions of Portuguese Escudos
ES	Spain, in billions of Spanish Pesetas
EC	European Community, in billions of US Dollars

The purpose of this model is to capture the interactions between the economies of the EC member countries, concentrating on the sensitivity of each country with respect to the others, in a medium term economic model. Such a kernal model of the EC-countries, which we shall use in this study, is specified in Appendix B.

This kernal model is a linear(ized) econometric model, with about 8 behaviourial equations per country. These equations refer to private expenditure (consumption and investment), foreign trade (total exports and imports), price indices (Gross Domestic Product deflator and total exports prices), unemployment rate and money stock. A definitional equation for Trade Balance was also introduced into the model. The specification of the vector of endogenous variables is given in table 2.

Table 2
Endogenous (Target) Variables

CPO	household consumption in constant '80 prices
IPO	investment (other than residential or governmental) in constant '80 prices
XTO	total exports in constant '80 prices
MTO	total imports in constant '80 prices
PY	GDP's deflator ('80=100)
UR	unemployment rate
FMD	money stock in current prices
PXT	price index of total exports ('80=100)
TB	trade balance TB:=(XTO*PXT)/(MTO*PMT) [3]

3 - Theoretical Framework

We shall define the structure of a hierarchical system consisting of several decision units or subsystems and a coordinator. The latter must try to neutralize the possible conflicts of interests that may arise among units, and optimize the performance of each subsystem, keeping in mind the goal of the system as a whole. Trying to capture the interrelationships and the

[3] The definitions of the variables, used in the model, are given in Appendix A.

forces which are taking place within the system, we may define a linear econometric model as follows:

$$Y_i(t)=A_iY_i(t-1)+A_{i0}Y_0(t-1)+B_iu_i(t)+D_id_i(t)+\eta_i(t) \qquad (1)$$

where:

$Y_i(t)$: an m_i-dimensional vector containing the endogenous variables of the i-th country, representing the objectives for the subsystem i (i=1,2,..,N) and the coordinator (i=0); it will be called the i-th **Target** vector; moreover, A_i (i=0,1,...,N) is a matrix of the system parameters belonging to the lagged endogenous variables and A_{i0} (i=1,2,...,N and i≠0) is the matrix of parameters which shows the effects of the coordinator's lagged endogenous variables on the i-th subsystem;

$u_i(t)$: a p_i-dimensional vector of the exogenous variables which are subject to control by the i-th policy maker; these variables will be called **Instrumental** or **Control** variables; moreover, B_i is the matrix of coefficients belonging to these control variables;

$d_i(t)$: an l_i-dimensional vector, called **Purely Exogenous** or **Data** vector, including the current and lagged non-controllable exogenous variables of the i-th subsystem; D_i is the matrix of coefficients belonging to these purely exogenous data;

$\eta_i(t)$: an m_i-dimensional residual vector, assuming that

$E(\eta_i(t))=0$ and $E(\eta_i(t)\eta_j'(s))=\delta_{ij}\delta_{ts}\Omega_{ij}$, where δ_{ij} and δ_{ts} are Kronecker deltas.

On the basis of this presentation, we can assume that in order to achieve a certain objective $Y_i^*(t)$, fixed in advance as an ideal path, each policy maker has to choose a control vector $u_i(t)$. He will penalize any deviation of the objectives from their ideal (desired) path. On the other hand, he should keep the control variables within a coherent range of values through the a priori imposition of some restrictions on the possible variation of the values for these control variables (setting an ideal or desired path for these variables also), and he will also penalize the deviations from the desired path. With this idea in mind, we can formulate the objective function (or cost function) for each policy maker, which is assumed to be quadratic and is expressed as a weighted sum of the squared deviations of the target and control variables from their desired values. This problem is an **Optimal Control Problem**, and will be analysed as a minimization of a weighted sum of objective functions, subject to the econometric model as a dynamic constraint.

The **Hierarchical Optimal Control Problem** can be thought of as a system where one coordinator, in the upper level, has to minimize his/her own cost function , while the subsystems, in the lower level, have their own cost functions to be minimized. Taking these into account, we can split the optimal control problem into two different control problems. The first one, the **Center Problem**, where the coordinator tries to adjust the interactions among subsystems, is the coordinator's problem. The second problem, related to the individual decision units, will be called the **Local Problem**. In this case each subsystem has to minimize its own weighted (cost) function. These two problems can be written in the following way:

Center Problem:

$$\underset{\{u_0(t)\}}{Min} J_0 = \underset{\{u_0(t)\}}{Min} \sum_t \mathrm{E}(\|Y_0(t)-Y^*_0(t)\|^2_{Q_0(t)}+\|u_0(t)-u^*_0(t)\|^2_{R_0(t)}) \qquad (2)$$

subject to

$$Y_0(t)=A_0Y_0(t-1)+B_0u_0(t)+D_0d_0(t)+\eta_0(t) \qquad (3)$$

Local Problem:

$$\underset{\{u_i(t)\}}{Min} J_i = \underset{\{u_i(t)\}}{Min} \sum_t \mathrm{E}(\|Y_i(t)-Y^*_i(t)\|^2_{Q_i(t)}+\|u_i(t)-u^*_i(t)\|^2_{R_i(t)}) \qquad (4)$$

subject to

$$Y_i(t)=A_iY_i(t-1)+A_{i0}Y_0(t-1)+B_iu_i(t)+D_id_i(t)+\eta_i(t) \qquad (5)$$

where $Y_i^*(t)$ and $u_i^*(t)$ (i=0,1,...,N) are the desired target and desired control variables respectively. The weighting matrices $Q_i(t)$ (i=0,1,...,N) are assumed to be positive semi-definite and $R_i(t)$ (i=0,1,...,N) are assumed to be positive definite; N is the number of subsystems.

It will be assumed that there is no (instantaneous) information exchange among the EC countries and the coordinator. Hence, the local decision units do not know the coordinator's target variables in advance, and, so, the policy makers of the local decision units cannot evaluate the future implications of the coordinator's target variables on their own target variables. Therefore, the subsystems would adopt a myopic behaviour, i.e., they would decide on their policy after receiving the information from the coordinator, period by period. The same holds for the coordinator. From now on, we shall consider that there are individual objective functions for each period of time, which can be written as:

$$J_i(t) = \mathbf{E}(\|Y_i(t) - Y^*_i(t)\|^2_{Q_i(t)} + \|u_i(t) - u^*_i(t)\|^2_{R_i(t)})$$

$$= (\|Y_i(t) - Y^*_i(t)\|^2_{Q_i(t)} + \|u_i(t) - u^*_i(t)\|^2_{R_i(t)}) + trQ_i(t)\Omega_{ii} \qquad (6)$$

so that, according to the Certainty Equivalence Principle, the optimal solutions will be the same in a stochastic optimal control problem with additive error term as in a deterministic optimal control problem. Taking the first partial derivatives of these objective functions with respect to the control variables, and equating these derivatives to zero, we obtain:

Coordinator's control solution:

$$\hat{u}_0(t) = -(B'_0(t)Q_0(t)B_0(t) + R_0(t))^{-1}[B'_0(t)Q_0(t)\{A_0Y_0(t-1) + D_0d_0(t) -$$

$$-Y^*_0(t)\} - R_0(t)u^*_0(t)] \qquad (7)$$

Subsystems' control solution:

$$\hat{u}_i(t) = -(B'_i(t)Q_i(t)B_i(t) + R_i(t))^{-1}[B'_i(t)Q_i(t)\{A_iY_i(t-1) + A_{i0}Y_0(t-1) +$$

$$+D_id_i(t) - Y^*_i(t)\} - R_i(t)u^*_i(t)] \qquad (8)$$

According to equation (8), the subsystems' control solutions at period t are determined by the coordinator's target variables at period t-1. Therefore, the subsystems' response to the different policies, determined by the coordinator, would occur with a delay. We may say that a forward information transmission is taking place between the coordinator and the subsystems. The reverse situation can also be considered (see equation (7)), where $Y_i(t-1)$ could influence $\hat{u}_0(t)$ via $Y_0(t-1)$).

4 - Application on a European Kernal Model

Considering that the econometric model presented in section 2 will be used to evaluate policy coordination, the instrumental (control) variables need to be defined. Table 3 gives a list of the instrumental variables used.

Table 3
Instrumental (Control) Variables

SIR	short term interest rate
LIR	long term interest rate
EXR	nominal exchange rate
WGU	compensation of employees of the general government in current prices
NG	total employment of the general government
ITR	indirect tax rate ITR:=IT/(CPU - IT)
SSHR	rate of social security contributions of households SSHR:=SSH/(WBU + GOSH)
DTCR	direct tax rate on companies' profits DTCR:=DTC/(YU-DPU-IT+SUB-WBU)
DTHR	direct tax rate on households' income DTHR:=DTH/(WBU+GOSH+SBH-SSC)
SUB	subsidies in current prices

The main instruments are fiscal and parafiscal variables as the (effective) direct tax rates on household income and company income, the indirect tax rate and the rate of social security contributions of households. Other important instruments are monetary policy variables as the long or short term interest rate, the (average) exchange rate with respect to the dollar and the governmental subsidies, wages and employment.

Analysing the hierarchical control problem, we can see that the control solutions will be affected by the magnitude of the elements of the (diagonal) weighting matrices $Q_i(t)$ and $R_i(t)$ (i=coordinator and countries). By setting different values for the elements of the $Q_i(t)$-matrices, the policy makers can state a ranking within the target variables. The policy makers may impose different penalties to the control variables also, by setting different elements for the $R_i(t)$-matrices. We have computed several experiments varying the weighting matrices, as well as considering different desired paths for the target and control variables, e.g., various experiments with constant and varying weights. However, in this paper we shall only show the results of the experiments with varying weights. The first experiment was computed considering the elements of the $Q_i(t)$-matrices being equal to the inverse of the square of the desired target variables, and the elements of the $R_i(t)$-matrices being equal to the inverse of the square of the desired control variables [4]. The second experiment was computed by doubling the penalty imposed for deviations from the desired paths for the GDP's deflator and the unemployment rate [5] vis à vis the other variables, stressing an economic priority on an anti-inflation and anti-unemployment policy.

To compute the hierarchical control solutions, desired paths were needed for the target and control variables during the planning period 1987-1992. The desired paths for the target variables were calculated following a desired evolution of the variables in the different countries. For the control variables, we considered that the desired path should be as close as possible to the observed or anticipated value of the variable. For that reason, we have used the OECD publication [6], which contains the observed values until 1988-1989, and the OECD forecasts of the evolution of

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[4] $Q_i(t):=1/Y_i^*(t)^2$ and $R_i(t):=1/u_i(t)^2$, where $Y_i^*(t)$ is the desired target vector and $u_i(t)$ is the anticipated value of agent i's control vector. The desired path of the control variables is considered to be their anticipated path. Notice that such weighting leads to similar cost contributions for different variables.

[5] $Q_j(t):=2/Y_j^*(t)^2$ when j=PY and UR. The other Q_i-elements and the R_i-matrices remain equal to the previous experiment.

[6] OECD, "Economic Outlook", July 1991.

the variables until 1992. As some values were missing, we used, for Portugal and Greece, the EC data [7] as an alternative. Hence, we assumed that the OECD (or EC) predictions are the most probable or anticipated values.

Within a hierarchical structure, the relationship between the coordinator and the subsystems does not need to be downwards from the top to the bottom level, but can also be the reverse. The optimal control solutions can be divided into different categories depending on the direction of the information transmission , which can be defined as follows:

- **Pure Top-Down Policy:** the coordinator determines the overall desired target and desired control variables, and transmits them into the subsystems' optimal policies in the next period.
- **Pure Bottom-Up Policy:** each subsystem determines its control policy, after receiving the initial targets from the coordinator. Then, the subsystems transmit the information of targets and control variables to the coordinator, who determines his/her optimal policy in the next period. In this case, the coordinator's desired target and desired control variables can be considered as a (weighted) sum of the subsystems' desired target and desired control variables.
- **Constrained Top-Down Policy:** the coordinator determines the overall targets, but imposes no restriction on the values of the subsystems' control variables. We can assume that the coordinator's desired control variables will be the (weighted) sum of the desired values of the subsystems' control variables, as in the Bottom-Up case.
- **Constrained Bottom-Up Policy:** the coordinator receives the information of targets from the subsystems. Afterwards, he transmits his desired control variables to the subsystems, which implies a restriction on the subsystems' optimal policies. The coordinator's target variables can be assumed to be the (weighted) sum of the subsystems' target variables.

We depict our assumptions in the following scheme:

	$u_0^* = \Sigma\, u_i^*$	u_0^*
$Y_0^* = \Sigma\, Y_i^*$	Pure Bottom-Up	Constrained Bottom-Up
Y_0^*	Constrained Top-Down	Pure Top-Down

[7] EC, "YEARNA" or "FINPUB", 1989.

where Y_0^* and u_0^* are the coordinator's desired target and desired (=anticipated) control vectors respectively, while $Y_0^*:=\Sigma Y_i^*$ and $u_0^*:=\Sigma u_i^*$ are the same vectors but considered as a (weighted) sum of the subsystems' desired target and desired (anticipated) control vectors [8]. We would like to remark that more informative structures can be considered within the constrained policies (i.e., divide the control variables into groups, depending on the various possibilities that the coordinator has to control these variables). Nevertheless, we have computed (only) the four types of information exchange explained above in this paper.

Once the optimal solutions were computed, we have calculated the Targets' Deviations (TD) [9] measuring the magnitude of the difference between the desired target variables and the optimal targets (tables 1 and 1' in appendix C). Looking at these values we can see that the optimal targets track their desired paths pretty well, allowing us to conclude that the optimal targets are (very) near to the desired targets.

