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HERPOR 3 – A MACROECONOMETRIC MODEL FOR THE PORTUGUESE ECONOMY

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Title: HERPOR 3 – A Macroeconometric Model for the Portuguese Economy

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ABSTRACT

HERPOR is a four-sector annual macroeconometric model for the Portuguese economy, designed for policy evaluation. Although inspired in the HERMIN model, HERPOR presents several differences in relation to it, implying different results in terms of the evaluation of the impact of structural policies on the Portuguese economy.

HERPOR considers four sectors of activity: Tradable, Non-tradable, Agriculture and Non-Market services. In the short term output is mainly determined by demand and there is a trade-off between inflation and unemployment. In the long term, supply side conditions, driven by the accumulation of physical and human capital, play a key role, with actual output converging to potential output.

This paper presents a description of the third version of the model, developed in 2008, and its application to the analysis of comparative effects of different types of public expenditure shocks (Investment in infrastructures, incentives to private investment and investment in human capital).

Keywords: Macroeconometric model; Portugal; policy evaluation.

HERPOR 3 – A MACROECONOMETRIC MODEL FOR THE PORTUGUESE ECONOMY

1. INTRODUCTION

HERPOR is a macroeconometric model for the Portuguese economy developed in the Department of Prospective and Planning (DPP) with the purpose of evaluating the macroeconomic impact of structural policies on the Portuguese economy. The model was built with the aim of considering both supply and demand side effects of these policies in the short, medium and long term.

The first version of HERPOR (described in Dias *et al*, 2003) was completed in 2003 by a team including DPP staff and two professors from the Technical University of Lisbon (ISEG). This version was used in the mid-term evaluation of the Community Support Framework 2000-2006, CSF III (Dias *et al.*, 2003) and in the evaluation of the Portuguese Central Government Investment Programme, PIDDAC (Dias and Lopes, 2004).

Lopes (2005) developed in his Master's thesis an adapted version of HERPOR to simulate the impact (on the Portuguese economy and on Social Security financing) of alternative changes in the Social Security system for Portugal (*vide* also: Garcia and Lopes, 2006).

In 2005 the model was revised and updated in order to be used in the update of CSF III mid-term evaluation, originating the second version of HERPOR, presented in Dias and Lopes (2005) and in Dias (2006). This version was also used in the *ex-ante* evaluation of the National Strategic Reference Framework 2007-2013 (NSRF), presented in Dias and Lopes (2007a) and in Dias (2007).

In 2008 the model data basis was totally revised and updated in order to make it compatible with basis 2000 of National Accounts. This revision implied the complete reestimation, and in some cases, reespecification, of the model, giving birth to HERPOR 3, which is the object of the present paper.

The next section presents a model description, starting with general features, followed by an explanation of the demand and supply mechanisms (in the short and in the long-run) present in the model and completed with the description of the public finance block.

Section 3 refers to model estimation and validation, including the presentation of model historical simulation results. Section 4 presents model applications, including

the comparative analysis of the effect of the main three types of public expenditure co-financed by European structural funds (investment in infrastructures, incentives to private investment and investment in human capital).

Appendixes 1 to 6 complete this paper, presenting details of model specification, estimation and simulation.

2. MODEL DESCRIPTION

2.1. General features

HERPOR was initially inspired in the HERMIN model[1], in its version for Portugal. The HERMIN modelling framework was designed in the 1990s to evaluate the economic impact of EC structural interventions in Objective 1 countries (Bradley *et al.*, 1995; Bradley, 2000; Bradley and Untiedt, 2007).

Although inspired in HERMIN, HERPOR differs from it in many aspects of model specification, methods of parameter estimation and in the data basis used for estimation, implying different results in terms of the evaluation of the impact of structural policies on the Portuguese economy[2].

The main features of HERPOR model are:

- The sectoral breakdown in four sectors: A (Agriculture, Forestry and Fishing), T (tradable sector, including Mining, Manufacturing and Air and Water Transportation Services), N (non-tradable market sector, including Building and Construction, Utilities and other market services) and G (predominantly non-market services: Public Administration, Education, Health and Social services and Sanitation)[3];
- The essentially exogenous nature of the A and G sectors;
- In the short term, output in the T and N sectors is mainly determined by demand;
- The existence of a short-term trade-off between wage growth and unemployment;
- The leading role of the Tradable sector in wage determination;

[1] We are grateful to Professor John Bradley (the main author of HERMIN models) for his willingness to discuss all the features of HERMIN with the HERPOR team as well as for providing us all the information and files concerning various versions of HERMIN Portugal, and for his valuable comments on HERPOR's second version.

[2] A comparison of results of the impact of CSF III on the Portuguese economy, evaluated with HERPOR (version 2) *vs*. HERMIN and QUEST II, is presented in Dias (2006), pp 14-16.

[3] A complete identification of HERPOR sectors is presented in Appendix 4.

- Exports and imports are not explicitly modelled and the trade balance is obtained through the difference between GDP and total domestic demand;
- The consideration of long-term (supply-side) effects of public policies promoting changes in physical and human capital stocks;
- Parameters of behavioural equations mostly obtained from econometric estimation, considering long-run (cointegrating) and short-run relationships (with an error-correction mechanism);
- Explicit modelling of potential output as a function of productive factors (stock of infrastructures, stock of productive capital, human capital and labour).

HERPOR specification was also influenced by other modelling experiences of the HERPOR team, such as MEGA (Dias and Lopes, 2007b), a macroeconometric model also developed in DPP, which influenced the modelling of the Public Finance block and of Private Consumption in HERPOR.

2.2. Output, Demand and Balance of Goods and Services

GDP (at basic prices) is obtained through the sum of sectoral **output** (gross value added) across the four sectors.

Output in the **T** and **N** sectors depend on both domestic and international demand and, in the case of the T sector, also on profitability (proxied by real unit labour costs) and on price competitiveness (ratio of internal to international manufacturing prices). The relevance of international demand for explaining output in the N sector results from the fact that this sector has an increasing tradable component, particularly through tourism and, more recently, through the internet.

Real output in the **A** sector is exogenous.

In the **G** sector, given the predominance of Public Administration, nominal output is defined as the sum of a set of exogenous components (compensation of employees, self-employed income and other). Real output is obtained through the ratio between nominal output and its deflator.

Real **private consumption** depends on real personal disposable income and also on the unemployment and interest rates.

Real **public consumption** is obtained from the ratio of nominal public consumption (exogenous) to an endogenous public consumption deflator.

Total fixed **investment** is obtained through the sum of sectoral investment across all sectors to housing investment.

Real investment in Agriculture and nominal investment in infrastructures (defined as the sum of the investment in sector G with infrastructural investment in sector N[4]) are exogenous.

Investment in the N sector (excluding housing and infrastructures) depends positively on sectoral output and negatively on real interest rate, unemployment rate and the relative price of investment goods. It is also assumed that public incentives to this investment have a positive additive effect on it. Therefore, this aid was included as an explanatory variable.

Investment in the tradable sector depends positively on sectoral output and output gap and negatively on the user cost of capital. For this sector the econometric tests did not allow the acceptance of an additive effect of public aid on investment. In this case public aid has only an indirect effect on investment through the lowering of the user cost of capital.

Housing investment depends positively on real household disposable income and negatively on nominal interest rates and on a dummy assuming value 1 from 2003 onwards (reflecting legislation revision, occurred in 2002, which ended interest rate bonuses to housing loans).

Domestic demand addressed to sectors N and T is calculated through weighted sums of domestic demand components (private consumption, public consumption, investment in construction and investment in equipment), using coefficients derived from input-output matrices estimated for 2005 (Dias, 2008 and 2009). These coefficients represent the estimated value added content (direct+indirect) concerning the T and N sectors respectively, per unit of each domestic demand component[5].

The **Balance of Goods and Services** is obtained through the difference between GDP at market prices and total domestic demand.

2.3. Long-Term Supply and Potential Output

Long-term supply is determined by potential output, calculated through **production functions**. Production function modelling in HERPOR is inspired in Pina and St. Aubyn (2002), using Cobb-Douglas functions with four productive factors: labour (employment in volume), human capital (measured by the average number

[4] Infrastructural Investment in sector N was defined as the investment in construction in the branches of water, electricity, gas, land and pipeline transport, supporting transport activities and communications.

[5] The methodology for calculating value added contents of final demand is explained in Dias (2010).

of years of training in the working age population), public capital (or capital of infrastructures) and private capital (excluding housing). Constant returns to scale are assumed in labour and fixed capital.

In HERPOR two production functions are considered: one for the whole economy and another for the T sector.

Given the existence of problems of multicolinearity not all the production function parameters were econometrically estimated and some of them were calculated on the basis of theory-based and empirical assumptions.

In the **aggregate production function** the elasticities of (potential) GDP in relation to public and private fixed capital and to labour were calculated on the basis of the following assumptions: (i) constant returns to scale regarding these three productive factors; (ii) a 5% average real rate of return on both public and private capital. The elasticity of GDP in relation to human capital was then econometrically estimated, but we could not accept the constancy of this elasticity over time and so we estimated a time varying elasticity, which decreases over time (from 1.29 in 1977 to 1.01 in 2006).

For the **Tradable sector** we also assumed constant returns to scale in labour and fixed capital and a 5% average real rate of return on private capital but no assumption was made regarding public capital and so we estimated freely the parameters for public capital and for human capital. However we did not obtain an economically acceptable elasticity for public capital (the estimated parameter was negative) so we excluded public capital from the tradable sector production function. In this case we accepted a constant elasticity of output regarding human capital of 0.78.

Stocks of fixed capital are calculated from investment flows (decomposed into investment in equipment and investment in construction, with different depreciation rates) using the perpetual inventory method.

The **stock of human capital** (defined as the average number of years of schooling and training for population aged 15 to 64) is obtained through the sum of the stocks of academic education and of professional training. For simplification, the first is exogenous and the second is a function of investment in training. For the stock of academic education we used an updated version of the series estimated by Pereira (2003), concerning the average number of years of schooling of the working age population. The stock of professional training was estimated in DPP on the basis of the results of surveys made by the Ministry of Labour (DETEFP, 2000-2006) and of data concerning expenditure on professional training co-financed by EU structural funds (CSF and NSRF).

The production functions included in the model allow the estimation of potential output and **output gaps** for the whole economy and for the tradable sector. These output gaps interact with the other variables in the model, influencing labour demand and investment.

2.4. Short-Term Supply mechanisms: Labour Market, Wages and Prices

The labour market modelling plays an important role in the model self-stabilization properties, understood as the mechanisms that ensure convergence for a long-term equilibrium guided by supply conditions.

Labour demand (Employment) in the T and N sectors depends negatively on the real cost of labour and positively on sectoral output and on output gaps (in the T sector and in the whole economy, respectively). The latest link contributes to the closure of output gaps: In fact, a positive gap imply an increase in employment, pushing up potential output on one hand and making pressure on wages and prices (associated to the reduction of the rate of unemployment), which contributes to a loss in competitiveness, reducing total demand and actual output.

Agricultural employment is exogenous. In the G sector employment is obtained through the division of total compensation of employees (exogenous) by an endogenous wage rate.

Labour supply is a function of employment opportunities. This equation assumes an open policy in relation to migration flows in order to allow an adjustment between supply and demand in the labour market.

