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A Dynamic General Equilibrium Analysis of EC Structural Funds

(With an application to Portugal)

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Abstract

The purpose of this paper is to develop a methodology for studying the impact of international unilateral transfers on the growth path of a capital importing economy. Unilateral public transfers under the EC Structural Funds Programs are an essential part of the process of integration of the new Southern European entrants. The paper develops a two sector endogenous growth model of private and public physical capital and human capital accumulation in which the public sector and the current account balances play a crucial role. The model is applied to the case of Portugal. Simulation results suggest that ongoing structural changes have a substantial and permanent impact on economic growth and contribute markedly to the process of real convergence of the Portuguese economy to EC standards. However, the impact of structural funds on public deficits, current account, and real exchange rates adversely affects the long run requirements of nominal convergence and exacerbates the need for budgetary restraint.

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A Dynamic General Equilibrium Analysis of EC Structural Funds (with an application to Portugal)(*)

1. Introduction

The purpose of this paper is to develop a methodology for studying the impact of EC unilateral public transfers, under the EC Structural Funds Programs, on investment and the growth path of the less developed EC capital importing countries. In addition to evaluating the effects of the current structural policies, the paper addresses the merits of different changes in the design of future structural transfers. At the same time, this paper seeks to identify the impact of structural transfers on the public and foreign deficits, and on the main policy options faced by the national economic authorities.

The motivation behind the EC Structural Funds Programs is the realization that there are wide and persistent disparities in the economic performance of the EC countries as measures by GDP per capita in purchasing power standards. Currently, the GDP per capita of the poorest countries in the EC, Greece and Portugal are only 41.9% and 44.3%, respectively, of the GDP per capita of the richest country, Luxembourg. Also, Ireland at 54.9% of the highest GDP per capita in the EC and to a lesser extent Spain at 61.9%, are clearly lagging behind vis–a–vis the EC average. As a term of comparison, the ratio between the poorest and richest state of the USA is 58.8%. These disparities are persistent in historical terms and showed tendency to increase in the early 1980s. The size and persistence of disparities has recently led to efforts to stop and reverse the trend, a process which will be referred to as real convergence or catching up to EC standards.

The EC Structural Funds Programs, as they exist today, came into being against the backdrop of the European Single Act of 1986. The European Single Act postulates the formation of a single European market through the abolition of barriers to economic flows among EC countries. The Single Market Program is supposed to ensure the so–called four

freedoms – the free circulation of goods, services, capital and labor within the EC borders. Under the European Single Act the recognition of the existence of major economic disparities among EC member states generated great concern for economic and social cohesion.

There are different reasons for the legitimacy of such concern over economic and social cohesion. First, the current process of increasing integration in the EC takes place at a time when the EC's economic space has been expanded to include less developed countries. Before the 1980s, only Ireland was in a relatively disadvantaged position. Subsequently, Greece joined the EC in 1981 and Portugal and Spain in 1986, bringing with them a new dimension to the problem of economic disparity in the EC. Second, the increased market solidarity brought forth by the European Single Act made it crucial that the less developed EC countries converge to EC standards. This is to ensure that the benefits from the single market are fairly distributed and that the less developed EC countries are in a position to benefit from the positive spillovers of increased integration. Also, the transition of these less developed countries to a fully market oriented and open economic environment with foreign competition within the EC creates the possibility of great transitional losses for the domestic economies if some degree of real convergence is not achieved. In addition, these losses may translate into future liabilities for the more advanced economies.

In the sequel of the European Single Act, the EC Structural Funds Programs have undergone major changes in philosophy and design. The economic disparities among EC countries have, in general, been identified as the results of problems hindering long term growth in less developed EC countries. First, due to credit controls and/or the high cost of credit in general, these countries have had a relatively low availability of credit in private financial markets for private capital formation. Second, these countries are characterized by a relatively low availability of public infrastructures (transportation, energy, etc.), i.e. low public capital formation. Finally, there is lack of good vocational training and

institutions of higher education, leading to a relative low level of human capital formation. These problems assume the nature of market or national policy failures: incomplete and segmented markets for the financing of private investment; inadequate supply of public goods in the case of public investment; and inadequate supply of public goods/positive externalities in the case of human capital formation. The central objective of the Structural Funds Programs is to promote real convergence through efficiency improving mechanisms, i.e. generate market conditions where they do not exist and help the public provision of goods in short supply. The distributive considerations are residual in that Structural Funds generate higher levels of local public goods in the recipient countries without increasing to the same extent fiscal pressures on local tax payers.

The perceived importance of real convergence has translated into a major increase in the size of the funds assigned to the Structural Funds Programs. Structural Funds have thus become very significant from the standpoint of the EC, and are expected to double in real terms between 1987 and 1993. For the five year period beginning in 1989, EC Structural Funds Programs will channel more than 60 billion Ecus (more than 80 billion dollars) to the less developed regions of the EC. By 1993, the share of Structural Funds in the EC's public budget will have attained 25%.

The greatest changes in the EC Structural Funds Programs have occurred in their design. The programs are now designed according to a multi–annual framework which assigns funds to specific objectives. Most of the funds (about 80%) correspond to objectives which have a clear regional focus: the development of lagging regions; the reversal of industrial decline; and the development of rural areas. These objectives are intended to benefit Greece, Ireland, Portugal, most of Spain, and the Italian Mezzogiorno. The remaining objectives, such as the developing of the labor markets and agricultural structures, have a broader base.

The amount of funds to be transferred to each country follows a Community Support Framework. The framework predetermines the different expenditure categories.

Following the logic of the programs, EC transfers are primarily designed to promote the construction of infrastructures. A smaller percentage of the transfers goes to favoring the accumulation of human capital through labor training programs, and to influencing the pattern and volume of private investment. The allocation of the funds according to the Community Support Framework follows some important rules. First, access to the funds is not automatic and depends on the submission and approval of national programs. Second, transfers are subject to the complementarity principle. They assume the form of matching funds which requires national governments, and in some cases the private sector, to contribute funds proportional to the funds provided by the EC. Finally, transfers are subordinated to the additionality principle. This principle attempts to prevent the recipient economies from decreasing their own financial engagements in the different target areas.

EC unilateral public transfers are vitally important to the recipient economies. In the framework of the EC's regional policies, Greece, Ireland, and Portugal are expected to receive substantial unilateral public transfers from the EC. For example, Portugal between 1989 and 1993 will receive grants of 7.4 billion Ecus or 3.5% of the GDP for the period. The total amount of resources involved in these programs in Portugal are estimated to be in excess of 9% of the GDP. Total EC transfers to Greece and Ireland for the same period are 2.3% and 2.9% and the total amount of resources involved in EC programs are 5.7% and 5.2% of their GDP, respectively.

This paper develops a two sector optimal growth model for a capital importing economy building upon Abel (1981), Abel and Blanchard (1983), Blanchard (1985), and the more recent endogenous growth literature, such as Barro (1990), Barro and Sala–i–Martin (1990), King and Rebelo (1991), Lucas (1990), Rebelo (1991) and Romer (1986). This model is intended to capture the optimal accumulation of private and public physical capital and human capital. Human capital is assumed to reflect the level of knowledge available in the economy and is a source of endogenous growth. Public capital, which

represents public infrastructures, is an externality for private production and a source of increasing returns. The accumulation of public capital is responsive to economic incentives and therefore is also a source of endogenous growth. In the determination of the optimal path for the economy, the behavior of the twin balances – the public sector deficit and the current account deficit – and their stock counterparts – public debt and foreign debt – play a crucial role. Our approach reconciles the basic features of the recent economic growth literature with a realistic representation of the EC Structural Funds transfers to the less developed EC capital importing economies.

The theoretical model is implemented numerically for simulation purposes with a detailed data and parameter set for the Portuguese economy. The Portuguese case is particularly interesting for several reasons. In only three cases, Greece, Ireland and Portugal, is the whole country eligible for EC structural Funds. Of these countries, Greece and Portugal are recent entrants in the EC and the countries showing the lowest GDP per capita in the EC. Portugal, which traditionally has ranked last in terms of this indicator, is scheduled to receive the largest amounts of EC funds as percentage of its domestic GDP. Finally, the conventional wisdom is that Portugal is the greatest success story in terms of the appropriate and comprehensive use of EC structural funds.