When inspecting these tables, a general conclusion is that, except for The Netherlands, Denmark, the United Kingdom and Spain the Top-down optimal solutions are closest to the desired policies, for both priorities. A Constrained Top-Down policy seems to be more efficient for The Netherlands and Denmark, whereas a Constrained Bottom-Up policy shows the lowest TD for the United Kingdom and Spain. In the case of France, in our first experiment, the desired targets were better achieved by the application of a Bottom-Up policy but, when we impose a double penalty for the GDP's deflator and the unemployment rate, the TD is lower when applying a Constrained Top-Down policy. Anyhow, the difference between the indices for various information structures is not important in this case (around 1.5%), so that the type of policy is somewhat irrelevant for France. Hence, a Top-Down type of policy tracks the desired paths best for 8 of the 11 EC-countries considered.

We would analyse the welfare loss as the costs, which each country has to incur for deviating from the desired target and desired control variables. Therefore, we have computed the Square

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[8] Notice, once more, that in our paper $u_i^*(t)=u_i(t)$, $\forall i,t$.

[9] Defined as: $$TD:=\sqrt{\sum_t \|Y^*_i(t)-\hat{Y}_i(t)\|^2_{Q_i(t)}}$$

where $Y^*_i(t)$ and $\hat{Y}_i(t)$ are the desired and optimal target variables, respectively. TD was calculated for the variables expressed in logarithms.

Root of the total Sum of Performance Costs (SRSPC) [10] over the planning period (tables 2 and 2' in appendix C). This index will measure the welfare loss that would take place by the application of a policy different from the ideal (desired) one, per country, and which was defined as:

$$SRSPC := \sqrt{\sum_{t} \{ \| Y^{*}_{i}(t) - \hat{Y}_{i}(t) \|^{2}_{Q_{i}(t)} + \| u_{i}(t) - \hat{u}_{i}(t) \|^{2}_{R_{i}(t)} \}}$$

where:

$Y_i^*(t)$ and $u_i(t)$: are the desired target and desired (anticipated) control variables of the i-th subsystem, and,
$\hat{Y}_i(t)$ and $\hat{u}_i(t)$: are the hierarchical optimal control solutions of the i-th subsystem.

Comparing the optimal results by means of this index, we found that there were no important differences in the results when applying a Top-Down policy or a Constrained Top-Down policy. The same can be said regarding the results of applying a Bottom-Up policy or a Constrained Bottom-Up policy. Hence, it seems to be very important who (coordinator or subsystems) is the first in determining the targets, and, hence, we can conclude that the optimal results are highly influenced by the initial targets (see also TD-conclusions).

Looking at the SRSPC in both experiments (tables 2 and 2' in appendix C), we can conclude that a Bottom-Up type of policy is less costly for the United Kingdom, Denmark, Spain and even for the aggregate European Community. For the rest of the EC-countries, the application of a Top-Down policy (or a Constrained Top-Down policy in the case of The Netherlands) implies lower costs. When we doubled the weights for PY and UR we found, as expected, higher SRSPC-values. However, these indices are still low enough as to conclude that the optimal policies were quite efficient to achieve a reasonable growth of the economy, lower prices and unemployment, and an equilibrium trade balance (i.e., a value close to 1 for TB).

Comparing the SRSPC-indices with the TD-indices, we can see that, for France, lowest costs were obtained by the application of a Top-Down policy, while the lowest TD belongs to a Bottom-Up policy. A similar effect was found for Denmark, where a Bottom-Up

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[10] The SRSPC-measure has been calculated for the variables expressed in logarithms.

policy shows the lowest SRSPC but a Constrained Top-Down policy shows the smallest Targets' Deviation. These uncommon effects are due to deviations of the control variables from their desired (anticipated) paths, and hence, higher costs were found for a Bottom-Up policy in France and a (Constrained) Top-Down policy in Denmark.

In order to compare the optimal results with the policies that are in fact taking place at this moment in the European Community, the Square Root of the Sum of Performance Costs for the observed (anticipated) values was also computed (tables 3 and 3' in appendix C). Since we need the observed (or forecasted) target values for the period 1987-1992, we have used the same data source as for the control variables (see footnotes 6 and 7). This index will indicate how close the actual policies are to the optimal ones for each country.

In the case of the United Kingdom, Ireland, Denmark and Spain we can conclude that the actual policies are far away from the optimal policies, since their SRSPC-values are quite large. For the rest of the countries, the SRSPC-values are small enough as to assume that a coordinated policy (i.e., a Top-Down policy) is close to the policies actually followed within the European Community. For the aggregate EC, a Bottom-Up type of policy seems to be closest to the actual policy since the corresponding SRSPC-values are much lower than those belonging to a Top-Down type of policy.

We consider that it would also be interesting to investigate whether the optimal target and optimal control variables track their desired paths or not, i.e., we want to analyse the efficiency of the optimal policies, for the different variables and countries. Looking for an indicator of efficiency, we have constructed the Theil's inequality coefficient [11] for the target and the control variables. This coefficient will measure the distance between the hierarchical optimal control solution and the corresponding desired values. Therefore, a small $T_{\hat{a}_i}$- value will mean that the hierarchical control policy solution is close to the desired policy. The coefficients corresponding to the optimal results are displayed in tables 4 to 5' in appendix C.

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[11] This coefficient was defined as:

$$T_{\hat{a}_i} := \frac{\sqrt{\frac{\sum(a_{it}^{*}-\hat{a}_{it})^2}{t}}}{\sqrt{\frac{\sum(a_{it}^{*})^2}{t}}}$$

where: i : countries and coordinator,
t : '87,..., '92,
a_{it}^{*} : desired target/control variable,
$\hat{a}_{it}$: optimal target/control variable.

Once again we can see that there is no significant difference between the application of a Top-Down (Bottom-Up) policy or a Constrained Top-Down (Constrained Bottom-Up) policy. The optimal policies seem to be rather efficient for most of the countries with some exceptions for France (some of the control variables), Ireland, Greece, Portugal, Spain and the aggregate EC. Looking at the Theil's coefficients for the second experiment, we do not find large differences with the previous results, although the Theil's-values referring to PY and UR show a slight decrease.

Analysing the efficiency of the optimal policies to achieve the targets, we may say that the money stock seems to be the most difficult variable for hierarchical optimal control. This effect may respond to the fact that the quantity of money can be considered not only as a target but also as an instrument. When we look at the control variables some large inequality coefficients were found, specially those referring to the government compensation of employees. This distortion can be caused, a.o., by the econometric policy model since it does not consider the budget deficit as a control variable. It is also important to consider that, when the optimal solutions are computed, we have to fix anticipated paths for the exogenous variables, and these variables can also introduce some perturbation on the results.

By way of example, we would like to analyse some results in more detail, since they may be of particular interest. The graphics of these cases will be shown in appendix D. As a first example, we may look at the total imports for Germany (MTODB, figure 1). This variable will, in part, be determined by the indirect tax rate (ITRDB, figure 2), which includes the taxes linked to production and those linked to imports. Since the import content of ITRDB is large w.r.t. the production content of ITRDB, large (optimal) changes in ITRDB have an important impact on (optimal) MTODB. (Constrained) Top-Down policy leads to the lowest increase of the German imports.

For the private investment in France (IPOFR, figure 3), the optimal results are lower than the desired path, and they show a similar performance to the observed (anticipated) values. Analysing the control variables, we can see that the optimal indirect tax rate (ITRFR, figure 4) increases much more than the anticipated path during the planning period. Hence, we can assume that the desired investment is not achieved for any of the policies due to the negative effect of taxes on investment. The best policy is the (Constrained) Top-Down policy, with lowest increase in the French indirect tax rate and highest increase of investment.

The optimal private investment in Ireland (IPOIR, figure 5) also shows large differences from the desired private investment.

A Top-Down type of policy seems to be the best policy since the optimal values become much higher than the desired ones, allowing for high production and employment increases. But if we look at the optimal control variables that are promoting this situation, we observed that, a. o., a relative decrease of the subsidies (SUBIR, figure 6, as in the (Constrained) Top-Down situation) leads to an increase of private investment. In a recent study [12] on the impact of the company tax rate on private investments, Plasmans and Vanneste ('91) conclude that a decrease of the company tax rate would stimulate private investments "... if and only if the marginal productivity of capital is sufficiently high. The critical value depends on the depreciation rate, the interest rate and the rate of investment tax credit. When there is no investment tax credit, a stimulating effect of corporate tax rate decreases emerges if and only if the marginal productivity of capital stock is larger than the depreciation rate". Since subsidies to firms can be considered as negative company taxes, and the average depreciation rates of recent investments in Ireland are rather high, this perverse tax effect is very probably occurring in this country.

Finally, we would like to show the evolution of the unemployment rate in Greece (URHE, figure 7) together with the government compensation per capita (WGUHE/NGHE, figure 8). We can see that in order to achieve a decrease of the UR it is necessary to force an increase of the Greek government employment (NGHE, figure 9); but the nominal compensation for government employees (WGUHE, figure 10) increases even stronger, so that the government compensation per capita is also strongly increasing (principally for the (Constrained) Bottom-Up policies). However, we have to remark that the optimal solutions are not taking into account the budget deficit, which would certainly result in a lower government wage increase.

5 - Conclusion

The idea of this paper is to present a coherent approach for policy evaluation, using a multi-country econometric model for the European Community. As a first attempt we may conclude that a Top-Down type of policy will be less costly for the system as a whole, although some notable exceptions were found (principally for the UK). The optimal policies were quite efficient presenting doubts only for Greece and Spain.

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[12] Plasmans, J. and Vanneste, J. (1991) "The Incidence of Corporate Taxation in Belgium on Employment and Investment". Cahiers Economiques de Bruxelles, N° 129, 1er trimestre, pp. 3-25.

From the analysis of the observed (anticipated) values, we may say that for most of the EC-countries a "coordinated" policy (a (Constrained) Top-Down policy), seems to be near to the policy that is taking place in the European Community. On the other hand, for the EC-coordinator, the values obtained by the application of a Bottom-Up policy (where the coordinator is "controlled" by the individual countries), were close to the observed (anticipated) target values.

One essential limitation for this policy approach is that the optimal solution is applied only to one period ahead (myopic behaviour). It will be important to extend the time interval in the policy horizon, involving matrix Riccatti and tracking equations for the optimal solutions. It will also be fruitful to improve this policy approach by refining the hierarchical control model (e.g., including a budget constraint) as well as introducing dynamic game theory in this macroeconomic framework. These extensions will be discussed in some subsequent papers.

Appendix A: Data Source

As a first step of model building, the construction of an homogeneous data bank was needed. A list of the variables used in the model (and its symbol) is given table 1, but we have to specify a few conventions beforehand in order to understand the symbols. A final letter **U** indicates aggregates in current prices, while a final letter **O** denotes variables in constant 1980-prices (approximation for volumes). A first letter **P** identifies price indices (1980 = 1), and a final **R** indicates rates. Finally, if the final letter is a **C**, **G** or **H**, this stands for Corporations, Government or Households, respectively.

The aggregates are expressed in billions of the local currency (or in dollars, in the case of the EC), with the exception of the United Kingdom and Ireland where the amounts are expressed in millions of British and Irish Pounds respectively. Accordingly, the exchange rates are measured by considering the value of one dollar in the national currency for all the countries, but for the United Kingdom and Ireland the value of 1000 dollars in local pounds is considered. The population variables are expressed in millions of people, while the unemployment rate and the interest rate are expressed as percentages.

For the sample period (1960-1986), the data sources we used were: (1) the "European System of Integrated Economic Accounts (ESA)" from the Statistical Office of the EC in Luxembourg, and for the monetary variables: (2) the "International Financial Statistics" from the Statistical Office of the IMF in Washington.

For the forecast period (1987-1992), we have used (3) the "National Accounts and Economic Outlook" from the Department of Economics and Statistics of the OECD in Paris (1990 and 1991) which provide observed data until 1988/89, and a forecast of the variables up to 1992. The observed monetary variables until 1989, were found in the 1990-publication of the "International Financial Statistics" (as mentioned above as (2)), while the values for 1990-1992 were calculated using the forecasts made by the OECD (the publication mentioned under (3)). Since many values were missing for Greece and Portugal in the OECD publications, we have used (4) the "Data Base for Annual Macro Economic Data, YEARNA" and (5) the "Data Base for General Government Data, FINPUB", both published by the Office of Publications of the EC in Brussels (1989), for these two countries.

The list of the variables (and the "calculated" variables) will be given in alphabetical order, and the source of each variable will be shown at the end of the definition of the variables. The suffices explained above were used for the data sources.

Table 1
Symbols of the Variables

CP	private consumption (1)(3)(4)
DP	total private depreciation (1)(4)
DT	direct taxes (1)(3)(4) DTCR:=DTC/(YU-DPU-IT+SUB-WBU) DTHR:=DTH/(WBU+GOSH+SBH-SSC)
EXR	exchange rate (yearly average) (1)(3)
FMD	money and quasi money M2 and M3 (2)(3)
GOS	gross operating surplus (1)(3)
I	total investment (1)(3)
IG	government investment (1)(5)
IRe	investment in residential construction (1)(3)(4)
IP	private investment IPO:=IO-IReO-IGO
IT	indirect taxes (1)(3)(4) ITR:=IT/(CPU-IT)
LI/SI	long term interest rate (government bank)/short term interest rate (discount rate) [13] (2)(3)
MT	total imports (1)(3)(4)
NG	government employment (1)(3)
PR	price ratio of total imports PR:=PY/PMT
PRX	price ratio of total exports PRX:=PXT/PXGC
PXGC	price index of the competitor's weighted tradable [14]
PY	deflator of the GDP at market prices (1)(3)(4)
SBH	social benefits receipts of households (1)(3)(4)
SSH	social security contributions of households (1)(3)(4) SSHR:=SSH/(WBU+GOSH)
SUB	subsidies (1)(3)(4)
TB	trade balance TB:=(XTO*PXT)/(MTO*PMT)
UR	unemployment rate (1)(3)(4)
WBU	total compensation of employees (1)(3)(4)
WGU	compensation of government employees (1)(3)(5)
XT	total exports (1)(3)(4)
XH	disposable income XH:=YU+SBH-DTH-SSH
Y	gross domestic product at market prices (1)(3)(4)

[13] In the model we referred to these variables as IR (interest rate), whether a short or a long term interest rate is meant or not.