The Tradable sector assumes a leading role in **wage** determination for the whole economy. The wage rate equation for this sector is specified in such a way so that the change in the labour share depends negatively on the rate of unemployment. There is an implicit equilibrium rate of unemployment corresponding to the stabilisation of the labour share, which is 5.9%, according to the estimated parameters. This value is close to some NAIRU estimates for the Portuguese economy such as in Martins and St.Aubyn (2001).

The wage rate growth in the various sectors (including the G sector) is guided by the Tradable sector, following the logic of the so-called Scandinavian model.

In the N sector the wage rate growth is also influenced by the productivity growth differential in relation to the T sector.

In sector G the wage rate growth depends also on the unemployment rate and on the public deficit (in percentage of GDP) observed in the previous period.

Internal **prices** are influenced by unit labour costs and by international prices.

Deflators of sectoral value added play a key role in the whole model price determination. Deflators for the T and N sectors depend on unit labour costs and on international prices converted to euros. Sector A has an exogenous deflator and the deflator for sector G is related to the corresponding gross wage rate (including employer's contributions).

GDP deflator at basic prices (PGDPBP) results from a weighted average of sectoral value added deflators. GDP deflator at market prices (PGDPM) is determined by PGDPBP and by the tax rate on products (net of subsidies).

Deflator of private consumption depends on PGDPM and on import prices (exogenous).

The deflator of investment in equipment depends on import prices and on the OT deflator.

The deflator of investment in construction depends on import prices and on labour costs in sector N (which includes the construction sector).

Finally, public consumption deflator depends on the deflator of value added in sector G.

2.5. Public Finance

Taxes and social contributions are functions of the corresponding tax basis (or a proxy of it) multiplied by exogenous tax rates: direct taxes on households (depending on personal income before tax) and on companies (depending on Profits), social contributions (depending on total wage bill), indirect taxes (depending on private consumption) and capital taxes (depending on GDP). Public sector investment income is also a function of GDP.

On the expenditure side, public consumption is obtained through the sum of two exogenous components (compensation of employees in the G sector and other public consumption expenditure). Public transfers, subsidies and public investment are also exogenous. Interest payments depend on the level of public debt multiplied by an exogenous interest rate.

Public deficit, obtained from the difference between total expenditure and total revenue, determines the evolution of public debt.

The above description corresponds to the standard version of the model, used in reference simulations. For variant simulations (used to evaluate the impact of policies and other exogenous shocks), a fiscal policy rule is often included in order to equate the public deficit (as percentage of GDP) to the reference scenario. This

rule is particularly important in the evaluation of policies involving additional public expenditure because it ensures its financing.

In the fiscal policy rule version, public deficit as a percentage of GDP is an exogenous variable (equal to the value simulated in the reference scenario) and the adjustment is made through the rate of taxation (less subsidies) on products.

3. MODEL ESTIMATION AND VALIDATION

For the model estimation a data basis was built with annual data from, at least, 1977 to 2006 (1958 to 2006, when possible), making series from different accounting systems compatible with basis 2000 of National Accounts.

HERPOR 3 has 142 equations of which 20 were econometrically estimated, two had their parameters calculated from input-output matrices and the remaining 120 are identities, definition or calibrated equations.

The estimated equations concern actual output (value added) for the T and N sectors, potential output (production functions – for the whole economy and for the T sector), investment (for the T and N sectors and for housing), wage rates in the four sectors, prices in the T and N sectors, deflators for consumption, equipment and construction, employment in the T and N sectors, private consumption and labour force.

Details of equation estimation are presented in Appendix 2. In principle the largest possible estimation period was used given the available actual data, unless there was evidence of structural change along that period.

Given the fact that a large number of the model series are non stationary (mostly I(1) in the logs), the econometric estimation was done considering, for most of the equations, long-run cointegration relationships and short-run relationships with an error-correction mechanism (ECM). These relationships were estimated either in two steps (following the procedure proposed by Engle and Granger, 1987) or in one step, using, in both cases, Ordinary Least Squares (OLS) or, for some cases of imposed parameter restrictions, Restricted Least Squares (RLS).

For each variable, several regressions were attempted with specifications inspired in economic theory and in the perceived behaviour of the Portuguese economy. Estimated equations were, in principle, only accepted when the estimated coefficients were statistically significant[6] and presented economically acceptable

[6] In some cases “non-significant” variables were kept in some equations for theoretical reasons or because their inclusion improved the overall performance of the model.

signs and values, the regression was globally significant and the residuals of the regression were "well behaved" (stationary in the case of long-run relationships, a condition for accepting cointegration; white-noises in the case of short-run relationships).

After the "best" regression equation was selected for each variable, the model was simulated as a whole in the sample period and in a projection period but initially the results were not satisfactory and so many alternative model versions were tried, with different equation combinations, before an acceptable model version was found.

Therefore, the criteria for equation selection was not only the goodness of fit of each regression itself but also the global performance of the model in the historical simulation and in the long-run projections and so, for some variables, the equations finally included in the model were not the best regressions assessed by individual equation criteria.

The inclusion of some parameter restrictions, such as a long-term unit income elasticity of private consumption, proved to be useful for the long-run model behaviour.

The 2008 model revision used the 2005 specification as a starting point for model reestimation with updated data and specification changes were introduced only when individual equation results or global model simulation were not satisfactory.

Particular attention was given to the equation performance in the most recent years of the sample period since a poor fit in this period might evidence recent structural changes which would disable the model for simulations in the future (one important purpose of the model).

The results of historical dynamic simulation of the whole model, for key economic variables, in 1981-2006, are presented in table 1 and in Appendix 5 (graphs).

Besides minimising simulation errors for the key variables, one concern for model selection was that it succeeded in simulating correctly the turning points observed in the Portuguese economy, which was basically achieved as it can be confirmed from the graphs for GDP in Appendix 5.

In addition to a good replication of the past it was also important to ensure that the model was well behaved in the long-run, producing acceptable reference scenarios for the future and responding to economic shocks in compliance with economic theory and empirical observation. This was confirmed through model simulations until 2050 (reference scenario and simulation of shocks).

Table 1 – Historical dynamic simulation (1981-2006) of HERPOR (version of 2008)

Simulation errors (%):

Variable	Description	RMSPE	MAPE	MPE
GDPM	real GDP at market prices	2,4	1,8	-0,6
OT	real Gross Value Added - T sector	3,6	3,2	-0,7
ON	real Gross Value Added - N sector	2,5	1,9	-0,5
CONS	real Private Consumption	2,4	1,8	-0,4
I	real Fixed Investment	4,1	3,1	-0,4
PGDPM	GDP deflator	3,4	2,2	0,5
LF	Labour Force	1,2	1,0	-0,3
L	Total Employment	1,9	1,6	-0,4
W	Wage rate	4,9	3,9	0,8

Simulation errors (percentage points):

Variable	Description	RMSE	MAE	ME
UR	Unemployment rate	0,9	0,8	0,2
NTSV/GDPMV%	Bal. Goods and Services (% of GDP)	1,2	0,9	0,2
GBORR	Public deficit (% of GDP)	0,8	0,7	0,0

RMSPE (Root Mean Square Percent Error)= $(\{\sum_{t=1}^{N}[(YS_t - YA_t)/YA_t]^2\}/N)^{0.5} *100$

MAPE (Mean Absolute Percent Error) = $\{\sum_{t=1}^{N}|(YS_t - YA_t)/YA_t|/N\}*100$

MPE (Mean Percent Error) = $\{\sum_{t=1}^{N}[(YS_t - YA_t)/YA_t]/N\}*100$

RMSE (Root Mean Square Error)= $[\sum_{t=1}^{N}(YS_t - YA_t)^2/N]^{0.5} *100$

MAE (Mean Absolute Error) = $(\sum_{t=1}^{N}|YS_t - YA_t|/N) *100$

ME (Mean Error) = $[\sum_{t=1}^{N}(YS_t - YA_t)/N] *100$

where YS and YA are the simulated and actual values of an endogenous variable and N is the number of simulation periods (26 in this case).

4. MODEL APPLICATIONS

4.1. Evaluation of the impact of structural policies

HERPOR has been used in the evaluation of the impact of exogenous shocks, in particular shocks of public expenditure co-financed by European Union structural funds.

Each evaluation is made through the comparison of the results of two model simulations, preformed for a long period (*eg*. until 2050), to allow the evaluation of long-term effects:

- a reference simulation, reproducing the observed/projected path for the Portuguese economy;
- a simulation corresponding to what would happen to the economy in the absence (presence) of the shock subject to evaluation (depending on whether the shock is already included or not in the reference simulation). This simulation is performed after revising the values of the exogenous variables in order to exclude (include) the direct effect of the shock on them.

The macroeconomic impact of the shock is usually measured through the percent deviation between the two simulations for each model variable

Portugal has benefited from community structural funds, since it joined the European Community in 1986, with the purpose of stimulating real convergence of the Portuguese economy to the average European levels. Since 1989 this community support was framed by the Community Support Frameworks (CSF: CSF I, from 1989 to 1993; CSF II, from 1994 to 1999; CSF III, from 2000 to 2006) and, more recently, by the National Strategic Reference Framework 2007-2013 (NSRF).

The second version of HERPOR was used for the interim evaluation of CSF III (which included also the evaluation of the impact of CSF I+II+III) and the *ex-ante* evaluation of NSRF. The results of these exercises are presented in Dias and Lopes (2005 and 2007a), for CSF and NSRF, respectively, as well as in Dias (2006), for CSF and in Dias (2007), for both CSF and NSRF.

HERPOR 3 is currently being used for an interim evaluation of the macroeconomic impact of the NSRF, considering the expenditure already made for the period 2007-2009 and the projected expenditure for 2010-2015.

The intensity of CSF/NSRF impact on the economy depends on the level of the corresponding implemented expenditure[7] as well as on its structure. Three main types of expenditure are considered in the evaluation: Investment in infrastructures, incentives to private investment and investment in human capital.

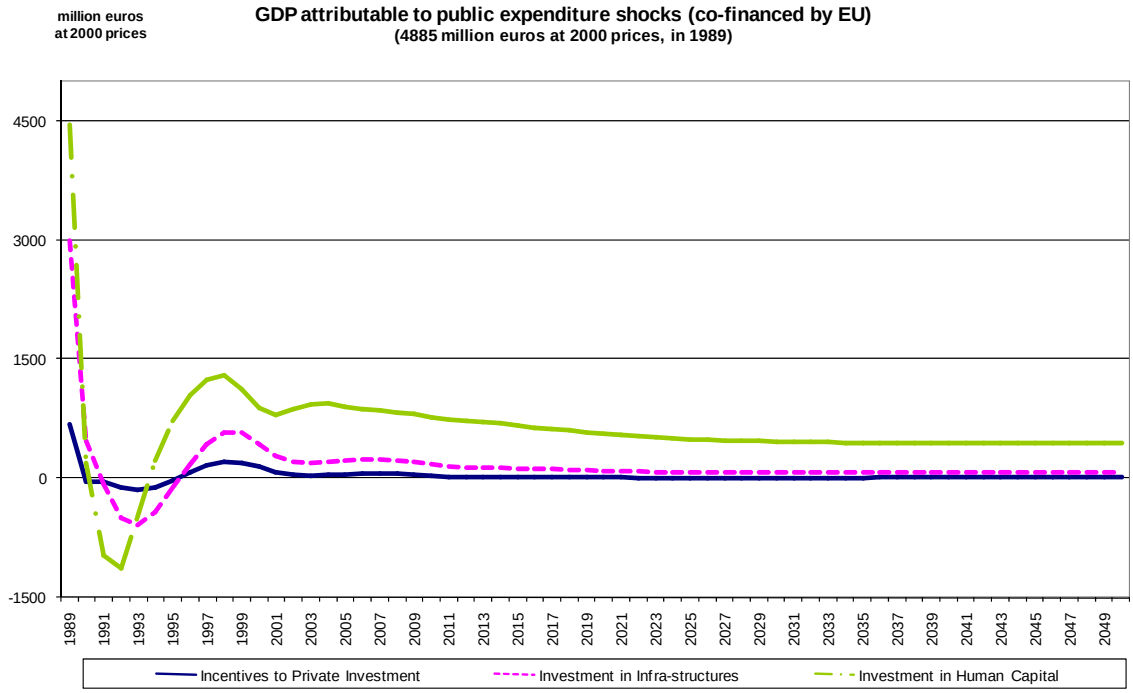
4.2. Comparing the impact of different types of public expenditure

In order to compare the effect of different types of expenditure co-financed by EU structural funds, we applied public expenditure shocks of 2500 million euros in 1989 (equivalent to 4885 million euros at 2000 prices), co-financed by EU funds at rates similar to those observed for CSF, and performed model simulations (with the fiscal policy rule option) for the period 1989-2050, for each of the main types of expenditure. The results of this exercise are presented in Graphs 1 and 2 (and Appendix 6) which show the impacts of the three main types of CSF/NSRF expenditure (investment in infra-structures, incentives to private investment[8] and investment in human capital).