The paper is organized as follows. In Section 2., the optimal growth model is presented and the main issues for the simulation design are introduced. In Section 3., the optimal growth model is applied to the Portuguese economy. The effects of EC Structural transfers are studied. Different alternative designs for structural funds are analyzed. Also, comprehensive sensitivity analysis of the simulation results is provided. Finally, Section 5. includes a summary of the results, concluding remarks, and direction for further research. In addition, the paper includes an appendix with the details of data construction and parameterization.

2. Optimal Growth for a Capital Importing Economy

This section describes the optimal growth model for a capital importing economy. It also details how the different relevant aspects of the EC structural funds are accommodated by the model.

2.1 The optimal growth model

We shall assume that the domestic economy produces two goods: a good traded internationally (denoted by T) and a non–traded good (denoted by N). The two sector optimal growth model for a capital importing economy is intended to capture the optimal accumulation of private and public physical capital and human capital. Private capital is sector specific and is installed in either the traded or the non–traded good sectors. Public capital and human capital are available for both sectors. Public capital is assumed to represent public infrastructures. Human capital is assumed to reflect the level of knowledge available in the economy. The evolution of the twin balances – the public sector deficit and the current account deficit – and their stock counterparts – public debt and foreign debt – play an important role in the determination of the optimal path for the economy. Accordingly, the evolution of the economy is summarized by the trajectories of six state variables: privately owned capital installed in the traded and non–traded good sectors, KT_t and KN_t respectively, public capital, PK_t, human capital, HK_t, foreign financing, F_t, and public debt, PD_t.

The equations of motion for private and public physical capital and human capital may be written as:

$$(1) \quad KT_{t+1} = IT_t - AC_{IT}(IT_t, KT_t) + (1-\delta_{KT})KT_t \quad (t=0,\ldots,\infty),$$

$$(2) \quad KN_{t+1} = IN_t - AC_{IN}(IN_t, KN_t) + (1-\delta_{KN})KN_t \quad (t=0,\ldots,\infty),$$

$$(3) \quad PK_{t+1} = PI_t - AC_{PI}(PI_t, PK_t) + (1-\delta_{PK})PK_t \quad (t=0,\ldots,\infty)$$

$$(4) \quad HK_{t+1} = HI_t - AC_{HI}(HI_t, HK_t) + (1-\delta_{HK})HK_t \quad (t=0,\ldots,\infty)$$

where, δ_{KT}, δ_{KN}, δ_{PK}, and δ_{HK}, are the rates of depreciation applicable to private and public physical capital, and human capital; $AC_{IT}(IT_t, KT_t)$ and $AC_{IN}(IN_t, KN_t)$ are the adjustment costs on private investment to be installed in the tradable and non–tradable sectors; $AC_{PI}(PI_t, PK_t)$ is the adjustment cost on public investment; and $AC_{HI}(HI_t, HK_t)$ is the adjustment cost on investment on human capital.

It is assumed that the stocks of physical capital, both private and public, and human capital are not susceptible to instantaneous and costless adjustments toward optimal levels. Also, physical capital is not perfectly mobile internationally nor between sectors. These features are captured by investment adjustment cost functions representing foregone capital accumulation. The adjustment cost functions are assumed to be non–negative, monotonically increasing, and strictly convex in investment. In particular, these functions are assumed to be quadratic in investment per unit of installed capital and can be written as:

$$(5) \quad AC_{IT}(IT_t, KT_t) = .5\mu_{IT}(IT_t)^2/KT_t$$

$$(6) \quad AC_{IN}(IN_t, KN_t) = .5\mu_{IN}(IN_t)^2/KN_t$$

$$(7) \quad AC_{PI}(PI_t, PK_t) = .5\mu_{PI}(PI_t)^2/PK_t$$

$$(8) \quad AC_{HI}(HI_t, HK_t) = .5\mu_{HI}(HI_t)^2/HK_t$$

where, μ_{IT}, μ_{IN}, μ_{PI}, and μ_{HI}, are the investment specific adjustment cost parameters associated with private and public physical capital accumulation, and human capital accumulation, respectively.

Domestic production possibilities are reflected in well behaved production functions. Production utilizes sector specific private capital, KT_t and KN_t, human capital, HK_t, and

public capital, PK_t. Private capital and human capital are inputs which receive explicit compensation. We follow Lucas (1988), King and Rebelo (1991), and Rebelo (1991) in permitting labor input to be reproducible and in assuming that the stock of human capital is embodied in workers. Human capital is a source of endogenous growth. The labor input can be adjusted by changing the number of workers in each sector, LT_t and LN_t, or by changing total human capital. The total number of workers, L_t ($= LT_t + LN_t$), is given exogenously and grows at a constant rate, n. It is assumed that, in both sectors, production technology displays constant returns to scale in private capital and human capital.

In addition, public capital represents a source of increasing returns and a positive externality for the private sector (see Arrow and Kurz (1970) for early efforts to consider public capital as a factor of production). Public capital does not generate explicit compensation such that intertemporal equilibrium can exist (see for example Romer (1989)). Public capital is assumed to be a pure public good in the tradition of Diewert (1988), who focuses on public capital corresponding to public infrastructures, and of Romer (1986), who focuses on externalities related to public knowledge. Alternatively, it could have been assumed following Barro (1990), that production depends on the flow of public services, or following Barro and Sala–i–Martin (1990), that public capital corresponds to a public good that is subject to congestion. In any case, the accumulation of PK_t is responsive to economic incentives and is therefore a source of endogenous growth.

In both sectors, the production function is assumed to be Cobb–Douglas with constant returns to scale on private capital and human capital, displaying increasing returns when public capital is also considered,

$$(9) \quad YT_t = \beta_{0T}\, KT^{\beta_T} (LT_t{*}HK_t)^{1-\beta_T} PK_t^{\nu_T}$$

$$(10) \quad YN_t = \beta_{0N}\, KN^{\beta_N} (LN_t{*}HK_t)^{1-\beta_N} PK_t^{\nu_N}$$

where β_{0j} is the output scaling factor; $0 < \beta_j < 1$ is the capital share factor on total output; $\nu_j > 0$ is the public capital externality factor.

The domestic production of the traded good YT_t and import of this good are absorbed by domestic expenditure on consumption, C_{Tt}, investment in the different types of capital that assumes the form of purchases of traded goods, and exports. For the sake of simplicity, it is assumed that fixed and exogenous fractions of private investment installed in both goods sectors, public investment, and investment in human capital, s_{IT}, s_{IN}, s_{PI}, and s_{HI}, respectively, represent purchases of the traded goods. The remaining correspond to purchases of the non–traded good. Net exports at t, X_t, can be written as:

$$(11) \quad X_t = C_{Tt} + s_{IT}IT_t + s_{IN}IN_t + s_{PI}PI_t + s_{HI}HI_t - YT_t$$

The equation of motion for foreign financing, F_t, provides a stylized description of the balance of payments and is equivalent to the intertemporal budget constraint of an open economy, or the equilibrium condition in the traded good market. The concept used for foreign financing corresponds to that of the net sale of domestic assets to foreigners, thereby reflecting debt and non–debt capital inflows. This is the relevant concept in the definition of the intertemporal budget constraint of the open economy, given that there is no explicit distinction in the model between debt and equity capital. The equation of motion for foreign financing may be written as:

$$(12) \quad F_{t+1} = (1+r_t)F_t + X_t - R_t - CF_t \quad (t=0,\ldots,\infty),$$

where R_t is the unilateral private transfers (emigrants' remittances, for example), and CF_t is the unilateral public transfers (community funds) to the domestic economy. The (exogenous) rate of return on the foreign financing of the national economy, r_t, is determined in the international financial markets. The capital importing country is a

small open economy that can obtain as much financing as desired at the going market interest rate (plus an idiosyncratic risk premium) without affecting this rate.

Equilibrium in the non–traded good market reflects the fact that production of this good YN_t is absorbed by private consumption of the non–traded good, C_{Nt}; public consumption (which is assumed to exclusively represent purchases of the non–traded good), PC_t; and by the fractions of private investment installed in both goods sectors, public investment, and investment in human capital, which represent purchases of the non–traded good.

$$(13) \quad YN_t = C_{Nt} + PC_t + (1-s_{IT})IT_t + (1-s_{IN})IN_t + (1-s_{PI})PI_t + (1-s_{HI})HI_t$$

In this paper, the equation of motion for public debt reflects the fact that government expenditures have to be financed by taxes and by increases in the level of public indebtedness. Government expenditures include spending in consumption and investment activities, PC_t, PI_t and HI_t (in traded and non–traded goods), as well as interest payments on public debt at a rate r_t (which equals the rate of return on foreign debt). In addition, the government receives unilateral public transfers from the EC, CF_t, and transfers funds to the private sector, PT_t. These transfers to the private sector include the funds from the EC and matching funds according to EC financing requirements. Finally, tax revenues are obtained by applying a flat and exogenous tax rate, t_y, to the domestic value added.