[14] the source for this variable was the "COMET IV" (data bank).

Appendix B: Macroeconomic Kernal Model

In order to analyse the optimal coordination in the European Community, we have built an annual interconnected econometric model. The countries under study are Germany (DB), France (FR), Italy (IT), The Netherlands (NL), Belgium (BE), United Kingdom (UK), Ireland (IR), Denmark (DK), Greece (HE), Portugal (PO), Spain (ES), and an aggregation of these countries denoted as EC. Five main objectives can be distinguished: low inflation and unemployment, an external balance, a reasonable growth of consumption and investment and a more or less similar income distribution among countries. Each country was measured in its own currency, while the EC was measured in US dollars. The model was estimated on a yearly basis by Ordinary Least Squares (OLS), for the sample period 1960-1986 (T=27).

The endogenous (target) variables are private consumption, private non-residential gross fixed investment, exports and imports of goods and services, the deflator of the gross domestic product, the unemployment rate, the money stock and the price index of total exports. A definitional equation for trade balance was introduced. The endogenous variables were explained by contemporaneous and past endogenous and exogenous variables. Most of the variables were considered as volumes, rates or indices rather than values. The base year is 1980. The behaviourial equations appear in the form of natural logarithms (ln). The set of country models should have a similar structure to facilitate the comparison among these models. The coordinator's influence on the countries was measured explicitly, by considering the coordinator's values for trade balance, gross domestic product and its deflator, and unemployment rate on each country equation. The interdependency among countries was measured by means of the quantity and price transmission in the international trade sector.

This appendix is organized as follows. A brief explanation of the equations is given, as well as a comment about the regression results. Afterwards, the regression coefficients and their corresponding "t" - values (the underlined figures) are presented for each behaviourial relationship. The coefficients showing the coordinator's influence on the countries (i.e., TB_{-1}, YO_{-1}, UR_{-1} and PY_{-1}) are also given. The last two columns in each table expose the adjusted coefficient of determination($\bar{R}^2$) and the Durbin-Watson statistic per country [15].

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[15] This statistic must be analysed with caution since we are in the presence of lagged endogenous variables. See Dezhbakhsh, H. (1990), "The inappropriate use of serial correlation tests in dynamic linear models", The Review of Economics and Statistics, vol. LXXII, n° 1, February 1990, pp. 126-132.

1 _ Private Consumption (CPO)

The private consumption depends on some expectations about the future and the present. The consumers' time preference was measured by means of the interest rate (IR) [16], the GDP's deflator (PY), and the money stock (FMD). These last two variables can be considered, with reserve, as an indicator of price development. The evaluation about the present was made by considering the different contributions, which the consumers are obliged to do (ITR, SSHR and DTHR), and by their disposable income (XH). The actual consumption is also affected by the past level of consumption (CPO_{-1}), and by the consumer's evaluation about the evolution of the domestic economy (YO_{-1}).

A negative sign of the coefficients for the interest rate and for the tax and social security contribution rate variables affecting the personal income (ITR, SSHR and DTHR), were expected. The same applies for the (negative) impact of the GDP's deflator. The large values for the t-statistics show the significant demand component of the private consumption. A positive sign for the disposable income (XH) was expected. The coefficient for the money stock is more difficult to predict. It may have a positive sign (by increasing the purchasing power when it is accompanied by a sufficient growth of the economy) or a negative sign (by increasing the price level when growth is not sufficient). The coefficients for the lagged private consumption and the lagged GDP are positive, as we expected.

2 - Private Investment (IPO)

The private non-residential gross fixed investment was considered to depend on the incentives to invest (SUB) and their capacities to invest (GOSC, ITR and DTCR). The investment decision also depends on the current interest rate (IR). Other contemporaneous and past values of variables were taken into account (FMD, YO, YO_{-1}, PY, PY_{-1}, UR_{-1} and TB_{-1}). The volume of private investment is also affected by its past value (IPO_{-1}).

A negative sign for the interest rate was expected. However, for DK and ES, the coefficients have an insignificant positive sign. The coefficient for the subsidies paid by the government was expected to be positive if these subsidies were allocated efficiently. On the other hand, the (direct and indirect) taxes' coefficients were expected to be negative. But as we explained before (page 15) this effect can be seen if the marginal productivity of capital stock is larger than the depreciation rate.

[16] Short Term Interest Rate for DB, FR, IT, HE and PO, and Long Term Interest Rate for NL, BE, UK, IR, DK, ES and EC.

This may be an explanation for the positive sign of the DTCR for NL. Furthermore, we can consider that the impact of money is twofold: on the one side, money is a way of financing investment and in that case a positive sign for the coefficient was expected (e.g., IT), and on the other side, if the available amount of money exceeds the needs for transaction purposes, a negative effect on the investment is expected. The coefficient for the GDP's deflator would have a negative influence on the private investment, while the coefficients for GDP and gross operating surplus are expected to be positive. The lagged private investment will have a positive effect on the contemporaneous private investment.

3 - Exports of Goods and Services (XTO)

The total exports of the countries were explained by the evolution of foreign trade prices (PXT, PXGC and PRX). Since these prices can be affected by changes in the domestic financial market, the interest rate was considered (IR). We assumed that the government can stimulate exports by means of the exchange rate (EXR). The volumes of past exports, as well as the general economic indicators were considered (XTO_{-1}, YO_{-1}, PY_{-1}, UR_{-1} and TB_{-1}).

A devaluation of the national currency would imply an increase of the total volume of exports. Hence, a positive sign for the coefficients belonging to the exchange rates was expected. The PXGC-variable can be considered as an indicator of our export prices on the foreign markets. In a demand equation of total exports a negative coefficient may be expected. Lagged exports would have a positive effect on present exports. The same holds for the lagged GDP and the GDP's deflator.

4 - Imports of Goods and Services (MTO)

Total imports depend on foreign and domestic prices. The level of the interest rate (IR), the indirect tax rate (ITR) and the exchange rate (EXR) may affect the price ratio (PR) and, consequently, the total imports. An evaluation of the evolution of the economy was considered (YO, YO_{-1}, PY_{-1}, UR_{-1} and TB_{-1}). The lagged volume of imports was also taken into account (MTO_{-1}).

An increase in the interest rate was expected to have a negative effect on the total imports. The ITR variable includes the indirect taxes linked to production as well as those linked to imports, and so the coefficients' signs were difficult to predict. It is also important to consider the imports' structure of each country. The coefficients for GDP and the price ratio of total imports are positive as expected. The same holds for the lagged imports.

5 - GDP's Deflator (PY)

The deflator of the gross domestic product can be interpreted as an indicator of the evolution of the prices. The expectations created by its lagged value must be taken into consideration (PY_{-1}). The financial market and the international market play an important role in the determination of this variable (IR and PMT). The impact of indirect taxes (ITR) and the quantity of currency money (FMD) were considered. The price evolution would be affected by the evolution of the economy in present and past (YO and YO_{-1}) and by past prices (PY_{-1}).

The coefficient for the interest rate was expected to be positive, unless the case when an explicit policy to diminish inflation is applied. An increase in the indirect taxes and in the imports prices is expected to increase the GDP's deflator. The quantity of money may have a twofold effect, as was explained above. It may increase prices in the long term if there is no increase of production, or it may be a way of financing investment. The GDP's coefficient was expected to be negative because this relationship is an inverse demand equation. However, for DB and ES the coefficient is positive (inverse supply equation). A positive sign for the coefficient of the lagged GDP's deflator was found for these countries; this variable can be seen as an inflationary expectation.

6 - Unemployment Rate (UR)

An important element in the determination of the unemployment rate was the evolution of the general economic indicators (YO, YO_{-1}, PY_{-1} and TB_{-1}). The inclusion of the lagged unemployment rate was also important (unemployment expectations). The salaries (WBU and WGU) and the people employed by the government (NG) were considered as determinants of the unemployment rate.

The National Accounts give information about the amount of salaries paid, but there is no information about the number of man-years receiving these salaries. For that reason, the sign of the coefficients for WGU and WBU was difficult to predict. A negative sign for the coefficient for the quantity of people employed by the government might be expected, since this was a common policy to diminish the unemployment rate in several countries (e.g., BE). However, the Eurostat figures for government employment in Belgium underestimate the real number of government employees, since they do not take the special public employment programs into account; e.g., on june 30 1989, the effective government employment (including the Special employment figures) was 968.435 persons (source: Ministry of Employment and Labour, Brussels), while the Eurostat figure was 732.518 persons working in the government. Hence, increases of the NG-value would imply more favourable effects on UR. On the other hand, a positive sign can be seen for DB, FR and the aggregate EC, indicating that the increase of government employment is not sufficient to decrease unemployment. An increase of the GDP is expected to decrease the unemployment rate. The lagged unemployment rate will have a positive impact on the current one.

7 - Money Stock (FMD)

The people's preference can be affected by their consideration of the evolution of the prices (PY_{-1}) and by the level of the interest rate (IR). The lagged quantity of money (FMD_{-1}) plays an important role in the determination of the money stock. The analysis of the economies' development was also taken into account (YO and YO_{-1}). The US dollar, which can be considered as a substitute of the national currency, was introduced in the model by means of the exchange rate (EXR).

In a money demand equation, the coefficient of the interest rate was expected to be negative. This was the case for DB, NL, BE, IR, DK, ES and the EC. On the other hand, the rest of the countries under study present a positive coefficient showing a money supply equation, raising the issue of identification. A positive sign for the GDP's coefficient was expected. In the case of IT, a negative GDP's coefficient, with a high absolute t-value, was found, while the coefficient for the interest rate is positive. A possible explanation is that we are in presence of (negative) autocorrelation (the Durbin-Watson statistic is pretty high). The lagged money stock and the GDP's deflator were expected to have a positive influence on the actual money stock.

8 - Price Index of the Total Exports (PXT)

The exports prices were affected by the evolution of the domestic and foreign prices (PY, PY_{-1}, YO_{-1}, PRX and PXT_{-1}). Indirectly, they depend on the interest rate (IR) and the exchange rate (EXR).

A devaluation of the national currency will increase the exports prices. The same holds for the coefficient of the price ratio of total exports and the lagged price index of exports. While foreign prices are positively correlated with domestic prices, we expected a positive sign for the coefficients of the GDP's deflator and the interest rate.

CPO

											Coordinator's variables					
	INT	IR	ITR	SSHR	DTHR	FMD	PY	XH	CPO_{-1}	YO_{-1}	TB_{-1}	YO_{-1}	UR_{-1}	PY_{-1}	$\bar{R}^2$	D-W
DB	-2.33 -1.34	-0.02 -1.09				-0.31 -1.41	-0.47 -2.14	0.72 2.22	0.60 2.92		0.30 1.65	0.21 0.69			.9965	1.037
FR	-0.29 -0.98	-0.02 -2.38					-1.09 -10.0	1.11 10.5			0.07 0.94	-0.13 -1.09		-0.03 -2.68	.9996	1.965
IT	-2.17 -0.87	-0.02 -0.45				-0.21 -1.57		0.18 1.73	0.60 3.21		0.69 1.69	0.50 1.75		0.13 1.10	.9910	1.910
NL	-0.27 -0.24		-0.21 -3.09			0.23 1.57	-1.06 -3.96	0.75 3.68	0.64 4.75		0.16 0.90	-0.43 -2.32	-0.03 -0.84	-0.05 -1.17	.9985	1.602
BE	-1.66 -0.99		-0.10 -1.92	-0.18 -2.13		0.17 1.74	-0.46 -3.78	0.39 3.33			0.23 1.62	0.38 2.01	0.01 0.51	0.02 0.60	.9982	1.967
UK	-0.86 -1.21	-0.06 -3.08	-0.04 -1.54		-0.06 -2.05		-0.30 -2.09	0.31 2.17	0.50 4.22		0.25 1.99	0.22 1.94			.9960	2.077
IR	-7.06 -5.11			-0.16 -4.55	-0.05 -1.25		-0.70 -3.65	0.63 3.49	0.08 0.59			0.60 3.41	0.05 1.21		.9965	2.567
DK	-4.74 -3.37		-0.16 -2.09				-0.88 -4.79	0.71 4.85	0.59 3.41		0.41 1.89	0.28 1.48			.9906	2.492
HE	-6.37 -4.43			-0.08 -2.58			-0.41 -4.36	0.37 3.22			0.06 0.46	0.87 4.55	0.12 3.21		.9987	2.347
PO	-8.04 -2.34	-0.10 -2.95		-0.08 -2.24			-0.79 -4.98	0.63 3.42	0.27 2.02			0.68 1.68	0.19 2.16		.9917	2.544
ES	-2.02 -1.00		-0.15 -2.99			0.10 2.22	-0.61 -3.03	0.53 2.45			0.14 0.81	0.39 1.27		-0.04 -0.59	.9977	1.843
EC	0.17 0.69	-0.01 -0.85				0.12 2.68	-0.48 -4.48	0.37 3.58	0.41 2.23	0.06 0.38					.9994	1.405