[7] Only public expenditure was considered in the evaluations, assuming that the private component of CSF/NSRF expenditure would be spent with or without CSF/NSRF, although with different applications.

[8] The impact of incentives to private investment depends on the sector of activity to which it is applied. The results presented in this paper are based on a sectoral breakdown of incentives similar to the average observed for the three CSF.

Graph 1



The cumulated impact on GDP per euro of public expenditure was calculated[9] for each type of expenditure and it is presented in Graph 2.

As it is evidenced by the graphs, Investment in Human Capital is the type of expenditure that presents the greater impact on GDP per euro invested[10] (in the short-term as well as in the long-term), followed by Investment in Infra-structures. Incentives to Private Investment present the lowest effect with an additional long-run cumulated GDP per euro invested, estimated in 0.3 euros, which compare with 1.3 euros for infra-structures and 4 euros for Human Capital.

In all cases there are temporary negative effects in the medium-term, normally between the third and fifth or sixth year after the application of the shock (execution of public expenditure) which result from the inflationary temporary effect of demand pressure. The relationship between demand and supply is

[9] The formula of calculation for this indicator (Z_t) is (all values at constant prices):

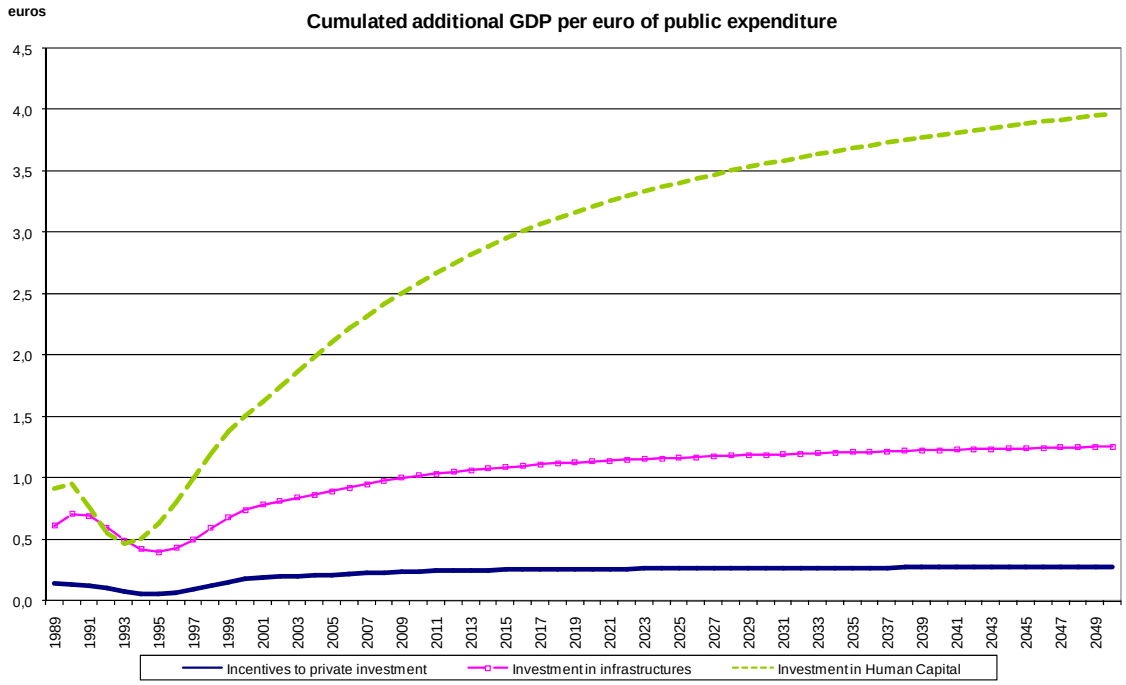
$Z_t = [\sum_{k=0}^{t}(Y_k/(1+i)^k)]/D$ where Y_k is GDP attributable to the expenditure shock, generated in year k

(difference between the values for the scenarios "with" and "without" the shock), D is the value of the expenditure shock and *i* is a discount rate (3%), to account for inter-temporal preference. k=0 represents the year of the expenditure shock (1989). The long-term value for this indicator (for $t=\infty$) may be interpreted as a Benefit-to-Cost ratio for the expenditure shock (assuming that the benefits are measured by additional GDP) or as a total long-run (discounted) multiplier of GDP in relation to this public expenditure, a value above 1 representing a real rate of return above the discount rate (and vice-versa).

[10] Note that, as the model is non-linear, multiplier effects may vary according to the size and time of the shock.

illustrated by graphs A6-3 to A6-5, in Appendix 6, where the effects on actual and potential output are compared.

Graph 2



The greater impact of Investment in Human Capital in the short-run, compared to the other types of expenditure, results from its lower import content as it implies directly an increase in the output of sector G (corresponding to the production of education and training services) and, indirectly, an increase in the output of sectors T and N to satisfy domestic demand boosted by the higher household disposable income associated to both scholarships and payments to instructors. The short-term impact of the Investment in Infra-structures is slightly lower due to its higher import content in equipment and materials. In relation to the Incentives to Private Investment, its short-term effect is even lower than that of infra-structures not only because private investment has an import content higher than investment in infra-structures but also because, in the case of the Tradable sector, these incentives have only, according to the estimated model, an indirect effect on investment (through the reduction of the user cost of capital) implying a relatively low impact on that investment.

In the long-run, the greater impact of investment in human capital compared to the other types of expenditure results also from the estimated parameters for the global production function which imply a higher direct effect on potential output of one euro of investment in human capital, compared to investment in infra-structures or in private investment. Graph A6-1 (Appendix 6) presents the impact of different types of expenditure on potential output.

The impact of different types of expenditure on Employment is illustrated by graph A6-2. After a positive initial impact, the effect on employment becomes negative in the medium term and virtually zero in the long-term in the case of investment in infra-structures and of incentives to private investment. In relation to investment in human capital the negative impact on Employment is more intense and it lasts for the long-term due to high impact of this type of expenditure on labour productivity, which is stronger than the impact on total output.

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APPENDIX 1 – HERPOR 3 – a simplified presentation

	Sectors of activity				Global economy
	T	**N**	**A**	**G**	
1. Output and Demand at 2000 prices:					
Actual output	OT= f (FDOT, *OW*, POT/*PWORLD*, ULCT/POT ,*T*)	ON= f (FDON, *OW*)	*OA* EXOGENOUS	OG = OGV / POG	GDPBP =OT + ON + *OA* + OG
Potential output	OTPOT= f (KT, KTRAIN, LT)				YPOT= f (KPR, KINF, KTRAIN, *T*, L)
Output gap	GAPOT = log(OT) - log (OTPOT)				GAPGDP = log(GDPBP) - log (YPOT)
GDP at market prices					GDPM = GDPBP + TP / PTP
Domestic demand	FDOT=0.06*CONS+0.02*G+0.10*IC+0.07*IME	FDON=0.46*CONS+0.13*G+0.59*IC+0.31*IME			DD = CONS+ G + I + DS
Private Consumption					CONS= f (YRPERD, *IRD*, UR,T)
Public Consumption					G = GV / PG
Total Fixed Investment (GFCF)					I = IT + IN + *IA* + IG + IH
Fixed Investment excl.housing	IT= f (OT, PKT, CSFT, GAPOT)	IN = IN2 + ININF	*IA* EXOGENOUS	IG = IGV / PIG	
Inv.excl.Infrastr. and Housing		IN2 = f (ON, UR, PIN2/PON, RIRLT, *TRIN*/PIN2)			
Inv. in Equipment	ITME = *WITME* * IT	INME = *WIN2ME* * IN2	IAME = *WIAME* * *IA*	IGME = *WIGME* * IG	IME = IAME + ITME + INME + IGME
Inv. Construction excl.Housing	ITBC=IT-ITME	INBC=IN-INME	IABC=*IA*-IAME	IGBC=IG-IGME	IBC = IABC + ITBC + INBC + IGBC
Housing investment					IH = f (YRPERD, IRLT, d2003ih)
Inv. in Construction					IC = IBC + IH
Inv. in infrastructures		ININF = *ININFV*/ PIC			IINF = ININF + IG
Change in inventories					DS = *ADS* * (*OA* + OT + ON)
Ext. Balance of Goods &Serv.					NTS = GDPM - DD
2. Physical capital stock at 1995 prices					
Cap.stock - Constr.excl.Hous.	KTBC = (1 - *DEPBC*) * KTBC(-1) + ITBC	KNBC = (1 - DEPBC) * KNBC(-1) + INBC	KABC = (1 - *DEPBC*) * KABC(-1) + IABC	KGBC = (1 - *DEPBC*) * KGBC(-1) + IGBC	
Capital stock - Equip.	KTME = (1 - *DEPME*) * KTME(-1) + ITME	KNME = (1 - DEPME) * KNME(-1) + INME	KAME = (1 - *DEPME*) * KAME(-1) + IAME	KGME = (1 - *DEPME*) * KGME(-1) + IGME	
Physical cap.stock excl.Hous.	KT = KTBC + KTME	KN = KNBC + KNME	KA = KABC + KAME	KG = KGBC + KGME	
Stock of Infrastructures		KNINF = (1-DEPBC)*KNINF(-1)+ININF			KINF = KG + KNINF
Phys.cap.stock excl.infr.&Hous.					KPR = KA + KT + KN - KNINF
3. Human capital					
Stock of professional training					KPTRAIN=KPTRAIN(-1)*(1-*DEPTRAIN*)+*PTRAIN/N1564*
Total human capital					KTRAIN = *KEDU* + KPTRAIN
4. Output and Demand at current prices:					
Actual output	OTV=OT*POT	ONV=ON*PON	OAV=*OA*POA*	OGV = *YWG* + *YGSEMP* + *OGVO*	GDPBPV = OTV+ONV+OAV+OGV
GDP at market prices					GDPMV = GDPBPV + TP
GDP at factor costs					GDPFCV = GDPMV - TI + SUB
Private Consumption					CONSV = PCONS * CONS
Public Consumption					GV = *YWG* + *GENW*
Total investment					IV = ITV + INV + IAV + IGV + IHV
Total Investment excl.housing	ITV = ITBC*PIC+ITME*PIME	INV = INBC*PIC+INME*PIME	IAV = IABC*PIC+IAME*PIME	IGV = *IS13V* + *IGVO*	
Housing investment					IHV = IH * PIC
Change in inventories					DSV = PDS * DS
Ext. Balance of Goods &Serv.					NTSV = GDPMV - (CONSV + GV + IV + DSV)