The optimal evolution of public indebtedness is determined by consumption smoothing in the domain of private and public consumption. The equation of motion for public debt can be written as:

$$(14) \quad PD_{t+1} = (1+r_t)PD_t + rer_t PC_t + [s_{PI}+rer_t(1-s_{PI})]PI_t + [s_{HI}+(1-s_{HI})]HI_t + PT_t - CF_t$$

$$-t_y(YT_t+rer_tYN_t) \qquad (t=0,\ldots,\infty),$$

where, rer_t, is the real exchange rate.

The optimal path for the national economy is obtained from the maximization of a social welfare indicator, W. This social welfare indicator is specified as time separable. More specifically, W is given by the discounted value of a well behaved, time invariant utility function defined on the space of private consumption per capita of traded and non–traded goods and public consumption per capita as follows:

$$(15) \qquad SW = \Sigma_{0<t<\infty} \rho^t L_t U(C_{Tt}/L_t, C_{Nt}/L_t, PC_t/L_t),$$

where $0 < \rho < 1$ is the social discount rate and may be interpreted as the marginal rate of substitution between present and future consumption when the composite consumption level is constant. We follow Barro (1990) in assuming that government finances some services, such as health, which enter into household utility. In what follows, U(.) has a nested structure. At the first level, we assume utility to be a CES function of the traded good and a composite non–traded good, with elasticity of substitution σ. At the second level, the non–traded good is a Cobb–Douglas aggregate of the private and the public consumption of the non–traded good.

Finally, the real exchange rate, i.e. the relative price of the non–traded good to the traded good, is defined as the marginal rate of substitution between the non–traded and the traded goods. The disaggregation between traded and non–traded goods allows for the consideration of real exchange rate effects on the real convergence of the capital importing EC countries to EC standards (see for example Branson (1990) and Krugman (1990)). In fact, to the extent that the inflow of structural funds will change the relative price of tradables and non–tradables, the evolution of the domestic GDP per capital in purchasing power parity will be affected.

2.2 On the Modeling of EC Structural Funds Programs

This section discusses how the different features of the EC structural Funds Programs are captured in the model in the previous subsections. In the optimal growth model unilateral public transfers are shown in equations (12) and (14) by CF_t. The availability of foreign unilateral public transfers means that the national economy will benefit from the additional resources to finance development (see (12)). In fact, ceteris paribus, an increase in CF_t corresponds to an outward shift in the resource constraint of the national economy. Funds are transferred from the EC to the domestic public sector, which is responsible for disbursing these funds (see (14)).

As we have discussed, the EC's unilateral transfers are not block grants. They are allocated to specific and well defined objectives, programs, and projects. The impact of the Community funds in the national economy depends particularly on the response of the domestic economy to the incentives provided. The EC's funds correspond to three types of programs: those designed to influence the pattern and volume of private capital accumulation in the traded and non–traded good sectors through appropriate incentives, $CFKT_t$ and $CFKN_t$; those designed to promote the development of public infrastructures, $CFPK_t$; and, those designed to improve human capital accumulation through training, $CFHK_t$. Therefore we can write:

$$(16) \quad CF_t = CFKT_t + CFKN_t + CFPK_t + CFHK_t$$

Given the principle of complementarity, these funds assume the form of matching funds. Therefore, the government and the private sector have also to disburse certain amounts of matching public and private funds, MF_{pub} and MF_{pri}, respectively. Public matching funds are included in (14) in PT, transfers to the private sector. Accordingly, these transfers can be written as

$$(17) \quad PT = PT' + CF_t + MF_{pub,}$$

where PT' represents discretionary transfers not related to the structural funds programs.

There is a complex interaction between the EC's unilateral transfers and domestic budgetary policies. It is clear that for a given pattern of government expenditures, the availability of EC funds represents an additional resource to the budget and therefore provides a positive contribution to a balanced budget. However, the complementarity principle implies that the net impact of EC funds on the domestic budget depends on the overall impact on the volume and composition of public expenditures. In fact, the amounts to be transferred are limited within the context of the Community Support Framework which implies that associated grants are matching and close–ended. At any rate national public expenditure requirements associated with the Community Support Framework are very substantial. Therefore, there is the potential for substantial pressure on the domestic public budgets which may conflict with the efforts to control inflation, and the objective of nominal convergence to EC patterns.

Different types of programs have different amounts of public and private co–financing requirements which are proportional to the amount of funds allocated to each type of capital formation. Therefore, we can write:

$$(18) \quad MF_{pub} = MFKT_{pub} + MFKN_{pub} + MFPK_{pub} + MFHK_{pub}$$

$$(19) \quad MF_{pri} = MFKT_{pri} + MFKN_{pri} + MFPK_{pri} + MFHK_{pri}.$$

In terms of the optimal growth model, programs that affect private capital formation are captured in equations (1) and (2). Equation (3) captures the effects of programs that affect public capital. Transfers designed to improve infrastructures also represent an increased positive externality to private production via equations (9) and (10). Finally, funds allocated for training programs are incorporated in equation (4). The

transfers and the matching funds conditions allow us to write the different types of investment as:

$$(20) \quad IT = IT^{O} + CFKT + MFKT_{pub} + MFKT_{pri}$$

$$(21) \quad IN = IN^{O} + CFKN + MFKN_{pub} + MFKN_{pri}$$

$$(22) \quad PI = PI^{O} + CFPK + MFPK_{pub} + MFPK_{pri}$$

$$(23) \quad HI = HI^{O} + CFHK + MFHK_{pub} + MFHK_{pri},$$

where IT^{O}, IN^{O}, PI^{O}, and HI^{O} are the optimal amounts of private investment in the traded and non–traded sectors, and public and human capital investment, not related to EC structural programs. Notice that in (20)–(23) additionality is not imposed. In fact, the model allows for the possibility that on the aggregate, funds associated to EC structural programs may crowd out investment which would take place even in the absence of such programs.

Finally, the total amount of funds involved in the structural funds programs can be written as:

$$(24) \quad Total = CF + MF_{pub} + MF_{pri}.$$

2.3 Characterization of the optimal solution

The optimization problem consists of the maximization of (15) subject to (1)–(14) and (16)–(24). The solution to this problem is obtained by using a discrete time version of Pontryagrin's Maximum Principle (a detailed description and interpretation of the optimality conditions is available from the authors upon request). Given the nature of the optimization problem under consideration, some restrictions on the production and adjustment cost parameters are imposed to make the model solvable. In fact, the

production function displays increasing returns to scale, and is therefore convex. The condition that $\beta_j + \nu_j < 1$, for j = T,N, is introduced. In addition, the presence of strictly convex adjustment costs makes the optimization problem well defined in a subset of the technology and adjustment cost parameters. Intuitively, the adjustment cost functions must be more convex than the production function.

The variational conditions for optimality investment decisions can be interpreted as yielding the different types of investment as positively correlated to generalized and investment specific versions of Tobin's Q. In fact, private investment per unit of installed capital is negatively correlated with the shadow price of foreign financing and the real exchange rate and positively to the shadow price of private capital accumulation. In turn, public investment per unit of installed public capital is negatively correlated with the shadow price of foreign financing, the shadow price of public debt and the real exchange rate and positively to the shadow price of public capital accumulation. Finally, investment in human capital per unit of installed human capital is negatively correlated with the shadow price of public debt and the real exchange rate and positively to the shadow price of human capital accumulation.

The characterization of the optimal solution to endogenous growth problem can be interpreted as a two–point boundary problem with twelve non–linear difference equations (six for the state variables and six for the co–state variables) and twelve unknowns. This problem has six initial conditions for the state variables and six terminal (transversality) conditions for the co–state variables. Given the complexity of this problem, no attempt has been made to develop an analytic solution or 'a fortiori' to perform comparative dynamic analysis. Instead, in subsequent section, this optimal growth problem is parameterized and solved numerically. Comparative dynamic analysis is approximated by solving the model numerically for different configurations of the most relevant parameters and exogenous variables in the economy and by providing a detailed sensitivity analysis of the results.