IPO

															Coordinator's variables					
	INT	IR	ITR	SUB	DTCR	FMD	PY	GOSC	YO	IPO_{-1}	PY_{-1}	TB_{-1}	UR_{-1}	YO_{-1}	TB_{-1}	YO_{-1}	UR_{-1}	PY_{-1}	$\bar{R}^2$	D-W
DB	-5.73 -1.04			-0.12 -1.38	-0.06 -0.52	-0.24 -0.65			3.92 5.06	0.07 0.25	-0.40 -1.10	0.80 2.19		3.53 1.84	-1.19 -1.97	-4.89 -2.09	0.18 2.08		.9757	1.599
FR	-4.28 -1.38	-0.01 -0.11				-0.14 -0.79	-0.56 -3.16	0.25 2.42	0.59 0.94	0.47 2.78					-0.36 -0.83	0.23 0.29	0.21 1.98	0.18 2.36	.9934	1.846
IT	14.57 2.23				-0.04 -0.45	0.58 2.33			3.06 6.75	0.86 5.64	-0.24 -2.21		0.34 3.89	-1.67 -2.41	-0.40 -0.94	-2.60 -2.35	-0.29 -2.41	-0.17 -1.80	.9801	2.045
NL	-12.13 -2.48			0.29 2.18	0.22 1.77	-0.41 -0.69	-2.27 -2.53	0.23 1.57	0.58 0.89		1.47 2.30	-0.77 -1.43	0.04 0.72	0.67 0.68	0.47 0.84	1.11 1.04		-0.36 -2.44	.9806	2.344
BE	-12.20 -3.29			-0.03 -0.23					-0.40 -0.72	0.21 1.33	0.26 1.18	1.38 3.26	0.15 2.02	-1.75 -2.15		3.06 3.92	-0.41 -2.87		.9817	2.056
UK	-7.51 -2.04		0.17 1.62			-0.06 -0.90	0.42 1.08	-0.02 -0.82	1.70 3.22		-0.22 -0.47	0.10 0.32	-0.02 -0.34	-0.18 -0.30	0.06 0.11		0.03 0.15	-0.16 -1.53	.9855	2.215
IR	-87.14 -5.10	-0.41 -0.91		0.59 0.99	0.10 0.49	-3.58 -1.86			0.39 0.09		1.08 0.73	0.30 0.39	-1.88 -2.29	-1.28 -0.30		9.18 2.76	2.12 2.53		.9106	2.116
DK	33.27 0.61	1.81 1.68		-0.06 -0.20	-0.24 -0.78	3.55 1.82			9.81 2.00	0.38 1.95	-3.19 -0.81	-1.63 -0.97	0.08 0.39		-2.50 -0.70	-11.5 -1.44	-0.98 -0.86	-0.10 -0.10	.9092	2.126
HE	-15.35 -0.98	-0.20 -1.47			-0.14 -1.65	-0.35 -0.90			1.30 1.89	-0.51 -2.10	0.01 0.03	0.25 1.88	0.04 0.47	1.57 1.59	1.46 1.71	0.35 0.18	0.09 0.38		.9799	2.553
PO	-1.20 -0.24		-0.14 -0.67			-0.21 -1.74		0.09 1.24	1.35 2.49	0.30 1.73					-1.80 -2.35	-0.29 -0.41		0.26 1.59	.9863	1.813
ES	5.89 0.40	0.11 0.45		-0.05 -0.34			0.47 1.26		3.54 2.53	0.29 1.67		-0.24 -0.91	0.23 1.36	-0.97 -0.57	1.35 1.20	-1.97 -0.91	-0.80 -2.29	-0.15 -0.82	.9874	2.053
EC	-1.42 -1.78				-0.02 -0.42	-0.26 -1.52	0.11 0.56	0.17 1.80	1.70 3.41	0.81 6.42				-1.26 -2.78					.9944	2.012

XTO

Coordinator's variables

	INT	IR	EXR	PXT	PXGC	PRX	XTO_{-1}	YO_{-1}	TB_{-1}	UR_{-1}	PY_{-1}	TB_{1}	YO_{1}	UR_{1}	PY_{1}	$\bar{R}^2$	D-W
DB	-5.32 -2.84		0.12 1.63				0.35 1.75					0.63 1.60	1.05 3.07	0.03 0.66	0.08 0.90	.9955	2.001
FR	-2.50 -1.19		-0.05 -0.59			-0.04 -1.00	0.86 4.69						0.38 1.15	0.03 0.43	-0.09 -0.91	.9951	1.509
IT	-18.89 -15.31		0.30 2.61		-0.45 -4.72							0.43 1.04	1.89 21.64	0.22 2.74	0.48 3.87	.9972	1.374
NL	-0.11 -0.05		0.31 2.55		-0.28 -2.36		0.95 6.03					0.99 2.72	0.02 0.05		0.29 1.97	.9955	1.914
BE	-5.80 -1.70	0.04 0.64					0.54 2.23					1.09 3.33	0.81 1.75			.9953	2.083
UK	-0.61 -0.76	0.03 0.68				-0.23 -2.54	0.43 2.89					0.50 2.38	0.55 3.90	0.08 2.64		.9953	1.991
IR	-11.32 -3.87		0.13 1.21			0.23 1.30	0.36 2.48						1.02 3.61	0.23 2.62	-0.07 -1.10	.9968	2.710
DK	-5.24 -2.14		0.12 1.67	-0.11 -0.56	-0.01 -0.09		0.52 2.43					-0.21 -0.69	0.79 2.32	0.07 1.31		.9963	1.983
HE	-10.53 -0.46		0.67 1.04			-0.49 -0.86	-0.04 -0.06	1.05 0.48	-0.10 -0.14	-0.46 -1.95	-0.18 -0.27	2.03 1.11	0.74 0.24	0.08 0.19	0.05 0.10	.9778	2.624
PO	8.46 0.76	-0.02 -0.10	0.43 2.01		-0.44 -1.26	-0.02 -0.04	0.42 1.26	1.51 1.07	-0.07 -0.24	0.26 2.65	0.35 1.03	1.01 0.92	-1.45 -0.89	-0.30 -1.01		.9637	2.192
ES	-30.43 -4.48	-0.14 -0.92	0.20 1.08	-0.12 -0.50			-0.20 -0.89						3.22 4.59	0.16 1.12	-0.08 -0.37	.9934	1.338
EC	-2.09 -1.67	-0.01 -0.28				-0.04 -0.94	0.68 4.26	0.56 1.92								.9964	1.994

MTO

	INT	IR	ITR	EXR	YO	PR	MTO_{-1}	YO_{-1}	TB_{-1}	UR_{-1}	PY_{-1}	Coordinator's variables TB_{-1}	YO_{-1}	UR_{-1}	PY_{-1}	$\bar{R}^2$	D-W
DB	-4.98 -2.64		-0.08 -0.45		2.11 4.92	0.15 1.26	0.18 1.12					0.15 0.45	-0.56 -1.62	-0.03 -1.04	0.07 1.39	.9974	1.524
FR	0.43 0.14		-0.21 -0.94		3.25 4.89		0.37 1.69					0.58 1.30	-2.36 -3.01	-0.04 -0.99	0.17 1.79	.9963	1.663
IT	-5.79 -1.34			-0.05 -0.42	2.18 3.41	0.10 0.83	0.14 0.81					0.34 0.49	-0.78 -1.21	-0.04 -0.32	0.12 0.94	.9932	1.572
NL	-5.63 -3.47	0.03 0.81			1.48 5.80	0.09 1.16	0.09 0.65					0.46 2.03	0.23 0.91		-0.10 -2.43	.9983	1.454
BE	-4.95 -6.26		-0.05 -0.65		1.66 23.11	0.21 3.17						0.55 2.40			0.04 1.00	.9977	2.626
UK	-7.97 -4.57		-0.04 -0.55		1.37 3.23		0.32 2.01					0.26 0.71	-0.12 -0.34	0.06 1.55	-0.05 -0.88	.9909	1.566
IR	-15.50 -2.12		-0.23 -0.65	-0.00 -0.00	1.26 1.14	0.69 1.78	-0.30 -1.18					-0.48 -0.48	1.27 1.56		-0.12 -0.43	.9727	2.138
DK	1.47 0.43		-0.09 -0.66		2.16 3.86	0.12 0.64	0.49 2.42					0.37 0.82	-1.14 -1.65	-0.12 -1.93	0.12 1.24	.9899	2.378
HE	-3.99 -2.73		0.12 0.74		1.17 4.82		0.23 1.62					-0.39 -0.67		0.08 1.33	-0.18 -1.50	.9922	1.933
PO	2.58 0.41		-0.26 -1.14	0.05 0.40	1.71 3.17	0.36 2.33	0.30 1.43		0.36 2.41	-0.02 -0.32	-0.16 -1.23	-1.32 -1.87	-0.80 -0.99	0.21 0.99		.9849	2.510
ES	2.01 0.26	-0.32 -2.14	0.38 1.83		1.81 2.53		0.45 3.20						-1.06 -0.98	-0.21 -2.09	0.40 1.98	.9915	2.199
EC	-3.23 -3.04		-0.05 -0.72		2.55 13.91	0.05 1.50	0.62 4.83	-1.81 -6.39								.9994	2.311

PY

	INT	IR	ITR	FMD	YO	PMT	PY_{-1}	YO_{-1}	Coordinator's variables				$\bar{R}^2$	D-W
									TB_{-1}	YO_{-1}	UR_{-1}	PY_{-1}		
DB	-4.93 -3.05	-0.01 -0.80		-0.43 -3.18	0.35 1.88		1.13 12.31		0.11 0.85	0.61 2.39	0.02 0.66		.9990	1.285
FR	-6.71 -2.66	-0.07 -1.52	0.19 0.99	0.28 2.19	-0.25 -0.43	0.37 4.83			0.30 0.75	0.52 0.72	0.19 2.40	-0.09 -1.51	.9979	1.759
IT	-3.09 -3.87	0.05 2.15			-0.08 -0.37	0.16 3.74	0.83 18.78			0.23 1.05	-0.06 -1.34		.9997	1.419
NL	1.36 1.08	0.06 1.95		0.37 2.84			0.69 4.55		-0.29 -2.04	-0.39 -1.84	-0.08 -2.76	-0.07 -1.55	.9994	2.172
BE	1.38 1.31	0.00 0.06		0.10 0.72		0.20 4.79	0.79 7.04	0.96 2.71	0.25 1.70	-0.93 -3.75	-0.08 -2.33	-0.06 -1.52	.9994	2.843
UK	-0.34 -0.21	0.01 0.06	0.03 0.37	-0.04 -0.65	-0.33 -0.76	0.27 2.55	0.86 4.26		0.17 0.53	0.28 0.81	-0.14 -1.16	0.02 0.20	.9990	2.510
IR	-0.46 -0.36		0.15 2.26	0.16 1.30			0.71 6.93			-0.05 -0.35		0.17 2.59	.9991	1.631
DK	-1.13 -0.80	0.06 1.39					0.95 8.59		-0.14 -0.79	0.11 0.77	-0.01 -0.28	-0.01 -0.18	.9994	1.866
HE	0.33 0.08	0.04 0.80		0.18 1.42		0.38 4.40	0.43 3.37		0.64 1.97	-0.28 -0.72	-0.05 -0.56	-0.02 -0.24	.9991	1.959
PO	-1.52 -0.53	0.15 2.59		0.08 0.56			0.79 5.57		-1.09 -2.33	0.03 0.09	0.16 1.61	-0.21 -2.25	.9983	2.202
ES	5.59 1.23	0.01 0.17			0.70 2.07		1.01 8.37		-0.38 -1.34	-0.99 -1.58	-0.03 -0.31	0.11 2.24	.9993	1.508
EC	1.24 1.91	0.05 1.64	0.52 6.88	0.79 19.96	-1.21 -5.91	0.32 6.73	-0.20 -3.54	0.21 1.17					.9996	1.730

UR

										Coordinator's variables					
	INT	WGU	NG	YO	WBU	UR_{-1}	YO_{-1}	TB_{-1}	PY_{-1}	TB_{-1}	YO_{-1}	UR_{-1}	PY_{-1}	$\bar{R}^2$	D-W
DB	48.62 3.03	6.67 3.18	5.52 1.86	-8.61 -3.33	-7.29 -2.78	0.19 1.20				-0.65 -0.34	2.44 0.78	1.02 3.06	0.15 0.40	.9741	2.449
FR	-17.30 -1.76	-0.24 -0.41	2.32 1.13	-1.16 -0.63	-0.70 -0.84	0.02 0.06				-1.26 -0.95	3.20 1.31	1.04 1.90	0.27 1.06	.9788	2.216
IT	-18.64 -2.73	0.59 2.05		-2.59 -2.43	-0.96 -2.33	0.31 1.83				0.55 0.60	3.91 2.79	0.60 2.57		.9216	1.682
NL	7.84 0.37	2.88 1.52		-5.09 -1.24	-4.32 -1.29	0.38 1.50	8.35 1.92	3.33 1.58	1.63 1.17		-1.54 -0.41		0.33 0.38	.9583	2.069
BE	30.07 3.68	6.81 5.11	-4.86 -2.79	-1.56 -1.25	-4.91 -3.96	0.27 2.31				1.33 1.06	-1.92 -1.54		0.47 1.47	.9866	1.643
UK	14.86 1.40	1.15 1.43		-5.48 -2.46	-0.89 -1.18	0.48 1.88				1.19 0.51	3.71 2.61	0.24 0.40	-0.11 -0.22	.9534	1.815
IR	10.95 1.07	0.31 1.72	0.05 0.05	-1.90 -1.54	1.93 2.09		-3.02 -1.66	0.17 0.78	-1.02 -1.60	-1.19 -0.83	1.13 1.04	0.67 2.02	-1.20 -3.44	.9603	2.533
DK	-13.20 -0.16	-2.36 -0.89	-0.87 -0.24	-8.65 -2.61	9.00 1.94	0.42 2.24	-4.94 -0.82		-4.75 -1.46	-2.33 -0.77	5.75 0.51	0.03 0.02		.9269	2.264
HE	-13.12 -1.12	-0.22 -0.77	-0.84 -0.74	-1.70 -1.78		1.22 8.97		0.15 0.60			2.25 1.42		1.19 3.46	.9398	1.835
PO	-128.2 -5.86	-0.42 -2.64	-4.06 -2.59	-1.48 -1.18		-0.23 -1.14	-7.63 -4.45	-0.35 -1.53			15.90 6.17	1.24 4.50	0.93 3.64	.9646	2.303
ES	21.05 1.51	2.32 2.56	-1.79 -1.85	-3.03 -3.68	-1.33 -1.70	0.14 1.36				-0.65 -0.73	1.75 1.24			.9909	2.290
EC	7.12 3.86	2.96 3.72	3.63 3.04	-1.59 -1.58	-3.02 -3.95	0.24 1.71	0.18 0.16							.9930	1.928