APPENDIX 1 – HERPOR 3 – a simplified presentation (continued)

	Sectors of activity				Global economy
	T	N	A	G	
5. Prices and costs:					
Output deflators	POT = f (*PWORLD*, ULCT)	PON = f (ULCN, *PWORLD*)	*POA* EXOGENOUS	POG = *POGW* * WG	PGDPBP = GDPBPV / GDPBP
deflator of GDP at market prices					PGDPM = GDPMV / GDPM
Private Consumption deflator					PCONS = f (*PM*, PGDPM)
Public Consumption deflator					PG = *RPGO*POG
Investment deflators	PIT = ITV / IT	PIN = INV / IN	PIA = IAV / *IA*	PIG = *WIGME* * PIME + (1 - *WIGME*) * PIC	PI = IV / I
Defl. Inv.excl.infr.and housing		PIN2 = (INV - *ININFV*) / IN2			
Defl. Investment in Equipment					PIME = f (*PM*, POT)
Defl. investment in Construction					PIC = f (*PM*, WN, ULCN, *T*)
Defl.of Taxes-Sub. on products					PTP=PTP(-1)*PCONS/PCONS(-1)**RTP/RTP(-1)**ADPTP*
User cost of capital	PKT=PIT/POT*((1+*IRLT*/100)/(PIT/PIT(-1))*(1+DEPT)-1)				
Real interest rate of credit					RIRLT = (1+*IRLT*/100)/(PCONS/PCONS(-1))-1
Depr. rate of capital stock	DEPT = 1 - (KT - IT) / KT(-1)				
Weight of inv.aid on total invest.	CSFT = *TRIT*/ ITV				
6. Labour market, labour productivity, labour costs and profits					
Total Employment	LT = f (OT, GAPOT, WT / POT)	LLN = f (ON, GAPGDP, ULCN/PON)	*LA* EXOGENOUS	LG = LGEMP + LGSEMP	L = LA + LT + LLN + LG
Self employment	LTSEMP = *SETRAT*LT/100	LLNSEMP = *SENRAT*LN/100	LASEMP = *SEARAT*LA/100	LGSEMP = *YGSEMP* / (1.157 * WG)	
Employees	LTEMP = LT – LTSEMP	LLNEMP = LLN – LLNSEMP	LAEMP = LA - LASEMP	LGEMP = *YWG* / WG	LEMP=LAEMP+LGEMP+LLNEMP+LTEMP
Labour Force					L F= f (L)
Unemployment rate					UR = 100*((*LF* - L)/*LF*)
Wage rate	WT = f (LPRT, POT, UR)	WN = f (WT, LPRN/LPRT)	WA = f (WT)	WG = f (WT, GBORR, UR)	W = YW / LEMP
Real wage rate (sectors T+N)					WR=(YWT+YWN)/(LTEMP+LLNEMP)/PGDPBP
Labour productivity	LPRT = OT / LT	LPRN = ON / LLN			LPROD = GDPBP / L
Unit labour costs	ULCT = WT / LPRT	ULCN = WN / LPRN			ULC = W / LPROD
Compensation of employees	YWT = LTEMP * WT	YWN = LLNEMP * WN	YWA = LAEMP * WA	*YWG* EXOGENOUS	YW = YWT + YWN + YWA + *YWG*
Profits	YCT = OT – YWT	YCN = ON – YWN	YCA = *OA* - YWA		YC = GDPBPV - YW

APPENDIX 1 – HERPOR 3 – a simplified presentation (continued)

Variable	Model version	Equation
7. Personal income		
Personal income before tax		YPER= GDPFCV * (1 - *RCS*) + *YFN* + *BPTPRNE* - GTYC - GTYSOC + GTR + GTRND - GTTI
Personal disposable income		YPERD = YPER – GTYPER – TD2S
Real personal disposable income		YRPERD = YPERD / PCONS
8. Public Finance		
Direct taxes on households		GTYPER = *RGTYPER* * YPER
Direct taxes on corporations		GTYC = *RGTYC* * YC(-1)
Social contributions received by Publ.Adm.		GTYSOC = *RGTYSOC* * YW
Taxes less Subsidies on products		TP = *RTP* * CONSV
Capital taxes		GTK = *RGTK* * GDPMV
Public sector investment income		GTTI = *RGTTI* * GDPMV
Interest on public debt		GTRND = (*RGDI* / 100) * ((GND(-1) + GND) / 2)
Total subsidies		SUB = *GSUB* + *ECSUB*
Public debt		GND = GND(-1) + GBOR + *DAT*
Indirect taxes received by Public Admin.	Standard version	GTE = *GTETI**TI
	Fiscal policy rule version	GTE = GV+*GTR*+*GSUB*+*IS13V*+GTRND-GTYPER-GTYC-GTYSOC-GTK-GTTI-*GTRF*-*GTRK*-*TD2S*-GBOR
Implicit rate of indirect taxation	Standard version	RTI = *RTITP * RTP*
	Fiscal policy rule version	RTI = TI / CONSV
Total indirect taxes	Standard version	TI = RTI * CONSV
	Fiscal policy rule version	TI = GTE / *GTETI*
Public sector deficit	Standard version	GBOR = GV+*GTR*+*GSUB*+*IS13V*+GTRND-GTYPER-GTYC-GTYSOC-GTE-GTK-GTTI-*GTRF*-*GTRK*-TD2S
	Fiscal policy rule version	GBOR = (GDPMV**GBORR*)/100
Public sector deficit as % of GDP	Standard version	GBORR = 100 * GBOR / GDPMV
Implicit rate of taxes less subsidies on products	Fiscal policy rule version	RTP = RTI / *RTITP*

Notes:

Exogenous variables are written in *italic*.

The econometrically estimated equations are highlighted in yellow. In this table they are presented in a very simplified form, only mentioning the explanatory variables with no reference to the functional form, lag structure or lagged dependent variables. An exact formulation is presented in Appendix 2.

The equations with coefficients derived from input-output matrices are highlighted in blue.

There are two versions in the model, concerning the Public Finance block, which affect five equations: the *standard version* and the *fiscal policy rule version.* In the *fiscal policy rule version* public deficit as % of GDP (GBORR) is exogenous and the adjustment is made through the rate of taxation (less subsidies) on products (RTP). Therefore GBORR is endogenous in the *standard version* and exogenous in the *fiscal policy rule version*, the opposite occurring with RTP (exogenous in the *standard version* and exogenous in the *policy rule version*).

APPENDIX 2

HERPOR 3

Econometrically estimated equations

1. Sectors of activity

1.1. Tradable sector (T)

1.1.1. Actual Output (OT): (ECM estimated in two steps)

Long-run relationship:

$$\log(OT^*) = \underset{(3.47)}{2.65} - \underset{(-10.2)}{0.64}*\log(ULCT/POT) + \underset{(9.08)}{0.79}*\log(FDOT) - \underset{(-3.07)}{0.19}*\log(POT/\mathbf{PWORLD}) + \underset{(0.80)}{0.06}*\log(\mathbf{OW}) - \underset{(-1.40)}{0.006}*\mathbf{T}$$

Estimation period: 1977-2006; R^2=0.99 DW=0.97 ADF on residuals = -5.18**

Short-run relationship:

$$dlog(OT) = \underset{(-1.60)}{-0.006} - \underset{(-3.96)}{0.71}*[\log(OT) - \log(OT^*)]_{-1} + \underset{(7.81)}{0.76}*dlog(FDOT)$$

$$- \underset{(-5.93)}{0.45}*dlog(ULCT/POT) - \underset{(-2.38)}{0.18}*dlog(POT/\mathbf{PWORLD}) + \underset{(2.13)}{0.25}*dlog(OT)_{-1}$$

Estimation period: 1979-2006; R^2=0.78 DW=1.63 BG1(p value) = 0.34

1.1.2. Potential Output (OTPOT): (restricted least squares)

$$\log(OTPOT) = \underset{(1.68)}{0.079} + 0.35*\log(KT_{-1}) + \underset{(31.72)}{0.65}*\log(LT) + 0.78*\log(KTRAIN)$$

Estimation period: 1977-2007; R^2=0.95 DW=0.49 ADF on residuals (GAPOT) = -4.73*

1.1.3. Fixed investment (IT) (ECM estimated in two steps):

Long-run relationship:

$$\log(IT^*) = \underset{(1.83)}{3.91} + \underset{(1.95)}{0.42}*\log(OT) - \underset{(-3.43)}{0.21}*\log[PKT*(1-CSFT)]$$

Estimation period: 1978-2006; R^2=0.27 DW=0.69 ADF on residuals = -4.58*

Short-run relationship:

$$dlog(IT) = \underset{(0.15)}{0.003} - \underset{(-3.53)}{0.54}*[\log(IT) - \log(IT^*)]_{-1} + \underset{(2.44)}{0.42}*dlog(IT)_{-1} + \underset{(1.19)}{0.85}*GAPOT_{-1}$$

Estimation period: 1979-2006; R^2=0.60 DW=2.05 BG1(p value) = 0.51

1.1.4. Output deflator (POT): (ECM estimated in one step)

$$dlog(POT) = \underset{(2.23)}{0.13} + \underset{(4.05)}{0.63}*dlog(\mathbf{PWORLD})_{-1} + \underset{(3.46)}{0.68}*dlog(ULCT)_{-1}$$

$$- \underset{(-2.39)}{0.49}*\log(POT)_{-1} + \underset{(2.08)}{0.23}*\log(\mathbf{PWORLD})_{-2} + \underset{(2.17)}{0.30}*\log(ULCT)_{-2}$$

Estimation period: 1979-2007; R^2=0.95 DW=1.66 BG1(p value) = 0.27

Implicit long-run relationship:

$$\log(POT^*) = 0.46*\log(\mathbf{PWORLD})_{-1} + 0.61*\log(ULCT)_{-1}$$

1.1.5. Employment (LT):

$$dlog(LT) = \underset{}{-0.013} + \underset{(7.32)}{0.49}*dlog(OT) - \underset{(-1.83)}{0.14}*dlog(WT / POT) + \underset{(4.81)}{0.23}*GAPOT_{-1}$$
$$\underset{(-6.19)}{}$$

Estimation period: 1978-2006; R^2=0.74 DW=2.62

1.1.6. Wage rate (WT):

$$dlog(WT/POT/LPRT) = \underset{(2.82)}{0.076} - \underset{(-2.75)}{0.013}*UR + \underset{(2.12)}{0.33}*dlog(WT/POT/LPRT)_{-1} - \underset{(-4.46)}{0.67}*dlog(WT/POT/LPRT)_{-2}$$

Estimation period: 1980-2006; R^2=0.60 DW=1.94 BG1(p value) = 0.99

Implicit long-run unemployment rate: UR* = 5,9%

1.2. Non-tradable sector (N)

1.2.1. Actual Output (ON): (ECM estimated in one step)

$$dlog(ON) = \underset{(1.74)}{1.24} + \underset{(10.35)}{0.71}*dlog(FDON) - \underset{(-3.32)}{0.45}*log(ON)_{-1} + \underset{(3.34)}{0.34}*log(FDON)_{-1} + \underset{(1.80)}{0.07}* log(\mathbf{OW})_{-1}$$