3. On the Effects of Structural Funds Programs: the Case of Portugal

In this section we discuss the results of the implementation of the optimal growth model developed in Section 2. to the Portuguese case. In the first subsection, the numerical implementation and the design of the numerical simulations are addressed. In the second subsection we analyze the general effects of EC Structural Funds Programs in Portugal. In the third subsection we consider the relative merits of alternative scenarios for the evolution of EC Structural Funds in Portugal. In the fourth subsection we provide detailed sensitivity analysis of the basic results.

3.1 Simulation Design

3.1.1 Data set and parameter specification

The optimal growth model in Section 2. is implemented numerically using a detailed data and parameter set for the Portuguese economy during 1985. The base year of 1985 is chosen for two reasons. First, 1986 is the year of accession of Portugal into the EC. Therefore, calibrating the model for 1985 allows us to capture the changes in the Portuguese economy generated by integration, and in particular, structural funds. Second, it allows us to develop a good sense of the accuracy of the model's results vis–a–vis the post sample data.

The variable values for the Portuguese economy in 1985 are reported in Table 1. Aggregate figures for balance of payments, public sector and national spending are obtained from Banco de Portugal (1989). Investment in human capital mirrors expenditures in education. According to the World Bank (1989), in the period 1980–85, 5% of total private consumption expenditures was allocated to education. On the other hand, according to OECD (1990), in 1985, public expenditures in education were 3.8% of the GDP. There is a question as to the nature of public spending in education, whether it is

mostly current expenditures or transfers (salaries). No data is available for Portugal. In the United States, between 70% and 80% of total spending in education is actually salaries (see Tax Foundation (1990)). We choose arbitrarily the figure of 75%.

The disaggregation of GDP into tradables and non–tradables follows Marston (1988). The national account statistics of the OECD provide a breakdown of total value added into ten sub sectors. We have designated agriculture, mining and quarrying, manufacturing, and electricity gas and water as tradables and construction, wholesale and retail trade, transport, finance, community services, and government services as non–tradables. The exact numbers obtained from OECD (1991) suggest that tradables correspond to 42% of the total GDP. In turn, according to sources from the Banco de Portugal, about 60% of investment expenditures corresponds to the purchase of tradable goods. Public consumption is assumed to correspond entirely to expenditures in non–tradables. The values for private consumption of tradables and non–tradables are obtained as residuals of the foreign account identity and the equilibrium identity in the non–tradable market. The figures correspond to a share of 54% of tradables and 46% of non–tradables in private consumption and are consistent with World Bank (1989) data.

There is no good data on the Portuguese capital stock. The figures for private, public, and human capital stock were obtained from the investment figures by assuming a net increase of 3%. This is the rate of growth of GDP in 1985. Therefore, the capital/output ratios for the different types of capital stock are assumed not to change in the base year. The figures for private and public capital stock correspond to an overall physical capital/output ratio of 2.9, somewhat below the capital/output ratios in more developed countries. The relatively low ratio captures the low availability of capital in the country. In turn, total physical capital is decomposed into public and private capital using a relation of 3:1. This is higher than the relation for more developed countries. In the US, for example, the ratio is 1.6:1 (see Boskin et al (1985)). The lower ratio in Portugal is intended to reflect the relatively lower availability of infrastructures.

Public debt and total labor force (as well as its growth rate) are obtained from Banco de Portugal (1989). The decomposition of total labor force between tradables and non–tradables is obtained from OECD (1991): 52% in tradable sector and 48% in non–tradable. We assume that the decomposition of private capital stock between the tradable and non–tradable sectors follows the decomposition of the total labor force. Also, the disaggregation of private investment into investment in the tradable and non–tradable sectors follows the relationship between the capital stock installed in both sectors. Accordingly, the two sectors have the same capital/labor ratio and no productivity bias is introduced in the central simulations.

The stock of foreign financing has two components. The first is foreign debt, which is obtained from Banco de Portugal (1989) and corresponds to 80.4% of the GDP. The second is the part of the domestic physical capital stock which is imputed to foreign owners (approximately 7.5%).

Parameter values for the Portuguese economy are reported on table 2. In the context of endogenous growth models, long term steady state growth requires that the rate of interest be greater than the rate of time preference. The difference is proportional to steady state growth. Accordingly, we use the long run after tax real rate of interest in the economy as a guide for the values which can be assumed by the subjective discount rate. According to Banco de Portugal (1989), the real long run rate of interest averaged 8.1% for the period 1985–1989 and the effective tax rate averaged 37.2%. Thus, the after tax rate of interest averaged 5.1%. Accordingly, the subjective discount factor should be greater than 94.9%, and it is chosen to be 96% in the central simulations. In turn, the elasticity of substitution between tradables and non–tradables is chosen to be .25 in the central simulations. Finally, the Cobb–Douglas size parameter is designed to replicate at the second level of the nested utility structure the figure for total consumption of non–tradables (both private and public).

The share of capital in domestic expenditure is obtained from Borges–Pereira (1991)

as the average for the period 1970–1978 of the share of capital in the value added of the manufacturing sector. The same capital share is assumed in both sectors. We have assumed the same capital/labor ratio in both sectors, and labor (and human capital) is an homogeneous factor eliciting the same wage rate in both sectors. Assuming the same capital (labor) share in value added reflects the idea that the return of capital, including adjustment costs, is the same in the base year in both sectors. The public good externality is chosen to be .10. In turn, the output scaling factor is a calibration parameter. It is obtained to replicate GDP in the base year conditional on the remaining parameter information.

In Borges–Pereira (1991), the value of the depreciation rate on private manufacturing capital is .07 for the period 1960–78. However, the stylized fact remains that other sectors, with a greater share of building structures and construction in their capital stock, have depreciation rates that are substantially lower. Accordingly, a rate of .06 is assumed. Given the nature of the public capital stock, which refers to infrastructures such as roads, bridges and other very long lived assets, the depreciation rate on public capital was chosen at .015. The depreciation for human capital is chosen to be 3% and falls in the middle of the range of values available in the literature, 1.2% in Mincer (1974) to 3. – 4.% in Haley (1976). Finally, in the base year adjustment costs are chosen to be 10% of private investment in both tradables and non–tradables, and 20% of public and human capital investment. This choice of values is arbitrary and follows the numbers used in the relevant literature.

The key parameters in terms of the descriptive power of the simulation results are the subjective discount rate, the elasticity of substitution between tradables and non–tradables for the representative household, the public capital externality factor, and the adjustment cost parameters. Broadly speaking, the subjective discount rate affects mostly the level of foreign indebtedness, the elasticity of substitution mostly affects the real exchange rate, the public externality mostly affects the level of transitional growth,

and the adjustment costs affects mostly the different types of investment. The values for these parameters, chosen as discussed above, were picked up for the sake of maximizing the descriptive power of the simulation results.

3.1.2 Simulation design: structural funds in the benchmark scenario

The benchmark case is designed to represent the actual path for the Portuguese economy in the period 1986–1990 and its most likely evolution. In the benchmark scenario, the path for structural funds satisfying (16)–(24) is based on the Regional Development Program under the Community Support Framework for Portugal for the period 1989–1993 (1990). The simulations accommodate the evolution, for the duration of the plan, of the relative importance of the different axes of development (infrastructures, private capital formation, and human capital formation), as well as, the evolution of the different financing requirements (EC grants, public financing and private financing).

The Regional Development Plan for 1989–1993 involves EC grants of 7.4 billion Ecus, which correspond to approximately 3.5% of the estimated GDP for the period. In addition, the public co–financing requirements are expected to total 6.7 billion Ecus. Therefore, public expenditures (EC and domestic) associated with the Plan reach 6.6% of the estimated GDP for the period. Finally, the Plan calls for 4.4 billion Ecus in private co–financing. The total amount of resources involved in these programs are estimated to be in excess of 9% of the GDP for the country during the period 1989–1993. Of the total amount of funds involved in the program 46.6% correspond to infrastructure development, 30.9% to private capital formation, and the remaining 22.5% to human capital formation. Over 80% of the matching fund requirements for private capital formation correspond to private funds. In turn, the matching fund requirements for infrastructure development correspond almost exclusively to public funds and for human capital formation 77% of the total matching funds correspond to public funds.