FMD

Coordinator's variables: TB-1, YO-1, UR-1, PY-1 (second group)

	INT	IR	EXR	YO	PY_{-1}	FMD_{-1}	YO_{-1}	TB_{-1}	YO_{-1}	UR_{-1}	PY_{-1}	$\bar{R}^2$	D-W
DB	-2.49 -1.52	-0.03 -2.70			0.13 1.15	0.78 6.19		-0.11 -0.71	0.46 1.68	0.01 0.28	-0.07 -2.36	.9997	2.245
FR	-7.20 -2.41	0.11 2.37		-0.72 -1.12		0.58 4.73		-1.10 -2.86	1.63 2.02	0.24 3.07		.9986	2.252
IT	-9.01 -2.61	0.04 1.08		-1.55 -4.97	-0.18 -1.35	0.93 4.48		0.41 1.36	1.99 4.30	0.22 3.30	0.00 0.01	.9997	2.663
NL	-1.01 -1.27	-0.10 -2.91		0.94 6.43	0.66 4.54	0.22 4.44		-0.19 -0.99		0.05 1.26	0.13 2.67	.9997	1.743
BE	-2.95 -3.53	-0.17 -3.10		1.32 13.44	0.72 4.75			-0.67 -2.48		0.05 0.78	0.07 1.21	.9990	1.412
UK	2.46 0.36	0.89 2.52	-0.09 -0.26	3.65 2.90	2.37 3.18	0.11 0.48			-2.66 -2.78	-0.78 -1.91	-1.07 -2.00	.9877	2.091
IR	-1.13 -1.08	-0.12 -2.18		0.90 5.14	0.38 3.27	0.21 1.35		0.90 2.53			0.44 4.39	.9991	1.770
DK	-2.40 -0.82	-0.29 -3.65			0.65 2.77	0.46 2.92		-0.04 -0.10	0.63 1.87	-0.02 -0.16		.9985	1.417
HE	-2.89 -0.83	0.01 0.23		0.16 0.59	0.17 1.14	0.82 5.52		-0.39 -1.15	0.27 0.66		0.01 0.11	.9996	1.574
PO	2.55 1.12	0.03 1.01		1.13 4.88	0.43 3.80	0.56 5.48		-0.40 -1.33	-0.61 -1.95			.9996	2.068
ES	-2.18 -0.13	-0.03 -0.10	-0.01 -0.05	3.01 2.11	0.44 0.87	-0.19 -0.45		-0.46 -0.26	-1.29 -0.58	0.35 0.75	0.67 1.90	.9960	1.724
EC	-0.53 -0.22	-0.53 -3.46			-1.12 -2.00	2.00 3.59	-0.70 -0.90					.9934	1.555

PXT

	INT	IR	EXR	PRX	PY	PY_{-1}	PXT_{-1}	YO_{-1}	Coordinator's variables TB_{-1}	YO_{-1}	UR_{-1}	PY_{-1}	$\bar{R}^2$	D-W
DB	5.89 3.06		0.11 2.60		1.10 3.73	-0.34 -1.01	0.40 1.92	-0.36 -1.07	0.32 1.34	-0.05 -0.16	-0.07 -1.66	0.15 3.12	.9964	2.052
FR	8.95 17.98		0.12 1.83		0.99 11.94	-0.03 -1.12		-0.57 -9.60	-0.24 -0.78			0.19 2.21	.9971	1.396
IT	4.62 1.35		0.21 2.75		1.59 5.91	-1.11 -4.96	0.36 2.13	-0.40 -1.17	0.30 1.13	0.13 0.32		0.16 2.06	.9990	1.876
NL	2.59 0.70		0.21 2.16			0.14 0.37	0.38 1.76	-0.59 -0.95	-0.15 -0.32	0.42 0.64		0.47 3.72	.9894	1.401
BE	3.69 1.98		0.24 4.89		2.02 6.74	-1.32 -4.69	0.20 1.14	-1.49 -2.59	0.24 0.81	0.99 1.83		0.37 6.52	.9979	2.152
UK	4.25 2.12		0.34 5.39		0.84 3.08	-0.50 -3.38	0.35 1.71		0.28 1.11	-0.24 -2.57		0.37 4.69	.9989	2.035
IR	-0.94 -1.27		0.33 3.59		0.37 1.61	-0.39 -1.61	0.86 7.20		0.42 1.16		-0.22 -2.45	0.31 3.57	.9985	0.890
DK	11.01 1.53		0.15 2.66		1.17 2.15	-0.34 -0.87	0.35 1.03		0.30 0.84	-0.82 -1.42	-0.16 -1.57	0.23 2.67	.9976	1.898
HE	-4.94 -0.98		0.33 2.91	0.38 2.92	1.41 6.88	-0.53 -2.30	-0.15 -0.95	-1.45 -2.91	-0.66 -1.65	1.52 2.07	-0.02 -0.25	0.50 4.06	.9989	2.278
PO	11.43 3.82	0.13 1.44			1.24 4.78		-0.08 -0.45		0.21 0.30	-0.54 -2.91	-0.23 -1.47	0.15 0.99	.9969	1.602
ES	4.95 3.95		0.38 5.02		0.96 4.07	-0.25 -1.10			0.30 0.83	-0.15 -1.51	-0.06 -0.69	0.28 3.35	.9991	0.862
EC	6.55 8.90	0.05 0.94			0.86 13.31		0.25 4.72	-0.40 -4.93					.9974	1.438

Appendix C

The optimal results are summarized by means of the Targets' Deviations (TD), the Square Root of Sum of Performance Costs (SRSPC), both per country and policy, and the Theil's inequality coefficients, per country, variable and policy. The results of the first experiment (i.e., $Q_i(t):=1/Y_i^*(t)^2$ and $R_i(t):=1/u_i(t)^2$) are displayed on tables 1 to 5, while the results belonging to the second experiment (i.e., $Q_j(t):=2/Y_j^*(t)^2$ for j=PY and UR, $Q_i(t):=1/Y_i^*(t)^2$, when $i \neq j$, and, $R_i(t):=1/u_i(t)^2$) are shown in tables 1' to 5'.

The Targets' Deviations can be found in tables 1 and 1'. Tables 2 and 3 show the SRSPC corresponding to the results of the first experiment. But, while table 2 compares the costs of applying an optimal policy with respect to the desired paths, table 3 compares the optimal results to the policies that are in fact taking place within the European Community. Analogous results, when a double penalty is imposed to the PY and UR, can be found in tables 2' and 3'.

In the last four tables, the Theil's inequality coefficients for the target and control variables are shown. In each table, the first row corresponds to the results of applying a **Top-Down** policy while the second row applies to a Bottom-up policy; the other two rows correspond to a **Constrained Top-Down** and Constrained Bottom-Up policies, respectively.

TABLE 1
TARGETS' DEVIATIONS

	Top-Down	Bottom-Up	Constrained Top-Down	Constrained Bottom-Up
DB	1.114642	1.647129	1.120550	1.640127
FR	0.359650	0.348783	0.358725	0.349883
IT	0.131067	0.151283	0.131223	0.151342
NL	0.390802	0.413085	0.381825	0.408695
BE	0.220743	0.270268	0.222489	0.272468
UK	0.252773	0.184832	0.253250	0.184429
IR	1.017609	1.185785	1.023468	1.180947
DK	0.175895	0.234446	0.174751	0.235194
HE	0.937233	1.039669	0.940696	1.036855
PO	0.282633	0.595555	0.283407	0.595045
ES	1.520836	1.415377	1.523886	1.412581
EC	0.804781	0.578835	0.853654	0.533537

TABLE 1'
TARGETS' DEVIATIONS

	Top-Down	Bottom-Up	Constrained Top-Down	Constrained Bottom-Up
DB	1.565409	2.108181	1.571140	2.105009
FR	0.473680	0.480852	0.472664	0.481604
IT	0.134012	0.163871	0.134205	0.163901
NL	0.472677	0.472793	0.465753	0.471531
BE	0.293508	0.355887	0.295210	0.358466
UK	0.323201	0.230147	0.323081	0.229525
IR	1.305747	1.481755	1.312443	1.477170
DK	0.178034	0.238544	0.177408	0.238748
HE	1.038138	1.151542	1.039422	1.150978
PO	0.304835	0.668589	0.305947	0.668695
ES	2.128928	1.972801	2.133156	1.968466
EC	0.985858	0.680403	1.045337	0.631126

TABLE 2
SQUARE ROOT of SUM of PERFORMANCE COSTS

	Top-Down	Bottom-Up	Constrained Top-Down	Constrained Bottom-Up
DB	1.123175	1.764848	1.129821	1.756203
FR	0.855238	1.428423	0.856879	1.427082
IT	0.153609	0.160633	0.153830	0.160672
NL	0.571628	0.691139	0.555591	0.683580
BE	0.237727	0.397048	0.238616	0.397870
UK	0.283858	0.192794	0.283345	0.192860
IR	1.074186	1.272930	1.080501	1.267618
DK	0.341298	0.302292	0.341818	0.302757
HE	1.107974	1.238544	1.113942	1.233660
PO	0.498004	0.739007	0.499181	0.738508
ES	1.528656	1.422185	1.531677	1.419404
EC	1.227995	0.839152	1.407196	0.679490

TABLE 2'
SQUARE ROOT of SUM of PERFORMANCE COSTS

	Top-Down	Bottom-Up	Constrained Top-Down	Constrained Bottom-Up
DB	1.571337	2.189761	1.577530	2.185950
FR	0.918237	1.437016	0.920276	1.436247
IT	0.157253	0.173339	0.157415	0.173408
NL	0.653581	0.714047	0.639713	0.711017
BE	0.308754	0.450074	0.309803	0.452084
UK	0.350416	0.239279	0.349591	0.238963
IR	1.398524	1.616279	1.405919	1.611175
DK	0.343157	0.309423	0.343668	0.309374
HE	1.208009	1.343246	1.211781	1.340863
PO	0.524206	0.831451	0.525633	0.831493
ES	2.137119	1.980407	2.141326	1.976077
EC	1.519012	0.839152	1.664082	0.741988

TABLE 3
SQUARE ROOT of SUM of PERFORMANCE COSTS

	Top-Down	Bottom-Up	Constrained Top-Down	Constrained Bottom-Up
DB	1.036935	1.731744	1.044536	1.722706
FR	1.767553	2.103274	1.768000	2.102410
IT	1.419291	1.421522	1.419301	1.421531
NL	1.515173	1.808759	1.520012	1.798594
BE	1.378110	1.398716	1.379104	1.398243
UK	8.065792	8.062741	8.065834	8.062692
IR	10.26710	10.29186	10.26782	10.29116
DK	79.90645	79.90775	79.90644	79.90777
HE	1.079701	1.101530	1.082577	1.098648
PO	1.347211	1.613003	1.348572	1.612328
ES	26.36111	26.35691	26.36123	26.35681
EC	7.822587	1.466960	7.827903	1.457894

TABLE 3'
SQUARE ROOT of SUM of PERFORMANCE COSTS

	Top-Down	Bottom-Up	Constrained Top-Down	Constrained Bottom-Up
DB	1.405700	2.067383	1.412436	2.063344
FR	1.866039	2.169265	1.866888	2.168791
IT	1.560489	1.562721	1.560506	1.562718
NL	1.547502	1.802022	1.551079	1.795759
BE	1.440833	1.427289	1.442141	1.426980
UK	8.073456	8.067177	8.073460	8.067135
IR	10.30936	10.34379	10.31042	10.34294
DK	79.90765	79.90890	79.90764	79.90891
HE	1.276373	1.256008	1.277359	1.254927
PO	1.612232	1.947614	1.614063	1.947502
ES	26.37844	26.37047	26.37867	26.37029
EC	8.001736	1.713956	7.996261	1.749793