Estimation period: 1978-2006; R^2=0.78 DW=2.14 BG1(p value) = 0.57

Implicit long-run relationship:

$$log(ON^*) = 0.76*log(FDON) + 0.15* log(OW)$$

1.2.2. Fixed investment excluding housing and infrastructures (IN2):
(ECM estimated in one step)

$$d(IN2) = \underset{(1.71)}{4307} - \underset{(-1.33)}{177.7}*d(UR) + \underset{(2.93)}{0.28}*d(ON) - \underset{(-3.19)}{8795}*d(PIN2/PON) - \underset{(-1.74)}{4544}*d(\mathbf{RIRLT})$$

$$\underset{(0.82)}{0.63}*d(\mathbf{TRIN}/PIN2) - \underset{(-2.86)}{4715}*(PIN2/PON)_{-1} \underset{(-3.53)}{-0.63}*IN2_{-1} \underset{(2.66)}{+0.12}*(ON)_{-1}$$

Estimation period: 1978-2006; R^2=0.75 DW=2.30 BG1(p value) = 0.25

Implicit long-run relationship:

$$IN2^* = -7465*(PIN2/PON) + 0.19*ON$$

1.2.3. Output deflator (PON): (ECM estimated in one step)

$$dlog(PON) = \underset{(2.45)}{0.186} + \underset{(5.55)}{0.30}*dlog(\mathbf{PWORLD}) + \underset{(5.58)}{0.35}*dlog(ULCN) - \underset{(-2.55)}{0.45}*log(PON)_{-1}$$

$$\underset{(2.76)}{+0.17}*log(\mathbf{PWORLD})_{-1} + \underset{(2.18)}{0.30}*log(ULCN)_{-1}$$

Estimation period: 1978-2006; R^2=0.97 DW=1.90 BG1(p value) = 0.91

Implicit long-run relationship:

$$log(PON^*) = 0.39*log(PWORLD) + 0.66*log(ULCN)$$

1.2.4. Employment (LLN):

$$dlog(LLN) = \underset{(1.16)}{0.004} + \underset{(4.58)}{0.46}*dlog(ON) - \underset{(-1.70)}{0.12}*dlog(ULCN/PON)_{-1} + \underset{(5.56)}{0.40}*GAPGDP_{-1}$$

Estimation period: 1979-2006; R^2=0.68 DW=1.67

1.2.5. Wage rate (WN): (ECM estimated in two steps)

Long-run relationship:

$$log(WN^*) = \underset{(-0.08)}{-0.003} + \underset{(108.9)}{1.03}*log(WT) + \underset{(4.42)}{0.31}*log(LPRN/LPRT)$$

Estimation period: 1977-2006; R^2=0.99 DW=0.85 ADF on residuals = -3.95*

Short-run relationship:

$$dlog(WN) = \underset{(-0.30)}{-0.001} - \underset{(-3.40)}{0.44}*[log(WN) - log(WN^*)]_{-1} + \underset{(12.76)}{0.86}*dlog(WT) + \underset{(2.42)}{0.23}*dlog(LPRN/LPRT) + \underset{(2.26)}{0.16}*dlog(WN)_{-1}$$

Estimation period: 1979-2006; R^2=0.98 DW=1.70 BG1(p value) = 0.44

1.3. Agricultural sector (A)

1.3.1. Wage rate (WA): (ECM estimated in one step)

$$dlog(WA) = \underset{(-0.90)}{-0.07} + \underset{(3.10)}{1.08}*dlog(WT) - \underset{(-3.56)}{0.42}*log(WA)_{-1} + \underset{(3.24)}{0.38}*log(WT)_{-1}$$

Estimation period: 1978-2006; R^2=0.79 DW=1.78 BG1(p value) = 0.22

Implicit long-run relationship:

$$log(WA^*) = 0.9 * log(WT)$$

1.4. Non-market services sector (G)

1.4.1. Wage rate (WG): (ECM estimated in one step)

$$dlog(WG) = \underset{(8.79)}{0.27} + \underset{(6.20)}{0.64}*dlog(WT) - \underset{(-7.26)}{0.33}*log(WG/WT)_{-1} - \underset{(-1.47)}{0.0027}*GBORR_{-1} - \underset{(-2.86)}{0.01}*UR_{-1}$$

Estimation period: 1978-2006; R^2=0.94 DW=2.30 BG1(p value) = 0.40

Implicit long-run relationship:

$$log(WG) = log(WT) + constant - 0.008*GBORR - 0.027*UR$$

2. Global economy

2.1. Potential output (YPOT): (restricted least squares)

$$log(YPOT) = \underset{(1.76)}{0.29} + 0.17*log(KPR)_{-2} + 0.06*log(KINF)_{-2} + \underset{(10.64)}{0.77}*log(L) + 1.30*log(KTRAIN)_{-1} - \underset{(-5.97)}{0.01}*T*log(KTRAIN)_{-1}$$

Estimation period: 1977-2006; R^2=0.99 DW=0.38 ADF on residuals (GAPGDP) = -3.35*

2.2. Private consumption (CONS): (ECM estimated in one step)

$$\underset{}{dlog(CONS)=} \underset{(2.25)}{2.24} - \underset{(-3.43)}{0.50}*log(CONS)_{-1} - \underset{(-3.70)}{0.0029}*\mathbf{IRD}_{-1} - \underset{(-1.81)}{0.005}*UR_{-1} + \underset{(2.62)}{0.30}*log(YRPERD - \mathbf{BPTPRNE}/PCONS)_{-1}$$

$$+ \underset{(3.43)}{0.37}*dlog(YRPERD - \mathbf{BPTPRNE}/PCONS) - \underset{(-3.19)}{0.01}*d(UR) - \underset{(-4.24)}{0.003}*d(\mathbf{IRD}) + \underset{(1.91)}{0.005}*\mathbf{T} + \underset{(1.87)}{0.16}*dlog(CONS)_{-1}$$

Estimation period: 1977-2006; R^2=0.90 DW=2.24

Implicit long-run relationship:

log(CONS*) = constant + 0.59*log(YRPERD-**BPTPRNE**/PCONS) – 0.006***IRD** – 0.009*UR + 0.009***T**

2.3. Housing investment (IH): (ECM estimated in one step)

$$\underset{}{dlog(IH) =} \underset{(7.55)}{5.19} - \underset{(-7.55)}{0.58}*log(IH)_{-1} - \underset{(-6.95)}{0.01}*IRLT_{-1} + \underset{(2.10)}{0.50}*dlog(YRPERD) - \underset{(-5.27)}{0.008}*d(IRLT) - \underset{(-8.87)}{0.21}*d2003IH$$

Estimation period: 1977-2006; R^2=0.84 DW= 1.57 BG1(p value) = 0.43

Implicit long-run relationship:

log(IH*) = constant - 0.02*IRLT – 0.36*d2003IH

2.4. Private Consumption Deflator (PCONS): (ECM estimated in one step)

$$\underset{}{dlog(PCONS)=} \underset{(0.24)}{0.0006} + \underset{(5.37)}{0.16}*dlog(\mathbf{PM}) + \underset{(15.00)}{0.92}*dlog(PGDPM) - \underset{(-4.14)}{0.41}*log(PCONS)_{-1}$$

$$+ \underset{(2.93)}{0.05}*log(\mathbf{PM})_{-1} + \underset{(4.12)}{0.37}*log(PGDPM)_{-1}$$

Estimation period: 1959-2006; R^2=0.98 DW= 2.10 BG1(p value) = 0.61

Implicit long-run relationship:

log(PCONS*) = 0.13*log(PM) + 0.89*log(PGDPM)

2.5. Equipment deflator (PIME): (ECM estimated in one step)

$$\underset{}{dlog(PIME) =} \underset{(2.35)}{0.008} + \underset{(3.86)}{0.36}*dlog(\mathbf{PM}) - \underset{(-3.86)}{0.34}*log(PIME)_{-1} + \underset{(1.25)}{0.06}*log(POT)_{-1} + \underset{(4.30)}{0.25}*log(\mathbf{PM})_{-1}$$

Estimation period: 1978-2006; R^2=0.97 DW= 1.43 BG1(p value) = 0.19

Implicit long-run relationship:

log(PIME*) = 0.73*log(PM) + 0.17*log(POT)

2.6. Construction deflator (PIC): (ECM estimated in one step)

$$\underset{}{dlog(PIC)=} \underset{(-3.18)}{-0.13} + \underset{(1.82)}{0.14}*dlog(\mathbf{PM}) + \underset{(2.71)}{0.35}*dlog(WN) - \underset{(-5.43)}{0.39}*log(PIC)_{-1} + \underset{(5.00)}{0.22}*log(\mathbf{PM})_{-1}$$

$$+ \underset{(1.61)}{0.08}*log(ULCN)_{-1} + \underset{(6.83)}{0.008}*\mathbf{T}$$

Estimation period: 1978-2006; R^2 = 0.97 DW = 1.98 BG1(p value) = 0.97

Implicit long-run relationship:

log(PIC*) = 0.56*log(PM) + 0.21*log(ULCN) + 0.021*T

2.7. Labour Force (LF): (ECM estimated in one step)

$$\underset{}{dlog(LF)} = \underset{(5.28)}{0.021} + \underset{(9.52)}{0.75}*dlog(L) - \underset{(-4.62)}{0.29}*log(LF/L)_{-1} - \underset{(-5.26)}{0.50}*dlog(L)_{-1} + \underset{(2.73)}{0.33}*dlog(LF)_{-1}$$

Estimation period: 1977-2006; $R^2 = 0.84$ DW = 2.31 BG1(p value) = 0.24

Implicit long-run relationship: (constant long-run unemployment rate)

log(LF*) = constant + log(L)

NOTES:

For any variable X,

dlog(X) = log (X) – log (X(-1))

d(X) = X – X(-1)

X* represents the long-run equilibrium value of X.

Exogenous variables are in bold.

t ratios are presented in brackets below the corresponding estimated parameters.

For the estimated long-run relationships cointegration was tested using the Engle-Granger ADF test on the residuals (Engle and Granger, 1987). One star in this test means that the null hypothesis of no cointegration is rejected at a 10% level of significance while two stars means the rejection at 5%, using the MacKinnon (1991) critical values.

In the regressions that included the lagged dependent variable in the regressors, an additional test for serial correlation was performed since the DW test is not valid in this case. This test, presented as BG1, is the Breush-Godfrey chi-square test for the null hypothesis of uncorrelated residuals against the alternatives of AR(1) or MA(1) (*vide* Johnston, 1984, pp 319-321). A high p value (more than 0.10) leads to accepting the null hypothesis (absence of first order autocorrelation in the residuals).