Different scenarios were constructed for the period after the current plan. The

composition and the matching funds requirements were kept constant at the projected values for 1993. However, the volume of structural transfers was allowed to vary. In the central scenario, the inflow of EC funds continues to increase at a rate of 3.4% a year. This rate reflects the average long run growth of the EC for the period 1961–90. This growth of the structural funds leaves, on average, the real inflow of funds constant as a fraction of the EC's GDP, but declining as a fraction of the Portuguese GDP. This central scenario represents a moderate evolution for EC structural transfers. In fact, this growth rate of funds represents a large deceleration with respect to the amounts of funds and growth rates under the current Regional Development Plan. The projected average yearly real growth for the duration of the Plan is 12%. Also, while there is no guarantee of the continuation of the CSF programs beyond 1993, in the aftermath of the agreements reached in Maasterich in late 1991 the prospect of a further doubling of EC transfers for the period 1993–1998 is not farfetched.

Numerical simulations are run for a time horizon of 40 years. The economy approaches a steady state path by the year 2006. In the benchmark scenario, the model exactly replicates the data for the base year of 1985 and displays a good tracking of the stylized features of the Portuguese economy's GDP growth rates, composition of investment spending, public deficits, foreign financing, and real exchange rate for the period 1986–1989 (see Table 3).

In the numerical simulations discussed below we focus on the impact of EC Structural Funds on growth, different types of investment, public sector deficit, foreign financing, and the real exchange rate. Simulations differ according to the specifics of the counter factual scenarios for the path of unilateral public transfers.

3.2 Basic Effects of EC Structural Funds

The effects of the unilateral public transfers on GDP growth, investment (private,

public, and human capital), public deficit, foreign financing, and the real exchange rate, are reported in Table 4. The effects can be analyzed by comparing Case 2, which reflects the status quo since it allows for structural funds, and Case 1, which ignores structural funds.

3.2.1 Effects on investment and growth

Simulation results suggest that unilateral public transfers induce an important and permanent improvement on the rate of growth of the Portuguese GDP. GDP growth is shown to increase between .4 and .5 percentage points in the transitional period and by .5 in the steady state. The structural changes help to bring long term GDP growth in Portugal to 3.0% which is .4 percentage points above the average long run EC growth in the last two decades. In the absence of these structural changes the domestic GDP growth would fall short of the long term EC average growth by at least .1 percentage points thus accentuating the relative backwardness of the country vis–a–vis the EC.

The impact of structural funds on the different types of investment is equally substantial. Structural changes increase private investment between 1.0 and 1.5 percentage points of the GDP per year. The effect is even more substantial for public investment. Public investment increases between 3.9 and 4.4 percentage points of the GDP. The optimal levels for the private and public physical investment rate exceed 27.5 of GDP through the late 1990s. Finally, investment in human capital remains relatively stable as a share of GDP, reflecting an increase of about .5 percentage points in absolute value.

One important issue is the extent to which the EC structural programs may be crowding out programs that would otherwise be undertaken. The additionality and complementarity conditions of the structural funds grants are designed to ensure that funds are used in private and capital accumulation and not used, directly or indirectly, in consumption activities. However, the optimal response may lead to a reduction in the autonomous private and public investment, not related to structural funds programs. Accordingly, there is a possibility that EC funds will crowd out part of the domestic

investment as a mechanism to indirectly transfer some of the inflow of funds for immediate consumption activities. The greater the part of the structural inflow of funds channeled to investment activities, the greater the gains in economic growth.

Simulation results suggest that private investment shows a low degree of crowding out. Public contributions, from both the EC and the national authorities, represent a net increase in investment expenditure. However, for each Ecu of the targeted private contribution, only half corresponds to a net increase expenditure. In turn, public investment shows a complete absence of crowding out. This is directly related to the pure public good nature of public capital. Finally, investment in human capital shows a relatively high degree of crowding out. Each Ecu contributed into this investment category only induces an increase of .28 Ecu in expenditure. All things considered, it can be assumed that part of the success of the EC Structural Funds Programs in Portugal is due to the relative low degree of crowding out of domestic investment by EC funds.

3.2.2 Effects on the real convergence process

Unilateral structural funds provide a very important role in closing the gap between Portugal and the EC, i.e. in the catching–up process. Not only do they bring long run GDP growth in Portugal up to EC standards of growth, but they also generate, in the transitional period, growth rates substantially above the EC average. By the end of the transitional period, the level of GDP per capita in purchasing power standards will have been improved by more than 17 percentage points. This improvement can be measured in terms of the EC average assuming that the EC GDP grows at the long term rate of 2.6%. In the absence of structural funds Portugal would have improved its position slightly by the year 2006 from 55.4% to 57.0% of the EC average. With structural funds, the relative position by the year 2006 is 63.7% of the EC average. Structural funds bring forth an important and permanent contribution to the catching up process of the Portuguese economy to EC standards. However, it can also be said that even with the help of

structural funds, Portugal would, in the long run, still be very distant from EC standards.

Under the structural funds policy, the real exchange rate appreciates in the long run by 8.5 percentage points more than in the absence of these funds. This dampens the process of real convergence for the Portuguese economy. Accelerated real exchange rate appreciation reduces by about 10% the increase in the relative position of the Portuguese GDP per capita in terms of the EC standards.

3.2.3 Effects on public deficits

In the absence of structural funds, it would be optimal for Portugal to run moderate and declining public deficits throughout the 1990s. The EC Structural Funds Programs have led to an increase in the optimal deficits. Despite the acceleration in GDP growth, the structural changes induce an increase in the public deficit to GDP ratio. Public spending in the early 1990s increases by over 1 percentage point of the GDP.

This increase of public deficits with the structural funds programs is not surprising given the public co–financing requirements. In fact, public matching funds average 3.0% of the GDP. Of this 3%, only one third was translated into higher deficits. Through a simultaneous increase in tax revenues and a decrease in public consumption, it is possible to translate only 1% into higher deficits. Notice that we have assumed a constant average tax rate.

3.2.4 Effects on the foreign account

In the absence of financial integration and structural funds, it would be optimal for Portugal to pay off its foreign debt in a 10 year period. This reflects the relatively high cost of international funds vis–a–vis the domestic return on such funds. Note that optimal repayment of foreign debt is plausible given the high level of domestic reserves in gold and foreign currency (with a market value comparable to the nominal value in dollars of the foreign debt).

The effects of EC Structural Funds Programs relate to the transfer problem literature pioneered by Keynes (1929), Ohlin (1929), Metzler (1942), and developed more recently by Bhagwati, Brecher, and Hatta (1983), Bretcher and Bhagwati (1981) (1982), Chipman (1974), Jones (1970), and Samuelson (1971). The traditional result suggests that in the context of a Keynesian model, an international transfer necessarily reduces the current account deficit (increases the surplus) of the recipient economy. The transfer problem in this paper can be examined in the context of a full–fledged intertemporal general equilibrium model. In this framework, it is possible to determine the impact of the transfer on the balance of payments, as well as on private and public capital accumulation, public borrowing, and economic growth.

The most surprising simulation result is that the inflow of unilateral public transfers causes a decline in the optimal amount of foreign financing surplus (note that we have ignored the effects of financial integration). Recall that in this model foreign financing is equivalent to the current account deficit. Therefore, the decrease in the outflow of funds induced by structural transfers contradicts the traditional result of the transfer problem. The simulation results imply that the traditional Keynesian result cannot be generalized in the context of an intertemporal endogenous growth model of a capital importing economy.

There are several possible explanations for the reversal of this traditional result. First, the private and public domestic co–financing requirements associated with the unilateral transfers are very substantial, about 5.5% of the GDP. Of these co–financing requirements, about half, or 2.6% of the GDP, are in the form of purchases of traded goods. While the co–financing mechanisms certainly contribute to the reversal of the traditional result, they cannot explain the full reversal. Indeed, even if all the co–financing in the form of purchases of traded goods corresponded to increased imports, we should still witness an increase in the current account surplus (decrease of the deficit) of about 1% of the GDP. In fact, we observe a 1% decrease in the current account surplus.

A second explanation may be related to the intertemporal and endogenous growth

nature of our modeling. The traditional result was developed in a static framework, while this counter–example results from a fully intertemporal model. Dynamic effects may play a role. A great deal of funds are allocated to the improvement of infrastructures, involving externalities for private production. The marginal productivity of private capital is enhanced and this induces greater future investment. To the extent that part of the investment is in the form of imports, this may explain a decrease in the current account surplus (increase in the deficit) both currently and in the future. This conjecture is reinforced by the observation that the reversal of the traditional result is less likely when the inflow of structural funds is known to be discontinued at some point in the near future (see below).