TABLE 4
THEIL'S INEQUALITY COEFFICIENTS
DESIRED TARGET VARIABLES

	DB	FR	IT	NL	BE	UK	IR	DK	HE	PO	ES	EC
CPO	**.09**	**.07**	**.30**	**.05**	**.02**	**.14**	**.09**	**.01**	**.03**	**.17**	**.15**	**.11**
	.09	.08	.40	.03	.01	.14	.10	.05	.02	.33	.13	.03
	.09	**.07**	**.30**	**.05**	**.02**	**.14**	**.09**	**.01**	**.03**	**.17**	**.15**	**.11**
	.09	.09	.40	.03	.01	.14	.10	.05	.02	.33	.13	.02
IPO	**.25**	**.05**	**.31**	**.17**	**.21**	**.10**	**.31**	**.24**	**.14**	**.16**	**.46**	**.12**
	.18	.07	.29	.14	.32	.09	.22	.40	.11	.22	.90	.14
	.25	**.05**	**.31**	**.18**	**.21**	**.10**	**.30**	**.24**	**.14**	**.16**	**.46**	**.15**
	.18	.07	.29	.14	.32	.09	.22	.40	.11	.22	.91	.12
XTO	**.06**	**.02**	**.20**	**.06**	**.07**	**.08**	**.07**	**.06**	**.41**	**.11**	**.10**	**.08**
	.09	.02	.19	.02	.17	.06	.02	.08	.42	.13	.08	.05
	.06	**.02**	**.20**	**.06**	**.07**	**.08**	**.07**	**.06**	**.41**	**.11**	**.10**	**.09**
	.09	.02	.19	.02	.17	.06	.02	.08	.42	.14	.08	.05
MTO	**.23**	**.02**	**.27**	**.03**	**.11**	**.16**	**.36**	**.03**	**.02**	**.21**	**.53**	**.02**
	.29	.03	.31	.05	.15	.16	.37	.07	.06	.34	.62	.21
	.23	**.02**	**.27**	**.03**	**.11**	**.16**	**.36**	**.03**	**.02**	**.21**	**.53**	**.01**
	.29	.03	.31	.05	.15	.16	.37	.07	.06	.34	.62	.20
PY	**.15**	**.08**	**.01**	**.03**	**.03**	**.05**	**.35**	**.01**	**.39**	**.10**	**.64**	**.09**
	.20	.08	.03	.03	.04	.04	.41	.01	.46	.24	.58	.08
	.15	**.08**	**.01**	**.03**	**.03**	**.05**	**.36**	**.01**	**.39**	**.10**	**.64**	**.10**
	.20	.08	.03	.03	.04	.04	.41	.01	.46	.24	.58	.07
UR	**.00**	**.09**	**.01**	**.01**	**.00**	**.00**	**.24**	**.01**	**.50**	**.05**	**.06**	**.00**
	.00	.06	.01	.02	.00	.00	.31	.01	.58	.04	.05	.00
	.00	**.09**	**.01**	**.01**	**.00**	**.00**	**.24**	**.01**	**.51**	**.06**	**.06**	**.00**
	.00	.06	.01	.02	.00	.00	.31	.01	.57	.04	.05	.00
FMD	**.12**	**.12**	**.16**	**.13**	**.20**	**.16**	**.47**	**.34**	**.97**	**.42**	**.55**	**.69**
	.11	.07	.18	.07	.18	.28	.60	.30	.90	.27	.43	.55
	.12	**.12**	**.16**	**.13**	**.20**	**.17**	**.47**	**.34**	**.97**	**.42**	**.55**	**.81**
	.11	.07	.18	.07	.18	.29	.59	.30	.90	.27	.43	.44
PXT	**.17**	**.01**	**.06**	**.08**	**.04**	**.26**	**.27**	**.07**	**.76**	**.11**	**.38**	**.08**
	.28	.02	.11	.05	.03	.22	.37	.16	.75	.23	.48	.15
	.18	**.01**	**.06**	**.08**	**.04**	**.26**	**.28**	**.07**	**.76**	**.11**	**.38**	**.09**
	.28	.02	.11	.05	.03	.22	.37	.16	.75	.23	.48	.14
TB	**.02**	**.00**	**.00**	**.02**	**.00**	**.00**	**.00**	**.00**	**.00**	**.01**	**.00**	**.00**
	.07	.00	.00	.02	.00	.00	.00	.00	.00	.02	.00	.00
	.02	**.00**	**.00**	**.02**	**.00**	**.00**	**.00**	**.00**	**.00**	**.01**	**.00**	**.00**
	.07	.00	.00	.02	.00	.00	.00	.00	.00	.02	.00	.00

TABLE 5
THEIL'S INEQUALITY COEFFICIENTS
DESIRED CONTROL VARIABLES

	DB	FR	IT	NL	BE	UK	IR	DK	HE	PO	ES	EC
SI	**.02** .04 **.02** .04	**.15** .25 **.15** .25	**.00** .01 **.00** .01	- - - -	- - - -	- - - -	- - - -	- - - -	**.12** .13 **.12** .13	**.05** .10 **.05** .10	- - - -	- - - -
LI	- - - -	- - - -	- - - -	**.10** .10 **.10** .10	**.01** .01 **.01** .01	**.01** .01 **.01** .01	**.07** .08 **.07** .08	**.11** .09 **.11** .09	- - - -	- - - -	**.05** .03 **.05** .03	**1.2** .67 **1.5** .48
EX	**.01** .08 **.01** .08	**.10** .22 **.10** .22	**.05** .07 **.04** .08	**.10** .15 **.10** .15	**.12** .33 **.11** .33	**.38** .14 **.37** .15	**.12** .13 **.12** .13	**.16** .09 **.16** .09	**.29** .37 **.29** .37	**.47** .54 **.47** .54	**.11** .11 **.11** .11	- - - -
WGU	**.08** .11 **.07** .11	**.52** .24 **.53** .24	**.34** .23 **.34** .23	**.20** .20 **.20** .20	**.07** .07 **.07** .07	**.09** .05 **.09** .05	**1.8** 3.7 **1.8** 3.6	**.16** .18 **.16** .18	**6.8** 9.0 **7.0** 8.7	**.61** .33 **.62** .32	**.10** .10 **.10** .10	**.05** .08 **.02** .03
NG	**.00** .01 **.00** .01	**.13** .07 **.13** .07	- - - -	- - - -	**.00** .00 **.00** .00	- - - -	**.01** .01 **.01** .01	**.00** .00 **.00** .00	**.04** .05 **.04** .05	**.10** .06 **.10** .06	**.01** .01 **.01** .01	**.01** .02 **.01** .01
ITR	**.06** .23 **.06** .23	**.37** .88 **.38** .88	- - - -	**.00** .00 **.00** .00	**.00** .01 **.00** .01	**.01** .00 **.01** .00	**.05** .06 **.05** .06	**.01** .00 **.01** .00	**.00** .00 **.00** .00	**.03** .03 **.03** .03	**.02** .03 **.02** .03	**.24** .13 **.28** .06
SSHR	- - - -	- - - -	- - - -	- - - -	**.00** .00 **.00** .00	- - - -	**.00** .00 **.00** .00	- - - -	**.00** .00 **.00** .00	**.00** .01 **.00** .01	- - - -	- - - -
DTCR	**.00** .00 **.00** .00	- - - -	**.00** .00 **.00** .00	**.01** .01 **.01** .01	- - - -	- - - -	**.00** .00 **.00** .00	**.02** .03 **.02** .03	**.01** .01 **.01** .01	- - - -	- - - -	**.00** .00 **.00** .00
DTHR	- - - -	- - - -	- - - -	- - - -	- - - -	**.00** .00 **.00** .00	**.00** .00 **.00** .00	- - - -	- - - -	- - - -	- - - -	- - - -
SUB	**.01** .01 **.01** .01	- - - -	- - - -	**.03** .02 **.03** .02	**.00** .00 **.00** .01	- - - -	**.18** .18 **.18** .18	**.01** .01 **.01** .01	- - - -	- - - -	**.01** .02 **.01** .02	- - - -

TABLE 4'
THEIL'S INEQUALITY COEFFICIENTS
DESIRED TARGET VARIABLES

	DB	FR	IT	NL	BE	UK	IR	DK	HE	PO	ES	EC
CPO	**.09** .09 **.09** .09	**.07** .09 **.07** .09	**.30** .39 **.30** .39	**.05** .02 **.05** .02	**.02** .01 **.02** .01	**.14** .14 **.14** .14	**.08** .09 **.08** .09	**.01** .04 **.01** .04	**.03** .01 **.03** .01	**.15** .25 **.15** .24	**.15** .13 **.15** .13	**.10** .02 **.11** .02
IPO	**.25** .18 **.25** .18	**.05** .07 **.04** .07	**.31** .29 **.31** .29	**.17** .14 **.18** .14	**.21** .32 **.21** .32	**.10** .09 **.10** .09	**.22** .31 **.22** .31	**.23** .40 **.23** .41	**.13** .11 **.13** .11	**.17** .22 **.17** .22	**.44** .87 **.43** .87	**.12** .09 **.15** .07
XTO	**.06** .08 **.06** .08	**.03** .01 **.03** .01	**.20** .18 **.20** .18	**.06** .02 **.06** .02	**.07** .17 **.07** .17	**.08** .06 **.08** .06	**.07** .03 **.07** .03	**.06** .08 **.06** .08	**.38** .39 **.38** .39	**.12** .17 **.12** .17	**.11** .10 **.11** .10	**.09** .05 **.09** .05
MTO	**.23** .29 **.23** .29	**.02** .03 **.02** .03	**.27** .31 **.27** .31	**.03** .05 **.03** .05	**.11** .14 **.11** .14	**.16** .16 **.16** .16	**.36** .36 **.36** .36	**.03** .06 **.03** .06	**.02** .06 **.02** .06	**.21** .33 **.21** .33	**.57** .66 **.57** .65	**.03** .20 **.02** .19
PY	**.15** .20 **.15** .20	**.08** .08 **.08** .08	**.01** .03 **.01** .03	**.03** .02 **.03** .02	**.03** .04 **.03** .04	**.05** .04 **.05** .03	**.32** .37 **.33** .37	**.01** .01 **.01** .01	**.39** .44 **.38** .44	**.08** .20 **.08** .20	**.64** .58 **.64** .58	**.08** .07 **.08** .06
UR	**.00** .00 **.00** .00	**.05** .03 **.05** .03	**.01** .00 **.01** .00	**.01** .01 **.01** .01	**.00** .00 **.00** .00	**.00** .00 **.00** .00	**.17** .22 **.17** .22	**.00** .00 **.00** .00	**.24** .27 **.25** .27	**.03** .02 **.03** .02	**.04** .03 **.04** .03	**.00** .00 **.00** .00
FMD	**.13** .11 **.13** .11	**.11** .07 **.11** .07	**.16** .18 **.16** .18	**.13** .07 **.13** .07	**.20** .18 **.20** .18	**.17** .30 **.17** .31	**.44** .55 **.45** .55	**.34** .31 **.34** .31	**.96** .90 **.96** .90	**.43** .31 **.43** .30	**.54** .42 **.55** .42	**.63** .37 **.71** .29
PXT	**.17** .27 **.18** .27	**.02** .02 **.02** .02	**.06** .11 **.06** .11	**.08** .05 **.08** .05	**.04** .03 **.04** .03	**.26** .23 **.26** .23	**.27** .36 **.27** .36	**.07** .16 **.07** .16	**.67** .65 **.67** .65	**.09** .18 **.09** .18	**.40** .49 **.40** .49	**.09** .13 **.09** .13
TB	**.01** .07 **.02** .07	**.00** .00 **.00** .00	**.00** .00 **.00** .00	**.02** .02 **.02** .02	**.00** .00 **.00** .00	**.00** .00 **.00** .00	**.00** .00 **.00** .00	**.00** .00 **.00** .00	**.00** .00 **.00** .00	**.01** .02 **.01** .02	**.00** .00 **.00** .00	**.00** .01 **.00** .01

TABLE 5'
THEIL'S INEQUALITY COEFFICIENTS
DESIRED CONTROL VARIABLES

	DB	FR	IT	NL	BE	UK	IR	DK	HE	PO	ES	EC
SI	.04 .06 .04 .06	.17 .26 .17 .26	.01 .02 .01 .02	- - - -	- - - -	- - - -	- - - -	- - - -	.19 .21 .19 .21	.03 .21 .03 .21	- - - -	- - - -
LI	- - - -	- - - -	- - - -	.15 .13 .14 .13	.02 .03 .02 .03	.03 .02 .03 .02	.12 .14 .13 .14	.11 .10 .11 .10	- - - -	- - - -	.11 .08 .11 .08	1.9 .56 2.2 .41
EX	.01 .08 .01 .08	.08 .19 .08 .19	.05 .08 .04 .08	.10 .14 .10 .14	.12 .32 .12 .32	.38 .16 .37 .16	.12 .13 .12 .12	.16 .09 .16 .09	.34 .42 .34 .42	.48 .58 .48 .58	.10 .13 .10 .13	- - - -
WGU	.08 .11 .08 .11	.59 .27 .59 .27	.34 .23 .35 .23	.20 .20 .20 .20	.07 .07 .07 .07	.09 .05 .09 .05	2.7 6.1 2.8 6.0	.16 .18 .16 .18	5.5 6.9 5.7 6.7	.65 .34 .66 .34	.11 .11 .11 .11	.05 .08 .02 .03
NG	.00 .01 .00 .01	.14 .08 .14 .08	- - - -	- - - -	.00 .00 .00 .00	- - - -	.01 .02 .01 .01	.00 .00 .00 .00	.04 .05 .04 .05	.11 .07 .11 .07	.01 .01 .01 .01	.01 .02 .01 .01
ITR	.05 .22 .06 .21	.37 .85 .37 .85	- - - -	.00 .00 .00 .00	.00 .01 .00 .01	.01 .01 .01 .01	.09 .11 .10 .11	.01 .00 .01 .00	.00 .00 .00 .00	.03 .04 .03 .04	.02 .03 .02 .03	.31 .05 .30 .10
SSHR	- - - -	- - - -	- - - -	- - - -	.00 .00 .00 .00	- - - -	.00 .00 .00 .00	- - - -	.00 .00 .00 .00	.00 .01 .00 .01	- - - -	- - - -
DTCR	.00 .00 .00 .00	- - - -	.00 .00 .00 .00	.01 .01 .01 .01	- - - -	- - - -	.00 .00 .00 .00	.02 .03 .02 .03	.01 .01 .01 .01	- - - -	- - - -	.00 .00 .00 .00
DTHR	- - - -	- - - -	- - - -	- - - -	- - - -	.00 .00 .00 .00	.00 .00 .00 .00	- - - -	- - - -	- - - -	- - - -	- - - -
SUB	.01 .01 .01 .01	- - - -	- - - -	.03 .02 .03 .02	.00 .01 .00 .01	- - - -	.15 .28 .15 .28	.01 .01 .01 .01	- - - -	- - - -	.01 .02 .01 .02	- - - -