APPENDIX 3 – THE HERPOR VARIABLES

1. Endogenous variables

Designation	Description
CONS	Private Consumption (at 2000 prices)
CONSV	Private Consumption (at current prices)
CSFT	Weight of investment aids on sector T investment
DD	Domestic Demand (at 2000 prices)
DEPT	Average depreciation rate on sector T capital stock
DS	Change in inventories+Net acquisition of valuables (at 2000 prices)
DSV	Change in inventories+Net acquisition of valuables (at current prices)
FDON	Weighted Domestic Demand for sector N (using 2000 I-O coefficients, 2000 prices)
FDOT	Weighted Domestic Demand for sector T (using 2000 I-O coefficients, 2000 prices)
G	Public Consumption (at 2000 prices)
GAPGDP	Output gap (total economy)
GAPOT	Output gap (sector T)
GBOR	Public sector deficit (at current prices)
GBORR	GBOR as % of GDP
GDPBP	GDP at basic prices (at 2000 prices)
GDPBPV	GDP at basic prices (at current prices)
GDPFCV	GDP at factor costs (at current prices)
GDPM	GDP at market prices (at 2000 prices)
GDPMV	GDP at market prices (at current prices)
GND	Public debt
GNPV	Gross National Product (at current prices)
GTE	Indirect taxes received by Public Administration
GTK	Capital tax revenue
GTRND	Interests on Public debt
GTTI	Public sector Gross Operating Surplus+Investment income
GTY	Public revenue from direct taxes and social contributions
GTYC	Direct taxes on Corporations
GTYPER	Direct taxes on Households
GTYSOC	Social Contributions received by Public Administrations
GV	Public Consumption (at current prices)
I	Total Gross Fixed Capital Formation (at 2000 prices)
IABC	Investment in Construction excluding Housing - sector A (at 2000 prices)
IAME	Investment in Equipment - sector A (at 2000 prices)
IAV	Total fixed investment - sector A (at current prices)
IBC	Total investment in construction, excluding housing (at 2000 prices)
IC	Total investment in construction, including housing (at 2000 prices)
IG	Fixed investment - sector G (at 2000 prices)
IGBC	Investment in Construction excluding Housing - sector G (at 2000 prices)
IGME	Investment in Equipment -sector G (at 2000 prices)
IGV	Total fixed investment - sector G (at current prices)
IH	Housing investment (at 2000 prices)
IHV	Housing investment (at current prices)
IINF	Investment in infrastructures (at 2000 prices)
IME	Investment in Machinery and Equipment (at 2000 prices)
IN	Total fixed investment - sector N, excluding housing (at 2000 prices)
IN2	Fixed investment - sector N, excluding housing and infrastructures (at 2000 prices)

INBC	Investment in Construction excluding Housing - sector N (at 2000 prices)
ININF	Investment in infrastructures - sector N (at 2000 prices)
INME	Investment in equipment - sector N (at 2000 prices)
INV	Total fixed investment - sector N, excluding housing (at current prices)
IT	Total fixed investment - sector T (at 2000 prices)
ITBC	Investment in Construction - sector T (at 2000 prices)
ITME	Investment in Equipment - sector T (at 2000 prices)
ITV	Total fixed investment -sector T (at current prices)
IV	Total Gross Fixed Capital Formation (at current prices)
KA	Capital stock in A sector (at 2000 prices)
KABC	Capital stock of construction - sector A (2000 prices)
KAME	Capital stock of equipment - sector A (2000 prices)
KG	Capital stock - sector G (2000 prices)
KGBC	Capital stock of non-residential construction - sector G (at 2000 prices)
KGME	Capital stock of equipment - sector G (2000 prices)
KINF	Capital stock of infrastructures (at 2000 prices)
KN	Capital stock - sector N, excluding housing (at 2000 prices)
KNBC	Capital stock of non-residential construction - sector N (at 2000 prices)
KNINF	Capital stock of infrastructures - sector N (at 2000 prices)
KNME	Capital stock of equipment - sector N (2000 prices)
KPR	Total capital stock, excluding infrastructures and Housing (at 2000 prices)
KPTRAIN	Stock of professional training (average nº years of training for population aged 15 to 64)
KT	Capital stock in the T sector (2000 prices)
KTBC	Capital stock of construction - sector T (2000 prices)
KTME	Capital stock of equipment - sector T (2000 prices)
KTRAIN	Total Human Capital (average nº years of education+training for population aged 15 to 64)
L	Total Employment (volume)
LAEMP	Employees - sector A (volume)
LASEMP	Self employment in the A sector (volume)
LEMP	Employees (all sectors - volume)
LF	Labour Force (thousands of individuals)
LG	Employment in the G sector (volume)
LGEMP	Employees in the G sector (volume)
LGSEMP	Self Employment in the G sector (volume)
LLN	Employment in the N sector (volume)
LLNEMP	Employees in the N sector (volume)
LLNSEMP	Self employment in the N sector (volume)
LPRN	Labour productivity in the N sector (at 2000 prices)
LPROD	Total labour productivity (at 2000 prices)
LPRT	Labour productivity in the T sector (at 2000 prices)
LT	Employment in the T sector (volume)
LTEMP	Employees in the T sector (volume)
LTSEMP	Self employment in the T sector (volume)
NTS	External Balance of Goods and Services (at 2000 prices)
NTSV	External Balance of Goods and Services (at current prices)
OAV	Gross Value Added at basic prices in the A sector (at current prices)
OG	Gross Value Added at basic prices in the G sector (at 2000 prices)
OGV	Gross Value Added at basic prices in the G sector (at current prices)
ON	Gross Value Added at basic prices in the N sector (at 2000 prices)
ONV	Gross Value Added at basic prices in the N sector (at current prices)
OT	Gross Value Added at basic prices in the T sector (at 2000 prices)

OTPOT	Potential Output in the T sector (at 2000 prices)
OTV	Gross Value Added at basic prices in the T sector (at current prices)
PCONS	Private consumption deflator (index, 2000=1)
PG	Public consumption deflator (index, 2000=1)
PGDPBP	GDP deflator, at basic prices (index, 2000=1)
PGDPM	GDP deflator, at market prices (index, 2000=1)
PI	deflator of total investment (index, 2000=1)
PIA	deflator of sector A investment (index, 2000=1)
PIC	Deflator of Construction Investment (including Housing)
PIG	Deflator of sector G Investment
PIME	Deflator of Equipment Investment
PIN	Deflator of sector N investment (excluding housing)
PIN2	Deflator of sector N investment, excluding housing and infrastructures
PIT	Deflator of sector T investment
PKT	User cost of capital in the T sector
POG	Deflator of OGV
PON	Deflator of ONV
POT	Deflator of OTV
PTP	Deflator of taxes less subsidies on products
RDEBT	Public debt as a % of GDP
RIRLT	Real interest rate on 3 to 5 year loans
RTI	Implicit rate of Indirect taxation (weight on Private Consumption)
RULCT	Real unit labour costs in the T sector (at 2000 prices)
SAV	Household gross savings (at current prices)
SUB	Total Subsidies (at current prices)
TI	Total Indirect taxes
TP	Taxes less subsidies on products
U	Unemployment
ULC	Total Unit labour costs
ULCN	unit labour costs in the N sector (at current prices)
ULCT	unit labour costs in the T sector (at current prices)
UR	unemployment rate
URBAR	Two-year average of UR
W	Average annual wage rate (including employers' contributions)
WA	Annual wage rate in the A sector
WG	Annual wage rate in the G sector
WN	Annual wage rate in the N sector
WR	Annual average real wage rate in the T+N sectors
WT	Annual wage rate in the T sector
YC	Proxy of total profits (at current prices)
YCA	Proxy of profits in the A sector (at current prices)
YCN	Proxy of profits in the N sector (at current prices)
YCT	Proxy of profits in the T sector (at current prices)
YPER	Personal income before tax (at current prices)
YPERD	Personal disposable income (at current prices)
YPOT	Potential output (at 2000 prices)
YRPERD	Real personal disposable income (at 2000 prices)
YW	Compensation of employees (at current prices)
YWA	Compensation of employees (at current prices) in the A sector
YWN	Compensation of employees (at current prices) in the N sector
YWT	Compensation of employees (at current prices) in the T sector

2. Exogenous variables

Designation	Description
ADPTP	Adjustment factor for PTP
ADS	Proportion of DS in the output of sectors A+T+N (at 2000 prices)
BPTPRNE	Net private international transfers (at current prices)
D2003IH	Dummy which assumes the value 1 after 2002
DAT	Exogenous component of Public Debt change
DEPBC	Depreciation rate for Construction excluding housing
DEPME	Depreciation rate for Equipment
DEPTRAIN	Depreciation rate for the stock of professional training
ECSUB	Subsidies paid by EU
GENW	Diff. between Public Consumption and Compensation of Employees in the G sector (at current prices)
GSUB	Subsidies paid by Public Administration (at current prices)
GTETI	Proportion of indirect taxes received by Public Administration
GTR	Social benefits and other current transfers between Public Admin. and other domestic agents (net)
GTRF	Net current transfers between Public Administration and the rest of the World (received less paid)
GTRK	Net capital transfers between Public Administration and all other agents, incl. EU (received less paid)
IA	Total fixed investment in the A sector (at 2000 prices)
IGVO	Difference between total investment in the G sector and Public Investment (at current prices)
ININFV	Investment in infrastructures - sector N (at current prices)
IRD	Nominal Interest rate on deposits from 181 days to 1 year
IRLT	Nominal interest rate on 3 to 5 year loans
IS13V	Public investment (GFCF) at current prices
KEDU	Stock of Education (average nº years of education for population aged 15 to 64)
LA	Employment in the A sector (volume) (thousands)
N1564	Population aged 15 to 64 (thousands of individuals)
AO	Gross Value Added at basic prices in the A sector (at 2000 prices)
OGVO	Proxy of corporate gross profits in sector G (at current prices)
OW	International Demand (volume index, 2000=1)
PDS	Deflator of DSV
PM	Deflator of Imports
PMIE	International trade price index, converted to national currency (2000=1)
POA	Deflator of OAV
POGW	Ratio between the output deflator and the wage rate in the G sector
PTRAIN	Investment in Professional training (thousands of person-year of training)
PWORLD	Price index of world manufacturing output, converted to national currency (2000=1)
RCS	Proxy of corporate gross saving rate (weight on GDP at factor cost)
RGDI	Interest rate implicit on public debt
RGTK	Implicit rate of capital tax (weight on GDP)
RGTTI	Weight of GTTI on GDP
RGTYC	Implicit rate of direct corporate taxation
RGTYPER	Implicit rate of direct household taxation
RGTYSOC	Implicit rate of social contributions received by Public Administrations

RPGO	Ratio between Public Consumption deflator and the output deflator of the G sector
RTITP	Ratio between total indirect taxes and taxes less subsidies on products
RTP	Implicit rate of taxes less subsidies on products (weight on private consumption)
SEARAT	Fraction of self employed in LA
SENRAT	Fraction of self employed in LLN
SETRAT	Fraction of self employed in LT
T	Time index: 1977 =1
TD2S	Net Direct taxes on Households (received less paid) from abroad (value)
TRIN	Public aids to Investment in the N sector
TRIT	Public aids to Investment in the T sector
VPFP	Change in household net participation on Pension funds
WIAME	Fraction of IA consisting of Machinery and equipment
WIGME	Fraction of IG consisting of Machinery and equipment
WINME	Fraction of IN consisting of Machinery and equipment
WITME	Fraction of IT consisting of Machinery and equipment
YFN	Net factor income (received less paid) from abroad (value)
YGSEMP	Self employed income in the G sector (value)
YWG	Compensation of Employees in the G sector (at current prices)