The more structural funds, the more financing can be optimally accommodated by the domestic economy. In fact, structural funds improve the marginal productivity of domestic capital (return to domestic capital) and make investment in the Portuguese economy more profitable. With structural funds, investment in Portugal is more profitable because of better infrastructures and better qualified labor force. These improvements are at the very core of the objectives of the Regional Development Plan. As an externality and a source of increasing returns, more public capital leads to a real crowding in of private investment.

3.3 Effects of EC Structural Funds under Alternative Designs

As important as the structural funds policies may be, in the long run they still leave the Portuguese economy lagging substantially behind EC standards. This fact leads us to consider alternative scenarios for the future evolution of structural funds.

3.3.1 On the effects of different growth patterns and time horizons

Since the size of the current inflow of structural funds is not enough to bring the

Portuguese economy close to EC standards, we consider the marginal effects of changes in the annual rate of growth of EC transfers.

The marginal effects of different growth rates of structural funds transfers are depicted in Table 5. Different cases are considered for the rate of growth of structural funds. In the pessimistic case (Case 3), structural funds are assumed to grow at a yearly rate of 1.5%. In the optimistic case (Case 4), the growth rate of structural funds is set at 5.0%. In all three cases the values of the structural funds for the period 1989–93 follow the Regional Development Plan. Notice that even in the optimistic case, the rate of growth after 1993 is less than half the average rate of growth under the Regional Development Program for 1989–1993.

In the very short run, there are no differences in the marginal effects of structural funds on growth across the different cases. In fact, the same pattern of structural funds under the Regional Development Program is assumed in all three of the cases. After 1994, the increments in GDP growth are proportional to the increases in the rate of growth of structural funds. Also, the marginal impact of unilateral public transfers on the different types of investment is positive.

The marginal effect of increased growth of structural funds on public deficits through the 1990s is small and negative. The more the structural funds (and therefore, the greater the GDP growth) the lower are optimal deficits as a fraction of the GDP. This suggests that structural funds affect GDP growth more than the level of public deficit. In the presence of financial integration, and unlike the case when financial integration is absent, the lower marginal cost of funds and the optimal realignment of public expenditures and investment more than compensate for the increase in spending due to the complementarity and additionality provisions. In addition, the marginal effect of increased growth of structural funds on foreign financing is small but positive (less surplus). This reflects the fact that the economy is absorbing more of its own resources with the inflow of structural funds.

If the inflow of structural funds were to increase at 5% per year (Case 4), long term GDP growth would be increased by .6 percentage points and the relative position of the Portuguese GDP per capita would in the long run be 65.4% of the EC average as opposed to 63.7% in the central scenario. Most importantly, there is clearly a positive marginal effect of additional funds on the process of real convergence.

A related experiment is reported in Table 6. Here we consider the possibility of completely discontinuing the current programs by 1993 (Case 5) or prolonging the program for 1994–1998 (Case 6) or until 1999–2003 (Case 7). Our greatest concern is that the current program does not generate long term growth effects. Long term growth effects are only generated in Case 7. This suggests that, if a yearly growth rate of 3.4% were to be maintained, the continuation of EC programs until 2003 would be necessary to create long term effects in the GDP growth rates.

These two sets of experiments suggest that there is a clear need for sustained inflow of EC funds. A permanent inflow even at a relatively low rate of growth is important for the real convergence process. Also, an acceleration of the growth rate of structural funds transfers would have a positive marginal contribution to the real convergence process.

3.3.2 Timing effects of structural funds

Since a prolonged/quasi–permanent inflow of funds at a moderate yearly growth rate seems to be necessary to generate long term growth effects, one may ask if long term growth effects may be generated by a great acceleration of inflow of funds for a relatively short period. Given increasing returns to scale technology, concentrating the inflow of funds could possibly generate scale effects not achieved by smoothing out the inflow.

We analyze this point by comparing the results of increasing structural funds 10% per year for the period 1994–1998 and then discontinuing the programs (Case 8) with the results of keeping the inflow of funds at an annual rate of 3.4% for as long as necessary to yield the same inflow in present value (Case 9). (See Table 7 for details.) Even though the

two cases are very similar, there is a marginal benefit from spreading the inflow of funds throughout time as opposed to concentrating it into a few years. A smoother inflow of funds helps the process of real convergence: long run GDP per capita is marginally higher and so is the social welfare indicator under a smooth inflow of funds. In addition, the pressures from increased public deficits and short run real exchange rate appreciation are marginally reduced.

The marginal improvement from smoothing out the inflow of funds is determined by the fact that the scale benefits, in terms of the production technology from concentrating the inflow of funds, are dominated by the increase in adjustment costs induced by concentrating investment. Indeed, this must be the case for a well behaved (non–explosive) economy. The convexities in the production technology must be more than compensated by the convexity of the adjustment costs associated to the investment activities.

3.3.3 On the effects of the composition of structural funds

We have established the essential need for additional funds, and that the current level of structural funds is not sufficient to generate long term scale of growth effects. We have also discussed that concentrating the inflow of funds is not an answer to the need of creating greater scale and growth effects. Now, let us address the possibility of changing the composition, and matching fund requirements of the structural funds programs.

In Table 8 we consider the possibility that given the same volume of funds, no funds would be allocated to private capital formation (Case 10), or public capital formation (Case 11), or human capital formation (Case 12). In each case, the volume of funds for the remaining types of capital formation are adjusted to keep the volume of funds (including co–financing) fixed. This eliminates income effects and allows us to concentrate exclusively on allocation effects.

The single most striking feature of the results is the central role of investment in

infrastructures. When either of the other two types of investment are dropped, there is a clear improvement in the gains in GDP growth and the real convergence process induced by structural funds. For example, if aid to private investment is dropped, the long term gains in growth would be .6 percentage points compared to .5 in the central case. Also, due to increased GDP growth and increased real exchange rate appreciation, the long run position of the GDP per capita would be at 66.3% of the EC average as opposed to 63.4%.

An important aspect of this experiment is that despite the fact that there would be no EC aid to private investment, the increase in public capital formation would so much increase the marginal productivity of private capital that the share of private investment in the GDP would increase by between 2 and 3 percentage points of the GDP vis–a–vis the case of no structural funds, and by between .5 an 1 percentage points vis–s–vis the central scenario.

These improved conditions in investment and growth go hand in hand with the deterioration of long run policy trade offs. Indeed, concentrating on infrastructures would clearly increase public deficits by as much as 2.5 percentage points of the GDP, vis–a–vis the case without structural funds, and by as much as 1.5 percentage points of the GDP vis–a–vis the central case with structural funds. Also, the deterioration of the current account surplus and the appreciation of real exchange rate is much greater in the cases where greater emphasis is placed on infrastructures.

The increase of public deficits when the emphasis of structural funds is on infrastructures is hardly surprising since the co–financing requirements for this type of investment are virtually public only. Also, it is interesting to note that the reversal of the traditional transfer result does not occur, if EC aid to the development of infrastructures were abandoned in favor of increased aid to private and human capital formation. This confirms the central role of infrastructures as an externality and as a source of endogenous growth in the reversal of the traditional result, as argued above.

The same stories in terms of real convergence and long run policy trade offs could be

told from Table 9, although less dramatically. Here, the composition of EC flow of funds is maintained, but the co–financing requirements are eliminated for either private capital (Case 13), public capital (Case 14), or human capital (Case 15).

How can we explain the crucial role of EC aid to the development of infrastructures and the relatively less important role of aid to private and human capital? The key fact here is the pure public good nature of public capital. In the absence of government provision, public capital would be in short supply. Also, budgetary problems may keep public capital in short supply even with public provision. In this sense, EC funds fulfill a need for a certain type of investment which would otherwise be absent or in very short supply. In addition, EC funds for public investment, by their very nature, allow for a great degree of monitoring and therefore a low degree of crowding out of the existing investment plans. By contrast, aid to private investment is a pure private good supplied autonomously by the private sector given economic conditions are right. Therefore, it shows a greater degree of crowding out potential.

All of the above suggests that great gains can be achieved by merely changing the composition of structural funds with a still greater emphasis on infrastructures. In so doing, the process of real convergence would be greatly enhanced, whereas the long run policy trade offs associated with nominal convergence would deteriorate. Therefore, an ideal combination could be achieved by shifting composition in favor of infrastructures at the same time that the domestic co–financing requirements are lowered.