Appendix D

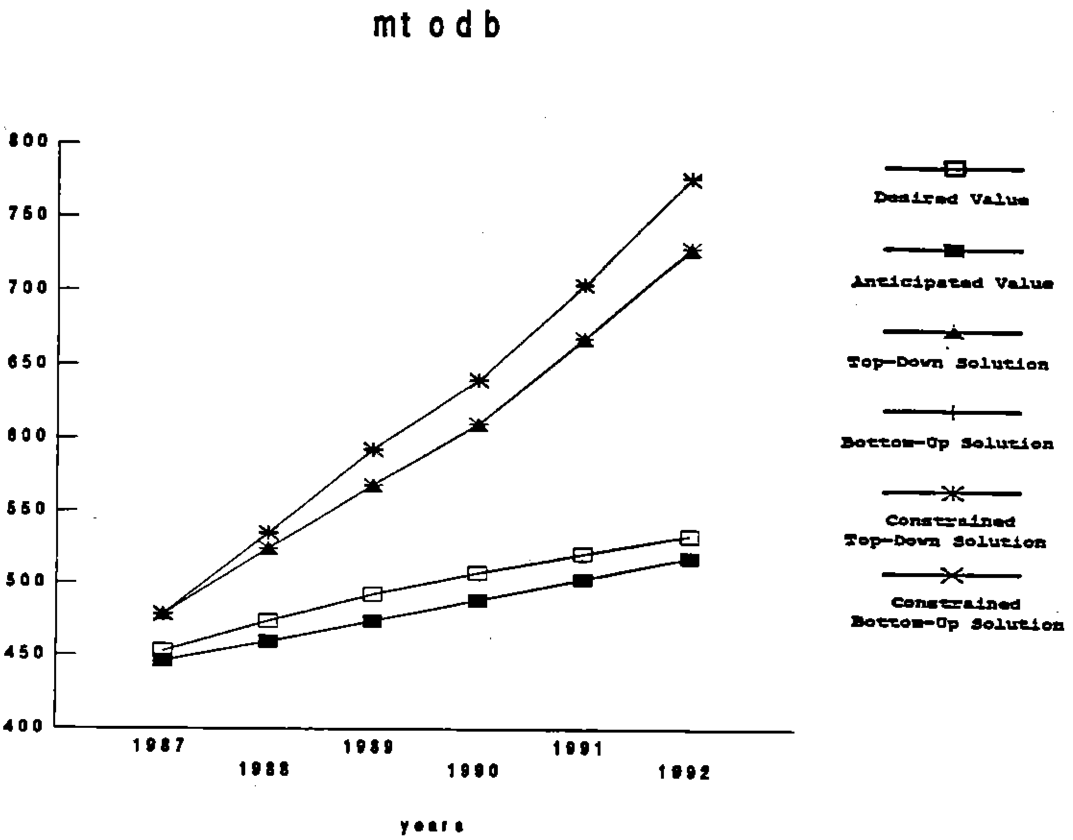

Figure 1

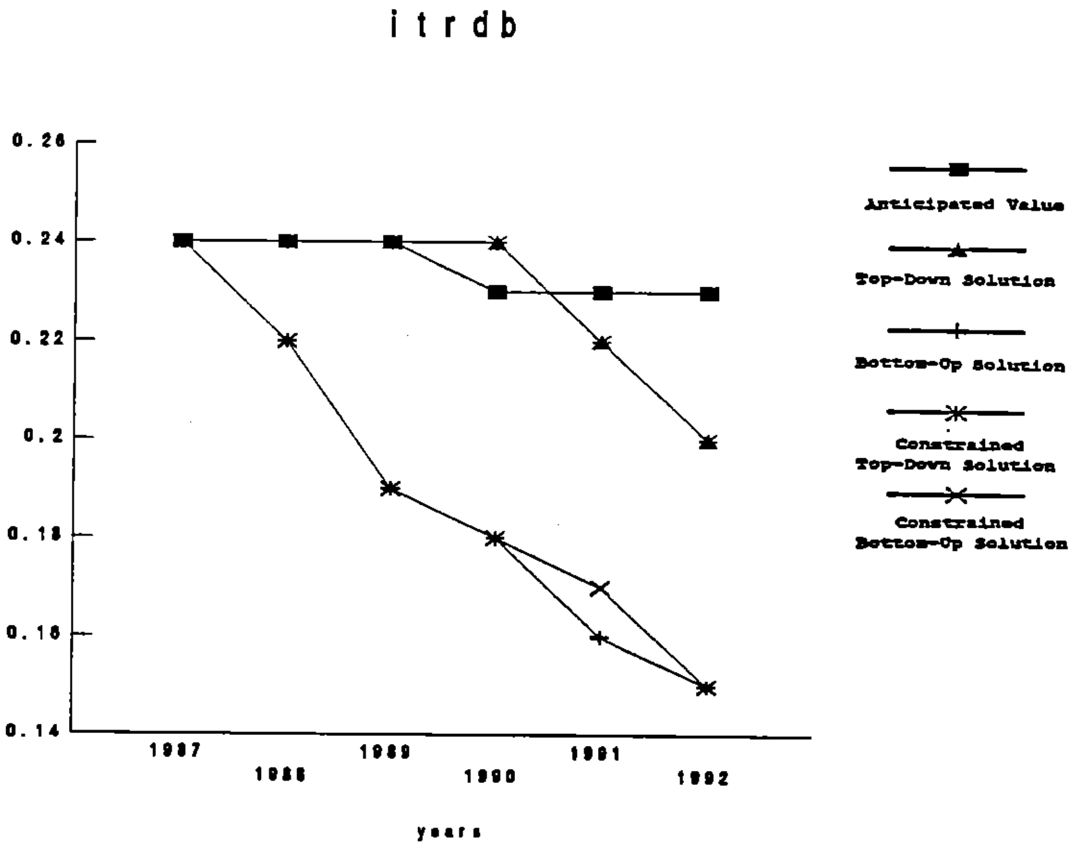

Figure 2

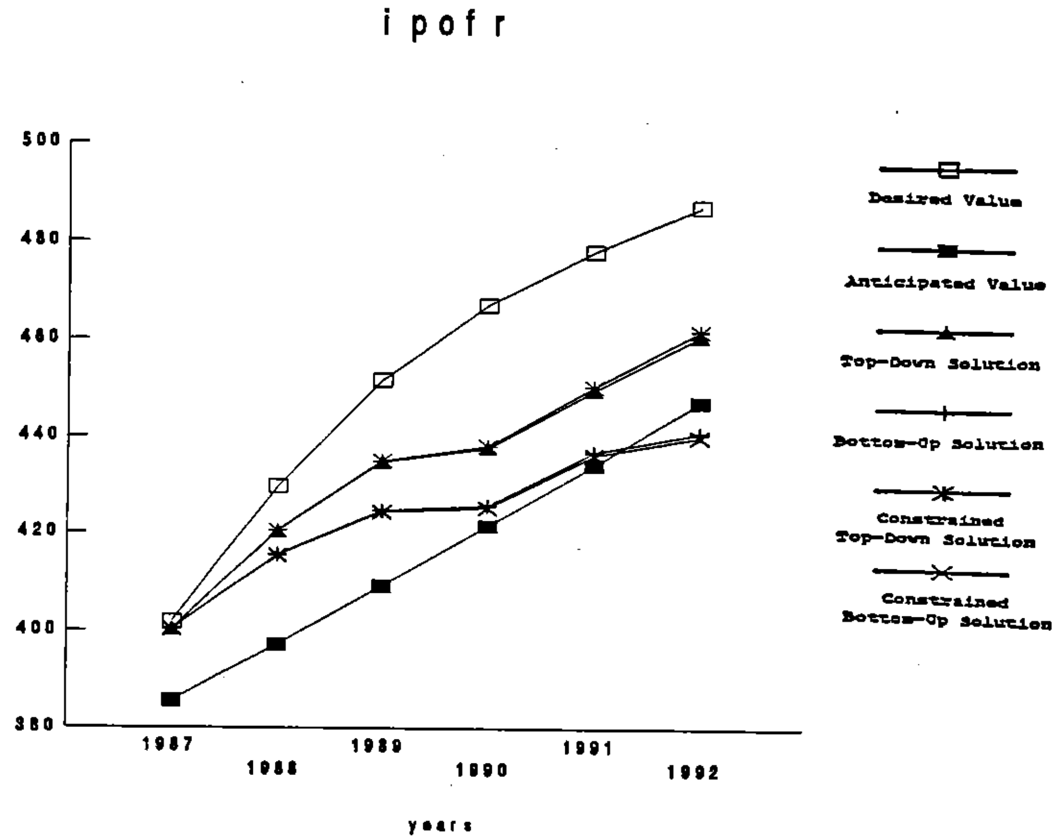

Figure 3

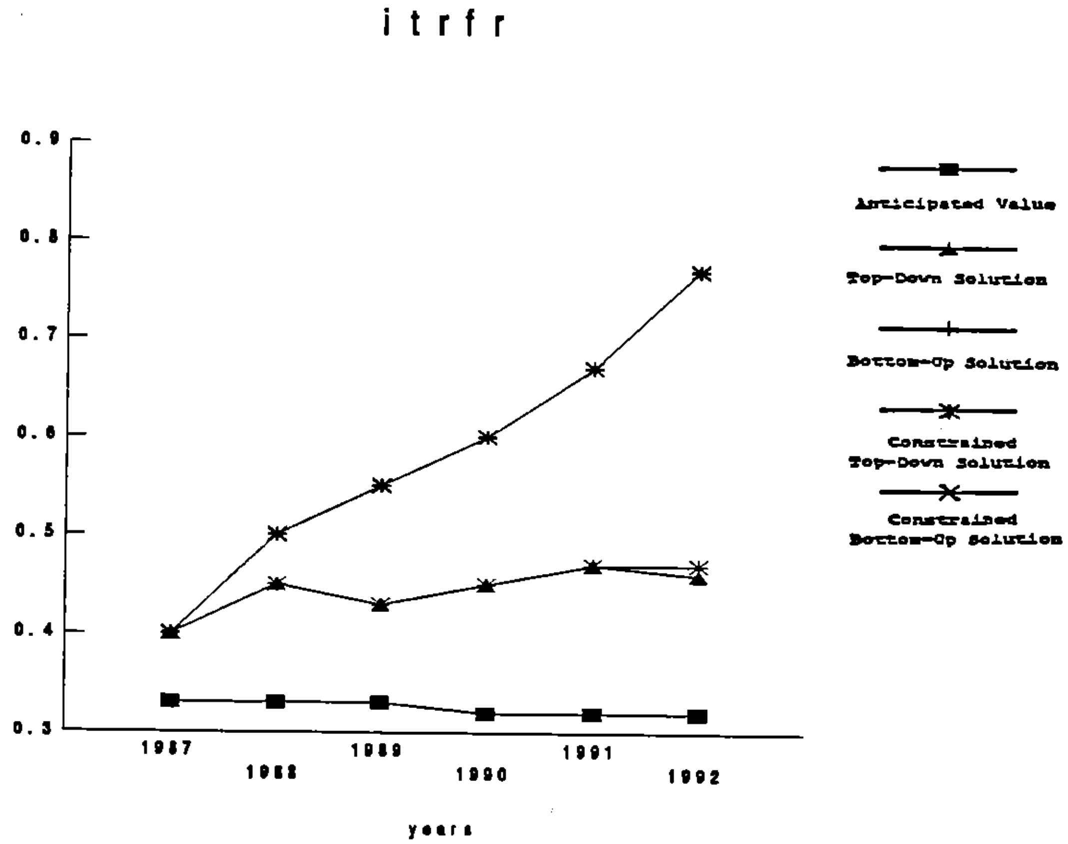

Figure 4

ipoir

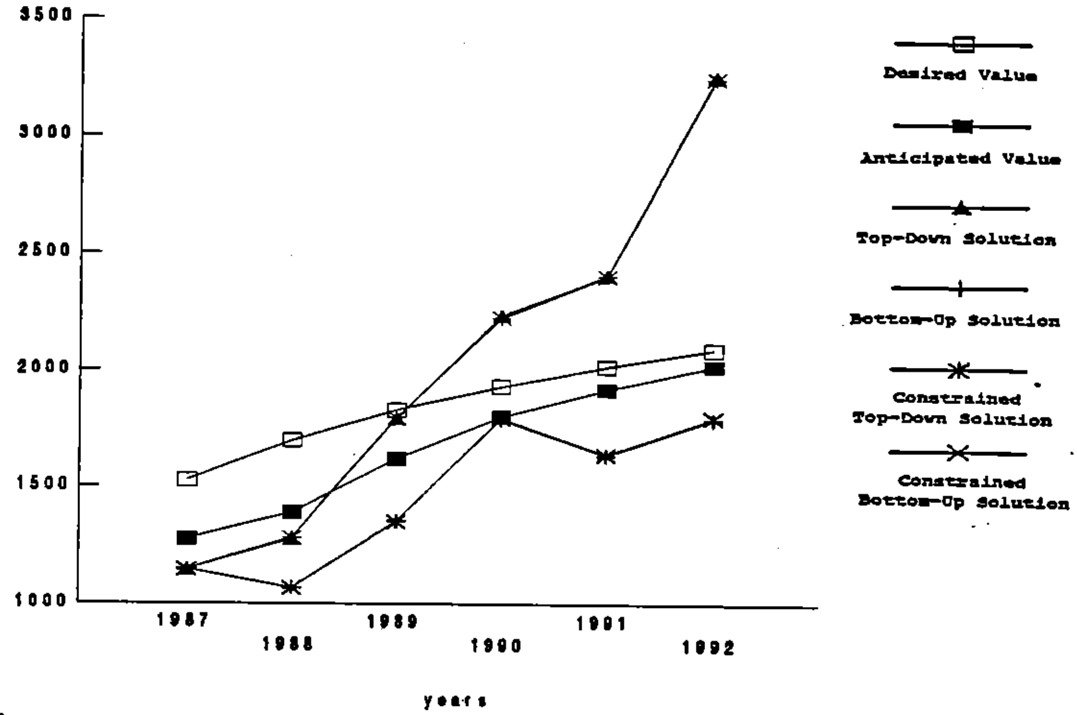

Figure 5

subir