APPENDIX 4 – HERPOR SECTORS

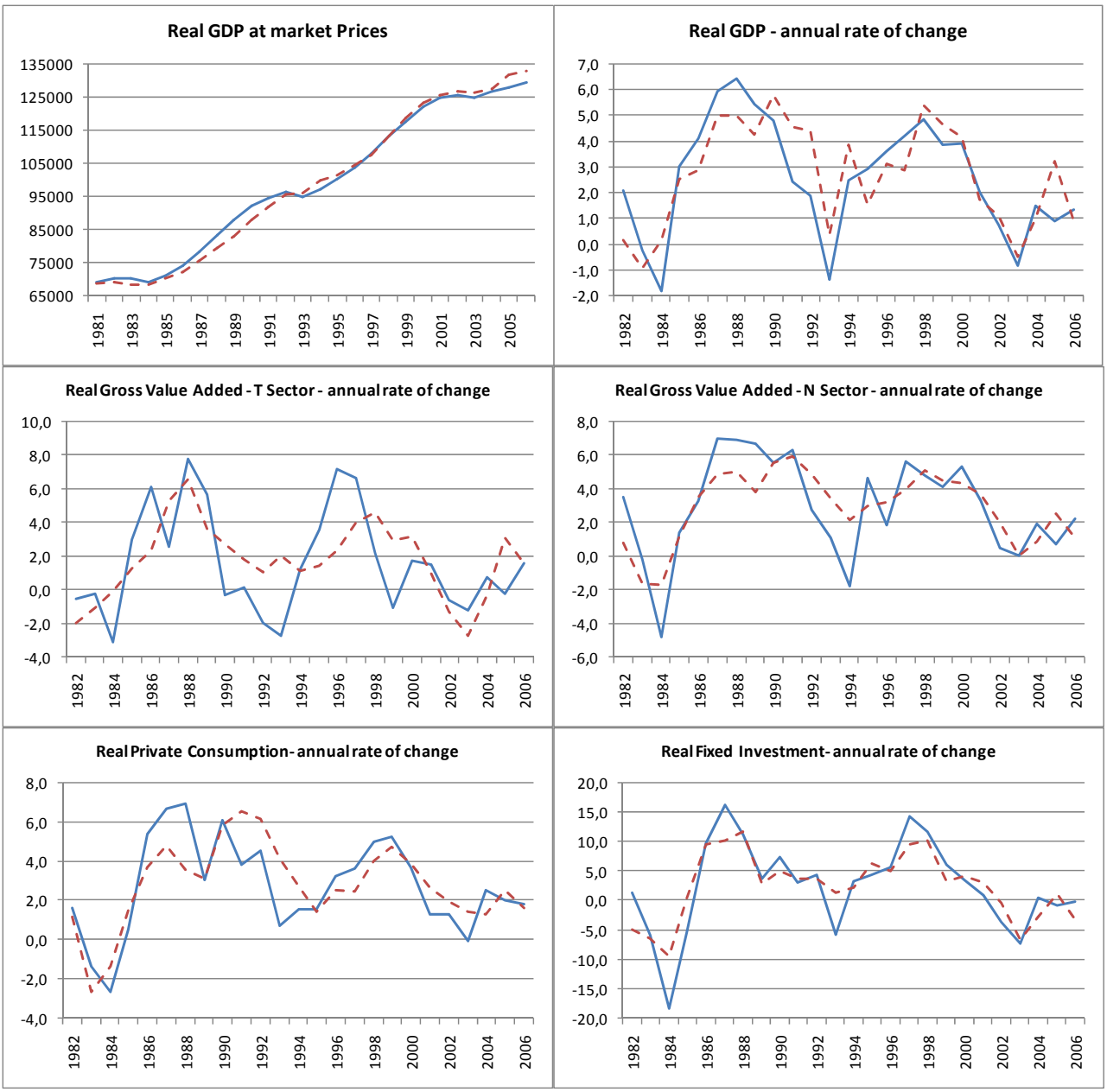
Description	ESA 95 (A60)
SECTOR A	
Agriculture, hunting and related service activities	1
Forestry, logging and related service activities	2
Fishing, aquaculture and service activities incidental to fishing	5
SECTOR T (TRADABLE)	
Mining of coal and lignite; extraction of peat	10
Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	11
Mining of uranium and thorium ores	12
Mining of metal ores	13
Other mining and quarrying	14
Manufacture of food products and beverages	15
Manufacture of tobacco products	16
Manufacture of textiles	17
Manufacture of wearing apparel; dressing and dyeing of fur	18
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	19
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	20
Manufacture of paper and paper products	21
Publishing, printing and reproduction of recorded media	22
Manufacture of coke, refined petroleum products and nuclear fuel	23
Manufacture of chemicals and chemical products	24
Manufacture of rubber and plastics products	25
Manufacture of other non-metallic mineral products	26
Manufacture of basic metals	27
Manufacture of fabricated metal products, except machinery and equipment	28
Manufacture of machinery and equipment n.e.c.	29
Manufacture of office, accounting and computing machinery	30
Manufacture of electrical machinery and apparatus n.e.c.	31
Manufacture of radio, television and communication equipment and apparatus	32
Manufacture of medical, precision and optical instruments, watches and clocks	33
Manufacture of motor vehicles, trailers and semi-trailers	34
Manufacture of other transport equipment	35
Manufacture of furniture; manufacturing n.e.c.	36
Water transport	61
Air transport	62

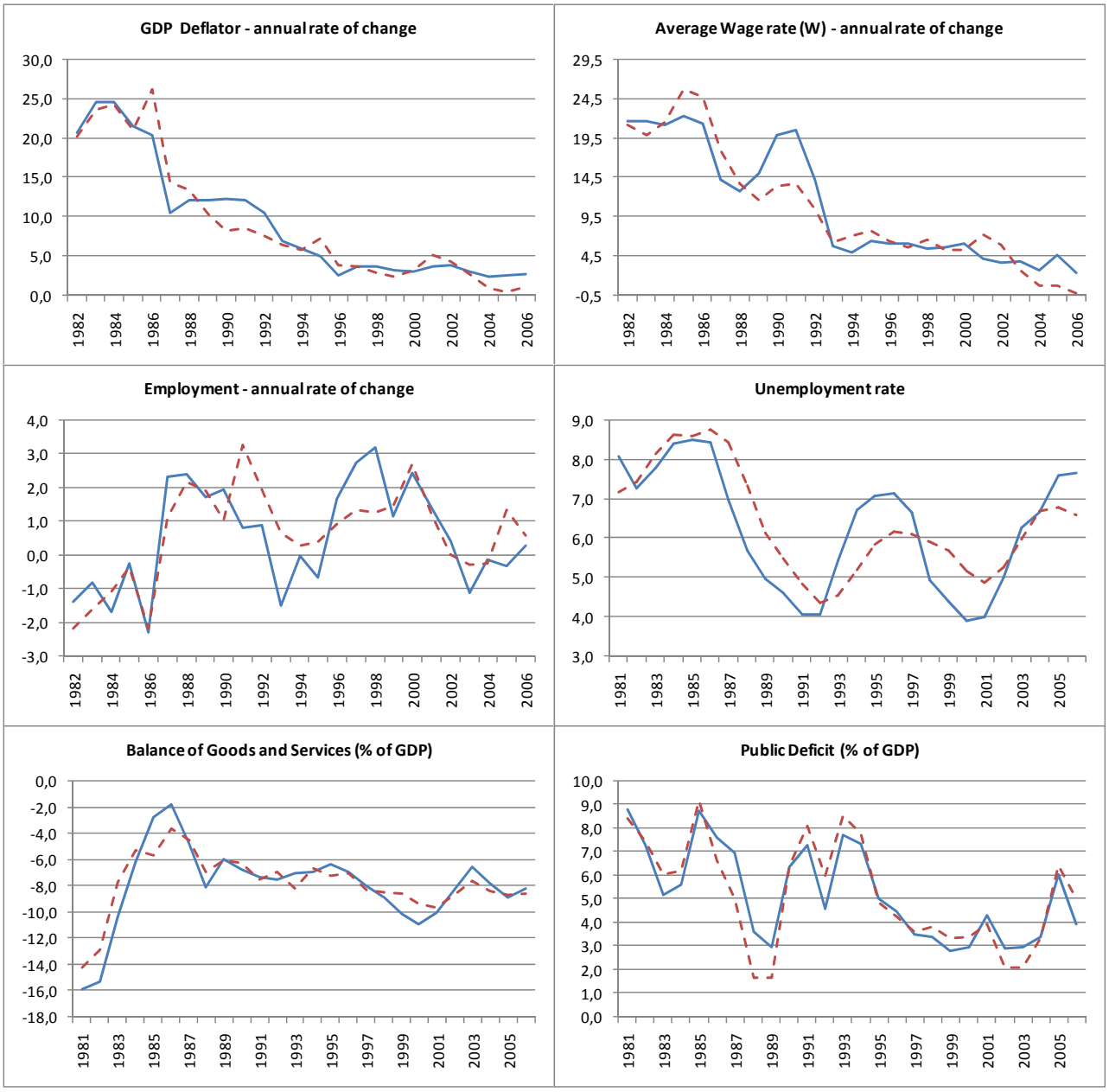
SECTOR N (PREDOMINANTLY NON TRADABLE)	
Recycling	37
Electricity, gas, steam and hot water supply	40
Collection, purification and distribution of water	41
Construction	45
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50
Wholesale trade and commission trade, except of motor vehicles and motorcycles	51
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	52
Hotels and restaurants	55
Land transport; transport via pipelines	60
Supporting and auxiliary transport activities; activities of travel agencies	63
Post and telecommunications	64
Financial intermediation, except insurance and pension funding	65
Insurance and pension funding, except compulsory social security	66
Activities auxiliary to financial intermediation	67
Real estate activities	70
Renting of machinery and equipment without operator and of personal and household goods	71
Computer and related activities	72
Other business activities	74
Activities of membership organizations n.e.c.	91
Recreational, cultural and sporting activities	92
Other service activities	93
Activities of private households as employers and undifferentiated production activities of private households	95
SECTOR G (PREDOMINANTLY NON MARKET SERVICES)	
Research and development	73
Public administration and defence; compulsory social security	75
Education	80
Health and social work	85
Sewage and refuse disposal, sanitation and similar activities	90

APPENDIX 5 – HERPOR 3 – HISTORICAL DYNAMIC SIMULATION (1981-2006)

Comparison of actual and simulation values for selected key variables

(--------- Actual - - - - Simulated)