3.4 Sensitivity Analysis

This section provides sensitivity analysis with respect to different variables and parameters in the model. For the sake of brevity, only the effects of structural funds on GDP growth and investment are reported. Tables 10–12 report the effects of changes in critical initial values of stock variables, technological factors, and preference related

factors, respectively.

Naturally, different specifications of parameters and variables lead to different levels of GDP growth and long term GDP per capita in purchasing power standards (as well as optimal investment, public deficits, optimal foreign financing, and real exchange rates, which are not reported). For example, the greater the physical capital/output ratio assumed, the lower the net increase in the stock of capital implied by observed investment in the base year, and the lower GDP growth (see Table 10). As another example (see Table 11), the greater the public capital externality, the greater the marginal productivity of both private and public capital, and the greater the GDP growth.

Despite the differences in the levels of GDP growth and long term GDP per capita under the different parameter and variable specifications, the size and pattern of changes induced by the inflow of structural funds are remarkably robust. Increases in GDP growth range between .4 and .6 percentage points both in the transitional period and in the steady state for most of the experiments. Also, the gains in the long term GDP per capita in purchasing power standards range from .14 to .20 in most cases. The results reported in the previous sections are indeed central in terms of these ranges of results.

It is, of course, possible to find exceptions to these ranges. For example, if the physical capital/output ratio is very low (see again Table 10), observed investment is very high vis–a–vis the capital stock which induces a very high rate of GDP growth. This high inertia in GDP growth, reflecting a relatively high degree of investment activities, reduces the marginal gains from structural policies designed to promote investment. The same reasoning may be applied to the case of the public capital externality parameter in the production functions (see again Table 11). A higher externality parameter reflects a greater inertia for growth, and naturally, a lower marginal contribution of structural policies. Notice however, the central case simulations by design are the only ones that bear a close resemblance to the actual data for the Portuguese economy. These more extreme cases should be dismissed on the grounds of a lack of descriptive realism.

4. Summary and Concluding Remarks

The purpose of this paper is to develop a methodology for studying the impact of EC unilateral public transfers on investment and the growth path of the EC capital importing countries. In addition to evaluating the effects of the current structural policies, the paper addresses the merits of different changes in the design of future structural transfers. At the same time, this paper seeks to identify the impact of structural transfers on the twin deficits, public and foreign, and on the main policy options faced by the national economic authorities.

This paper develops a two sector optimal growth model for a capital importing economy building upon the recent endogenous growth literature. This model is intended to determine the optimal accumulation of private, public, and human capital. In the determination of the optimal path for the economy the behavior of the twin balances – the public sector deficit and the current account deficit – and their stock counterparts – public debt and foreign debt – play a crucial role. This approach reconciles basic features of the recent economic growth literature with a realistic representation of the EC Structural Funds transfers to the less developed EC capital importing economies.

This optimal growth model is implemented numerically for simulation purposes with a detailed data and parameter set for the Portuguese economy. Structural funds induce a substantial and permanent increase in GDP growth and investment, averaging .5 percentage points in both the steady state and the transitional period. Accordingly, structural funds contribute markedly for the real convergence of the Portuguese economy to EC standards. However, the relative long run position of the Portuguese economy would be at 64% of the EC average, and therefore still far from EC standards.

From the standpoint of the process of real convergence, there is a clear need for a sustained inflow of EC structural funds. In fact, marginal increases in the rate of growth of funds generate positive effects in terms of the process of real convergence. Future flow of

funds should follow a smooth time path as this is preferable to a major increase for a short period of time. Finally, there would be great benefits in terms of real convergence from concentrating future EC structural funds on programs designed to develop infrastructures.

Structural funds induce increases in the public deficit, current account deficit, and an acceleration of real exchange rate appreciation. These changes have an adverse impact on the process of nominal convergence, and create adverse conditions for policy making in the long run. Then, there is a conflict between the long run real convergence benefits of structural funds and the long run requirements of nominal convergence associated with the process of formation of the Economic and Monetary Union as detailed in the agreements established in 1991 in Maasterich.

The inflow of structural funds leads to an increase in public deficits through the co–financing mechanisms. From a policy oriented perspective, increases in public deficits are hardly good news. Given the policy concerns over nominal convergence, any developments contrary to budgetary restraint may generate unwelcome additional inflationary pressures.

The traditional result of the transfer literature does not generally hold for the Portuguese case in the context of our intertemporal endogenous growth model. In fact, the inflow of structural funds leads in the transition period to an increase in the current account deficit. This may create additional problems to the extent that increased deficits translate into greater long term foreign debt. However, it also means that some of the positive effects from the structural transfers spillover to the EC partners of Portugal, its most important trade partners.

The inflow of structural funds accelerates real exchange rate appreciation. This dampens the process of real convergence of the Portuguese economy. In addition, for the same nominal exchange rate, real appreciation induces an increase in inflation. This leads to the need to control of nominal exchange rates or a tight grip on inflation. Furthermore, in the transition period to the Economic and Monetary Union structural funds may have an

adverse impact on the process of nominal convergence, create adverse conditions for policy making, and exacerbate the need for budgetary restraint.

The methodology presented in this paper could be developed in a number of directions to better accommodate the effects on the capital importing EC economies of financial integration and unilateral transfers. First, it would be important to further disaggregate the model to allow for a detailed analysis of the sectorial impact of the structural funds policies. At the same time, the model would be specified in a decentralized faction which would directly allow the discussion of the effects of structural policies on the relative prices and incentives in the different domestic markets.

Second, the model could be extended to consider international labor flows within the EC. As a result of the European Single Market Act, the EC labor market will soon be fully integrated. Some of the capital importing EC countries, in particular Greece, Portugal, and Spain, have also been labor exporting countries in the EC. Artificial barriers have prevented, in the last decades, further emigration from these Southern EC countries. The liberalization of labor force movements leaves the Northern EC labor markets wide open to further inflows from these Southern EC countries. The consideration of the possibility of international labor flows would allow the study of the relationship between international movements of capital and labor (see for example, Markusen (1983), Wong (1983) and (1986)) and the impact of labor mobility on the effects of structural funds, and vice–versa.

Among the objectives of the European Single Act is the unification of EC's financial markets. Financial integration is expected to affect the amount of market induced international capital flows into the capital importing EC economies. Integration of financial markets is expected to influence the capital importing countries by decreasing their cost of financing obtained through the decline of the idiosyncratic risk premium component on the return that must be paid to foreign lenders or investors. Accordingly, the ability of these economies to access the international financial markets is improved.

The model could be extended to consider the marginal benefits of structural funds in

the present of increasing financial integration. The relative abundance of financial funds made possible by financial integration may dampen the effects of structural funds. This is true in particular in what concerns private capital formation. In fact, well functioning domestic credit markets integrated in the EC financial world may neutralize the need for funds for private capital formation. In addition, the presence of financial integration may affect the policy trade offs generated by structural policies in that it may change the effects of structural funds on the public budget, foreign account, and the real exchange rate.

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Balance of Payments Account		
	trade and service balance	−211
	factor income transfer	−331
R	private unilateral transfers	656
	current account balance	114
Public Sector Account		
	tax revenues	2,162
PC	public consumption	873
PI	public investment	187
HI	public investmt in human capital	229
PT	public transfers	807
	interest payments on public debt	488
	public balance	−422
National Account		
	total GDP	6,021
YT	GDP tradables	2,529
YNT	GDP non tradables	3,492
	total private consumption	3,871
CT	private cons. of tradables	2,089
CNT	private cons. of non−tradables	1,782
	total private investment	1,036
IT	investment in tradable sector	539
INT	investment in non−tradable sector	497
PC	public consumption	873
PI	public investment	187
	current spending in human capital	265
HI	investment in human capital	434
Stock Variables		
	total private capital stock	12,950(*)
KT	capital stock in tradables	6,734(*)
KNT	capital stock in non−tradables	6,216(*)
PK	public capital stock	4,165(*)
HK	human capital stock	7,220(*)
L	labor force (million)	4.460
LT	labor force in tradable (million)	2.319(*)
LNT	labor force in nontradable	2.141(*)
F	foreign debt and equity	6,268
PD	public debt	4,678

Units: Million of 1989 escudos, unless indicated otherwise
Sources: See text.
(*) Sensitivity analysis is provided with respect to these variable values.