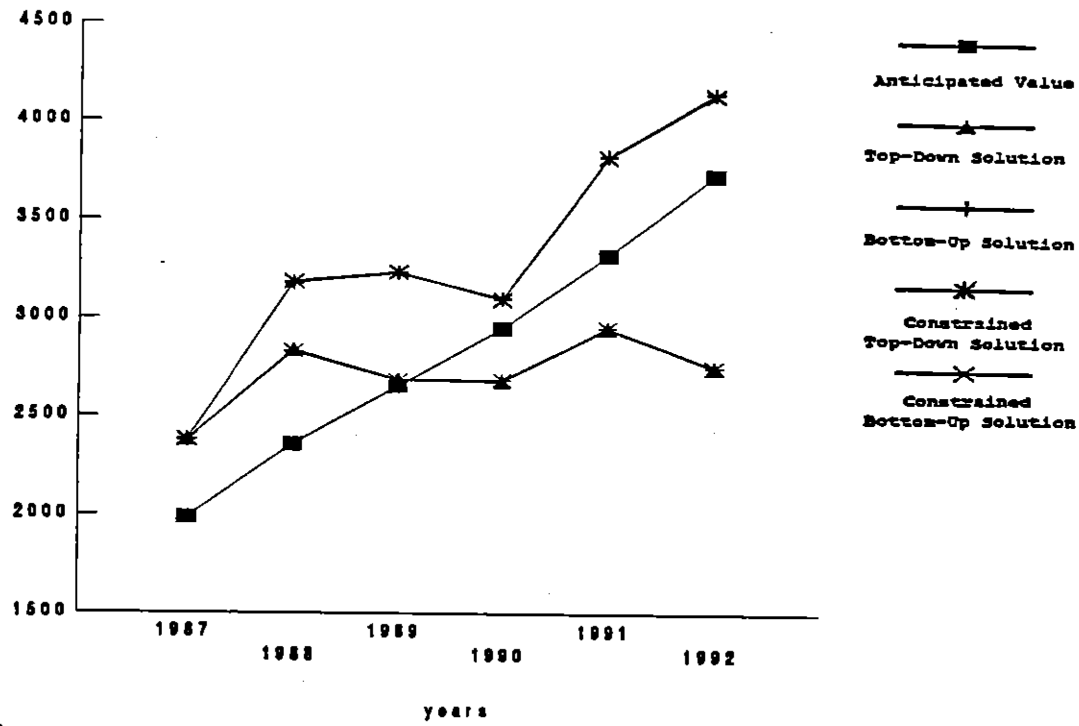

Figure 6

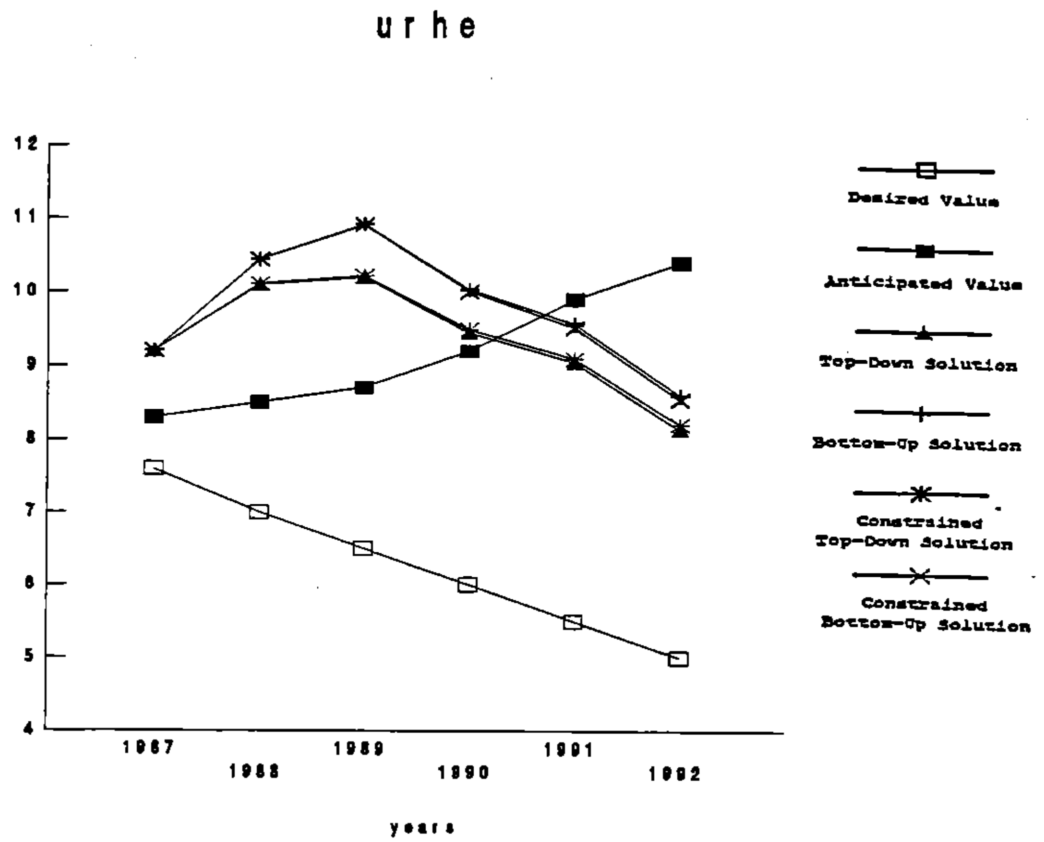

Figure 7

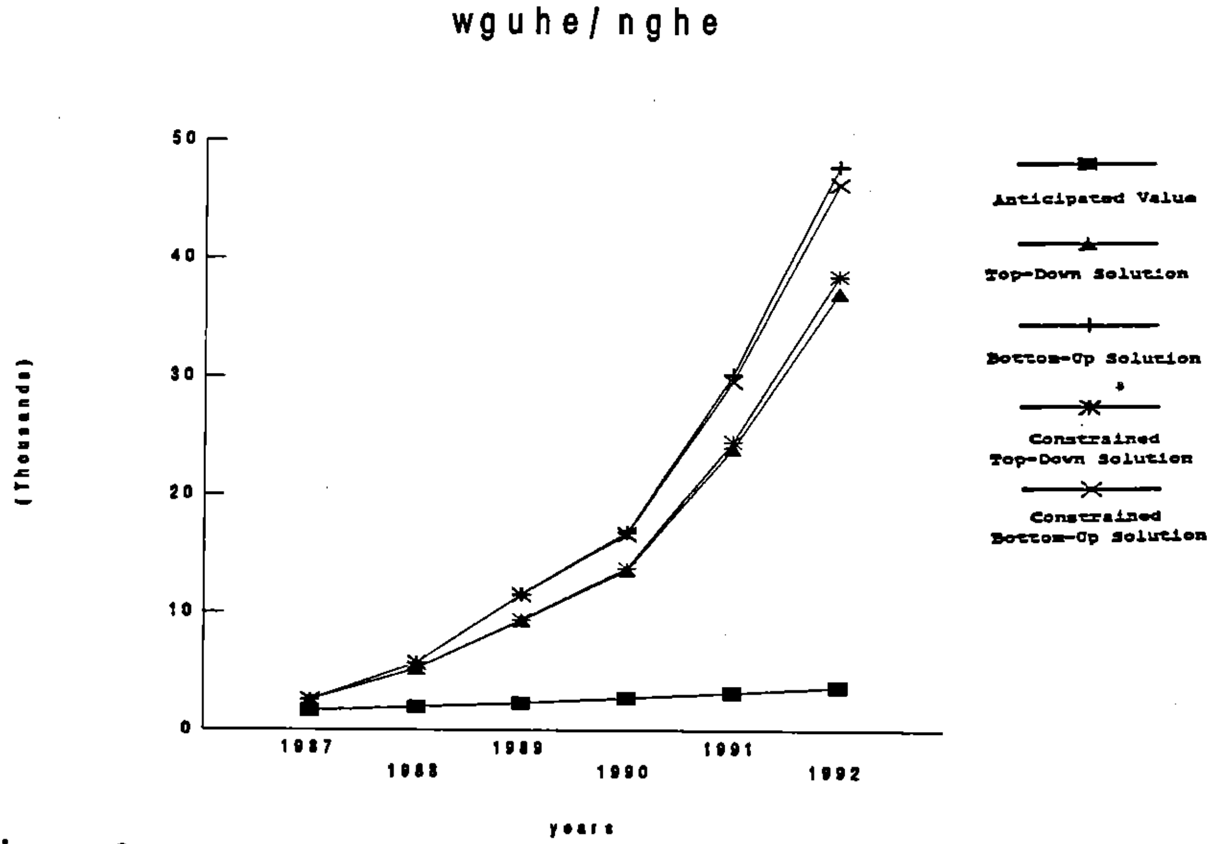

Figure 8

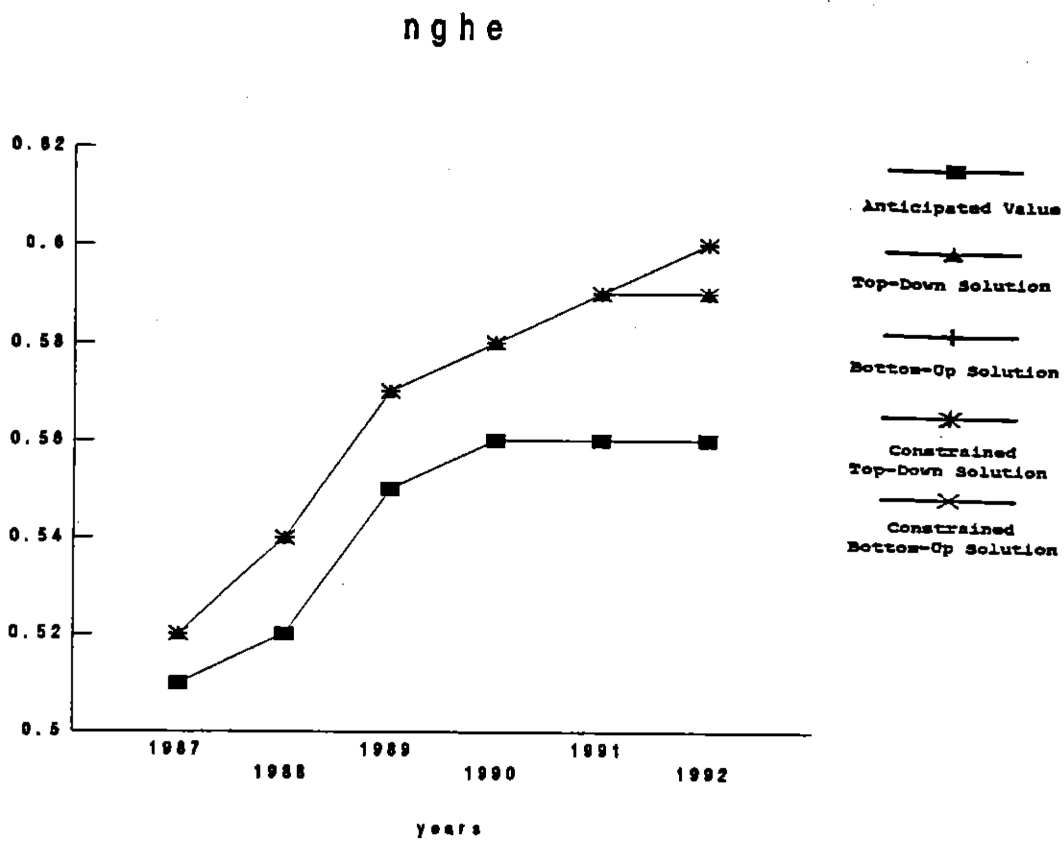

Figure 9

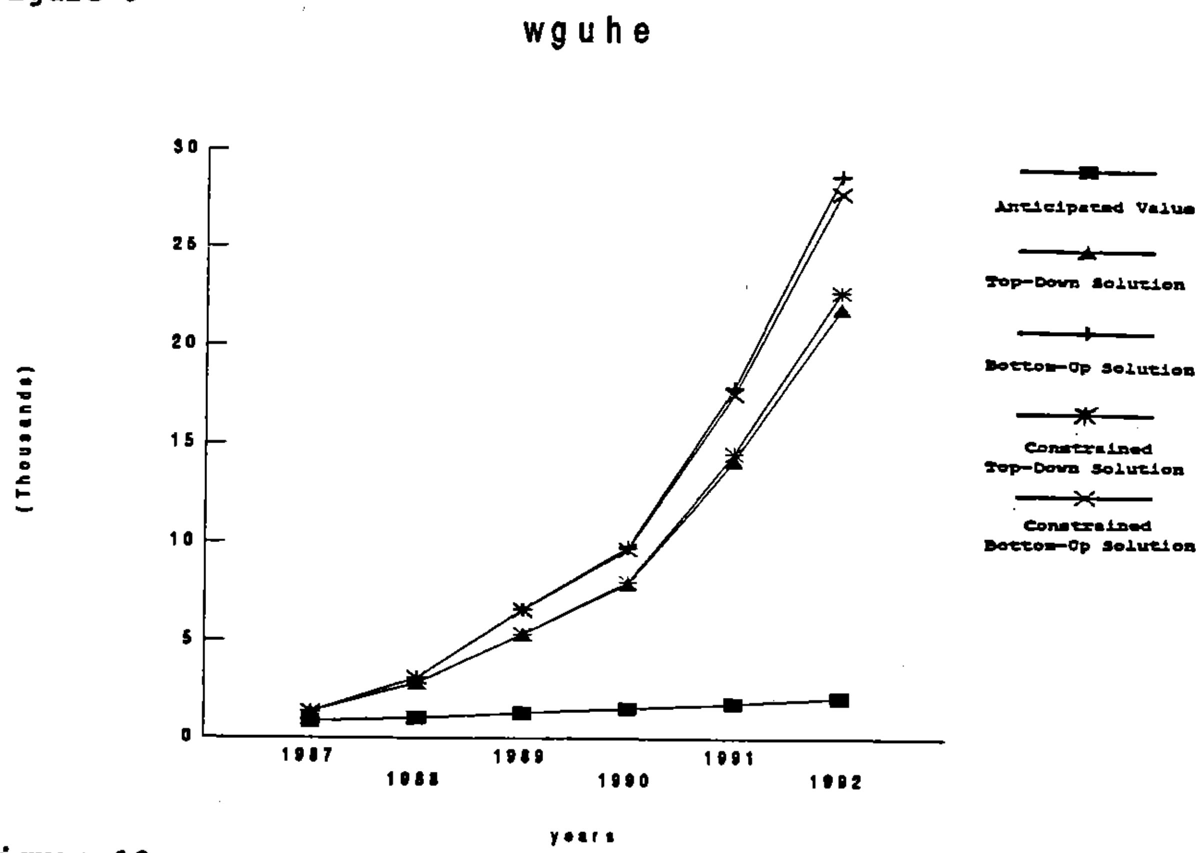

Figure 10

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