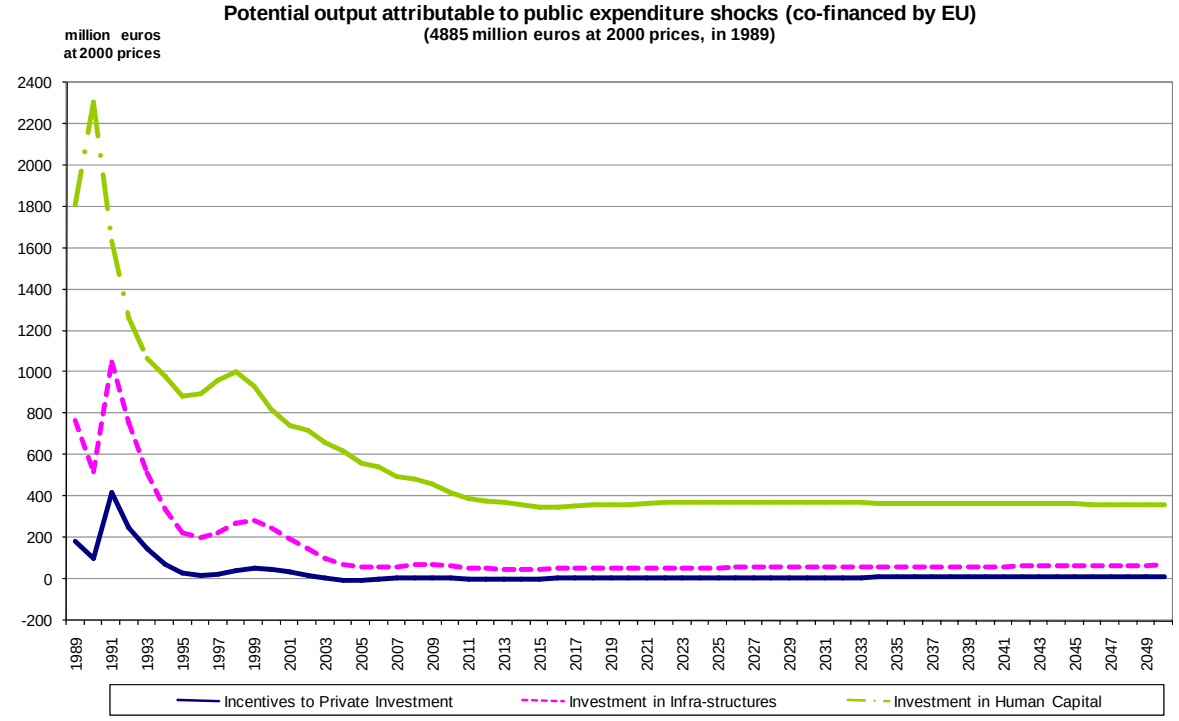

GDP Deflator - annual rate of change
30,0
25,0
20,0
15,0
10,0
5,0
0,0
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006
Average Wage rate (W) - annual rate of change
29,5
24,5
19,5
14,5
9,5
4,5
-0,5
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006
Employment - annual rate of change
4,0
3,0
2,0
1,0
0,0
-1,0
-2,0
-3,0
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006
Unemployment rate
9,0
8,0
7,0
6,0
5,0
4,0
3,0
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005
Balance of Goods and Services (% of GDP)
0,0
-2,0
-4,0
-6,0
-8,0
-10,0
-12,0
-14,0
-16,0
-18,0
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005
Public Deficit (% of GDP)
10,0
9,0
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005

APPENDIX 6

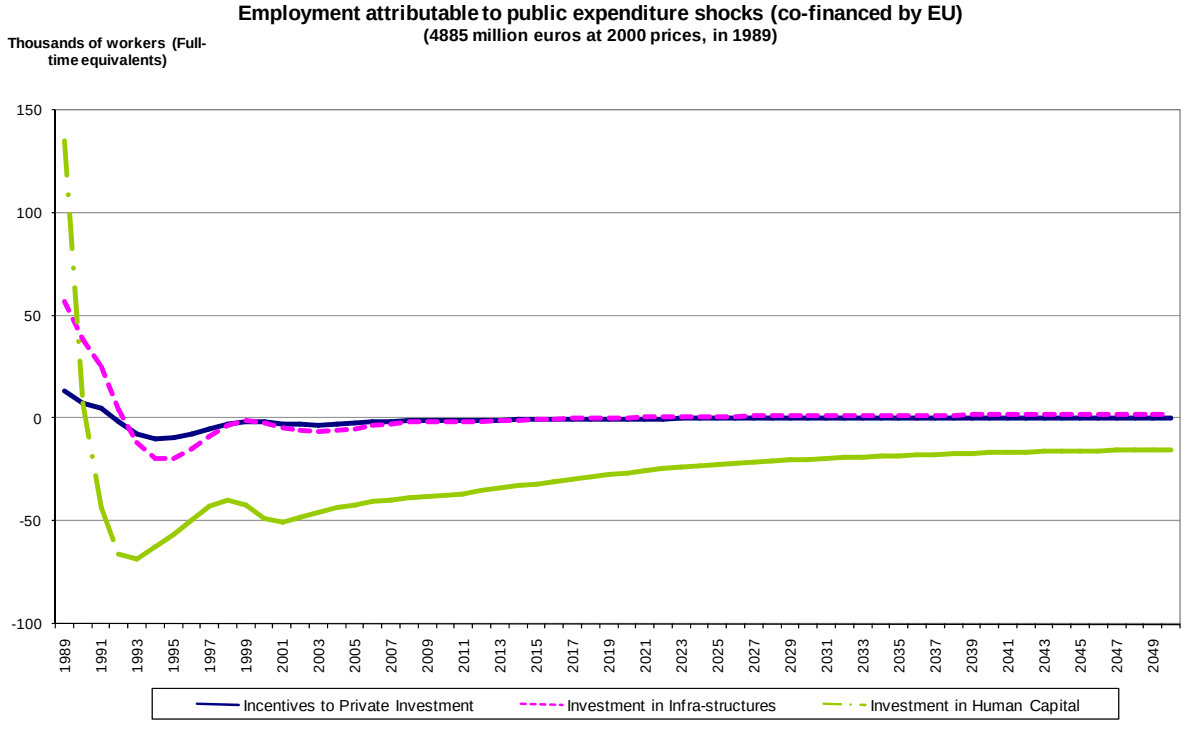
IMPACT OF DIFFERENT TYPES OF PUBLIC EXPENDITURE (CO-FINANCED BY EU FUNDS)

(public expenditure shock of 4885 million euros at 2000 prices, in 1989)

Graph A6-1

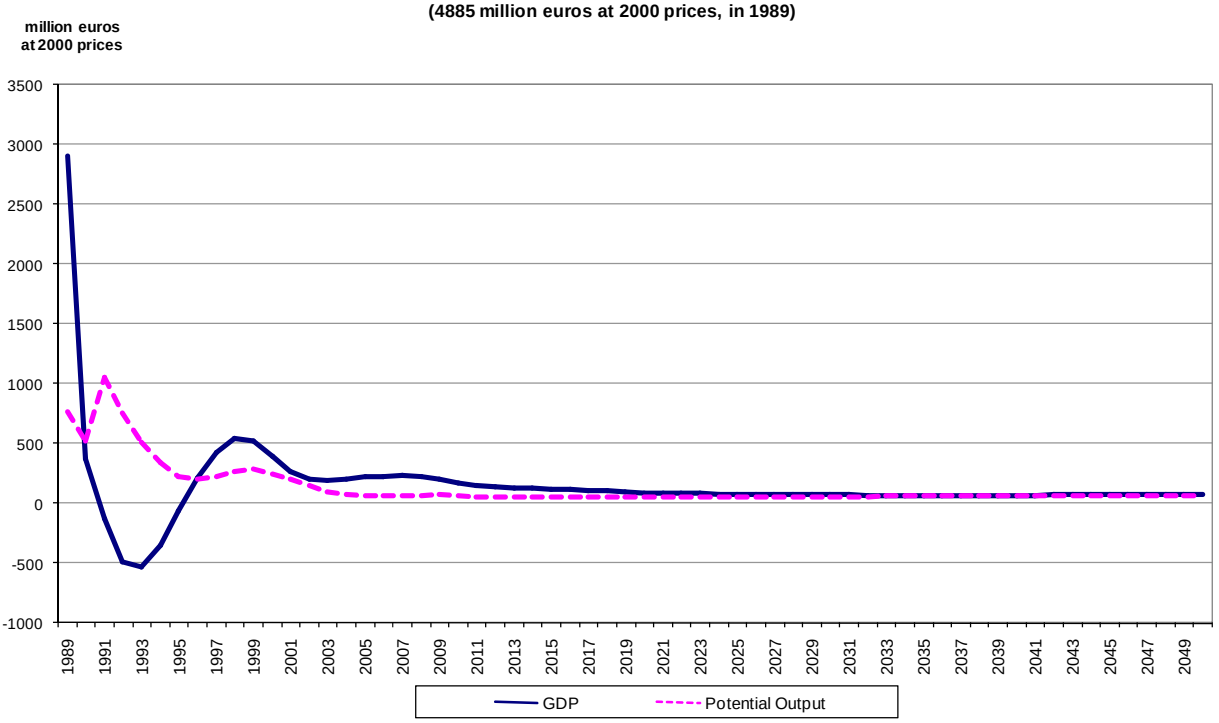


Graph A6-2



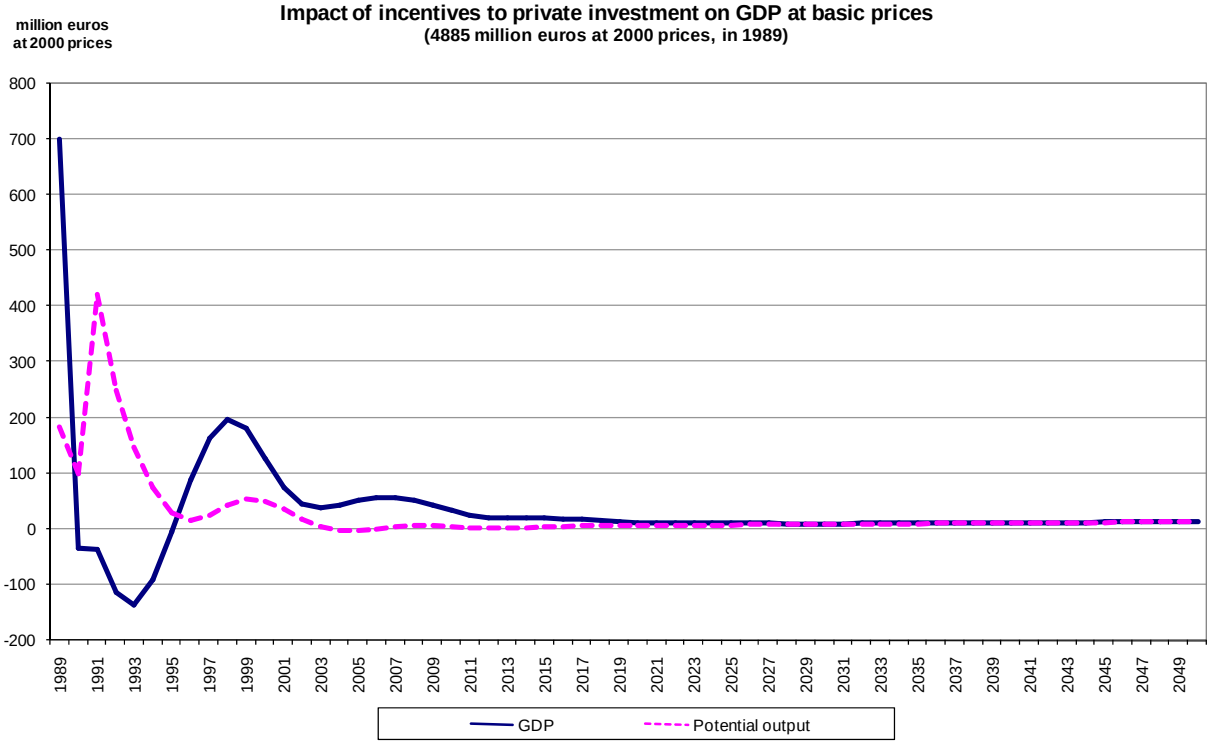
Graph A6-3

Impact of investment in infra-structures on GDP at basic prices
(4885 million euros at 2000 prices, in 1989)



Graph A6-4

Impact of incentives to private investment on GDP at basic prices
(4885 million euros at 2000 prices, in 1989)



Graph A6-5

Impact of Investment in Human Capital on GDP at basic prices
(4885 million euros at 2000 prices, in 1989)