Household Parameters

ρ	subjective discount rate	.960(*)
	population growth rate	.008
α_T	CES share of tradables	.440(*)
α_{NT}	CES share of non–tradables	.560(*)
σ	CES elast. of substitution	.250(*)
α	CD share of private cons. of NT	.671(*)
	CD size parameter	1.885
t_y	effective tax rate on expenditure	.372

Production Parameters

β_{0T}	scaling factor in tradables	.108
β_{0NT}	scaling factor in non–tradables	.160
β_T	cap. expend. share in tradables	.550(*)
β_{NT}	cap. expend. share in n–tradables	.550(*)
ν_T	pub. cap. extern. for tradables	.100(*)
ν_{NT}	pub. cap. extern. for n–tradables	.100(*)
δ_{kT}	cap. deprec. in tradables	.060(*)
δ_{kNT}	cap. deprec. in non–tradables	.060(*)
δ_{pk}	public capital depreciation rate	.015(*)
δ_{hk}	human capital depreciation rate	.030(*)
μ_{iT}	adjustment cost parameter – trad	.802(*)
μ_{iNT}	adjustment cost parameter – ntrad	.799(*)
μ_{Pi}	public adjustment cost parameter	.221(*)
μ_{hi}	human adjustment cost parameter	.242(*)

Other Parameters

r	interest rate on foreign loans	.085(*)
	growth rate of foreign transfers	.008
	growth rate of public transfers	.008

Sources: See text.
(*) Sensitivity analysis is provided with respect to these parameters

Table 5
Actual data versus simulated results

	Actual	Simulated
GDP Growth (%)		
average 1986–89	4.4	4.2
GDP per capita (1990=100.0)		
1986	84.5	84.7
Private Investment/GDP (%)		
average 1986–89	23.4	24.5
Public Investment/GDP (%)		
average 1986–89	4.3	4.0
Human Capital Investment/GDP (%)		
average 1986–89	7.2	7.0
Public Deficit/GDP (%)		
average 1986–89	6.7	6.4
Foreign Financing/GDP (%)		
average 1986–89	4.2	4.5
Real Exchange Rate (1990=100.0)		
1986	82.5	81.4

Sources: 1986–1989, European Economy 42, Commission of the European Communities.

Remarks:

1/ Foreign Financing is the balance of non–monetary operations.

2/ Real Exchange Rate is obtained from the deflators of GDP and exports adjusting for the composition of GDP between tradables nd non–tradables.

Table 4
Effects of structural funds

	Case 1	Case 2
Welfare	100.00	109.9
GDP Growth (%)		
1990	3.0	3.4
1994	3.0	3.5
1998	3.0	3.4
2002	2.9	3.3
2006	2.5	3.0
GDP per capita (1990=100.0)		
1990	100.0	100.0
1994	114.5	118.9
1998	129.4	138.1
2002	144.6	157.4
2006	160.0	177.2
Private Investment/GDP (%)		
1990	20.8	22.3
1994	21.3	22.7
1998	21.0	22.2
2002	19.7	20.8
2006	17.1	17.9
Public Investment/GDP (%)		
1990	1.3	4.2
1994	1.7	5.6
1998	1.8	5.5
2002	1.7	5.5
2006	1.1	5.5
Human Capital Investment/GDP (%)		
1990	7.7	7.6
1994	7.9	7.9
1998	7.9	7.8
2002	7.7	7.6
2006	7.4	7.3

Table 4 (continued)
Effects of structural funds

	Case 1	Case 2
Public Deficit/GDP (%)		
1990	4.4	5.6
1994	3.9	5.0
1998	2.9	3.4
2002	1.6	1.8
2006	0.0	0.3
Foreign Financing/GDP (%)		
1990	-7.1	-6.0
1994	-4.0	-3.0
1998	-1.9	-1.0
2002	-0.3	0.4
2006	0.8	1.2
Real Exchange Rate (1990=100.0)		
1990	100.0	100.0
1994	112.1	116.8
1998	120.3	127.4
2002	126.2	134.2
2006	131.6	140.1

Remarks:

Case 1: no structural funds
Case 2: structural funds - central scenario

Table 5
Effects of structural funds: different growth patterns

	Case 1	Case 3	Case 2	Case 4
Welfare	100.0	106.3	109.9	110.4
GDP Growth (%)				
1990	3.0	3.3	3.4	3.4
1994	3.0	3.4	3.5	3.5
1998	3.0	3.4	3.4	3.5
2002	2.9	3.2	3.3	3.4
2006	2.5	2.8	3.0	3.1
GDP per capita (1990=100.0)				
1990	100.0	100.0	100.0	100.0
1994	114.5	118.3	118.9	119.6
1998	129.4	136.6	138.1	139.7
2002	144.6	154.8	157.4	160.2
2006	160.0	173.3	177.2	181.8
Private Investment/GDP (%)				
1990	20.8	21.8	22.3	22.7
1994	21.3	22.4	22.7	23.1
1998	21.0	21.8	22.2	22.6
2002	19.7	20.6	20.8	21.1
2006	17.1	17.7	17.9	18.1
Public Investment/GDP (%)				
1990	1.3	4.2	4.2	4.2
1994	1.7	5.1	5.6	6.1
1998	1.8	4.7	5.5	6.3
2002	1.7	4.4	5.5	6.6
2006	1.1	4.1	5.5	7.0
Human Capital Investment/GDP (%)				
1990	7.7	7.6	7.6	7.6
1994	7.9	7.9	7.9	7.9
1998	7.9	7.8	7.8	7.8
2002	7.7	7.6	7.6	7.6
2006	7.4	7.3	7.3	7.3

Table 5 (continued)
Effects of structural funds: different growth patterns

	Case 1	Case 3	Case 2	Case 4
Public Deficit/GDP (%)				
1990	4.4	5.8	5.6	5.5
1994	3.9	5.0	5.0	4.9
1998	2.9	3.4	3.4	3.3
2002	1.6	1.7	1.8	1.8
2006	0.0	0.2	0.3	0.5
Foreign Financing/GDP (%)				
1990	-7.1	-6.4	-6.0	-5.6
1994	-4.0	-3.5	-3.0	-2.7
1998	-1.9	-1.4	-1.0	-0.7
2002	-0.3	0.0	0.4	0.6
2006	0.8	1.0	1.2	1.3
Real Exchange Rate (1990=100.0)				
1990	100.0	100.0	100.0	100.0
1994	112.1	116.2	116.8	117.6
1998	120.3	126.0	127.4	129.0
2002	126.2	132.4	134.2	136.6
2006	131.6	137.7	140.1	143.5

Remarks:
- Case 1: no structural funds
- Case 3: structural funds - low growth (annual growth of 1.5%)
- Case 2: structural funds - moderate growth (annual growth of 3.4%)
- Case 4: structural funds - high growth (annual growth of 5%)

Table 6
Effects of structural funds: different time horizons

	Case 1	Case 5	Case 6	Case 7
Welfare	100.0	102.5	105.4	108.0
GDP Growth (%)				
1990	3.0	3.1	3.2	3.2
1994	3.0	3.0	3.3	3.4
1998	3.0	3.0	3.2	3.3
2002	2.9	2.9	2.9	3.1
2006	2.5	2.5	2.5	2.6
GDP per capita (1990=100.0)				
1990	100.0	100.0	100.0	100.0
1994	114.5	116.1	117.0	147.7
1998	129.4	131.3	133.7	135.4
2002	144.6	146.6	149.2	152.8
2006	160.0	161.8	165.1	169.2
Private Investment/GDP (%)				
1990	20.8	20.8	21.2	21.5
1994	21.3	21.9	21.4	21.9
1998	21.0	21.1	20.4	21.2
2002	19.7	19.5	19.7	19.2
2006	17.1	16.1	16.9	18.1
Public Investment/GDP (%)				
1990	1.3	4.2	4.2	4.2
1994	1.7	1.0	5.6	5.5
1998	1.8	1.3	5.5	5.5
2002	1.7	1.2	7.7	5.5
2006	1.1	0.6	0.4	0.0
Human Capital Investment/GDP (%)				
1990	7.7	7.6	7.6	7.6
1994	7.9	7.8	7.9	7.9
1998	7.9	7.8	7.7	7.8
2002	7.7	7.6	7.6	7.5
2006	7.4	7.4	7.4	7.3

Table 6 (continued)
Effects of structural funds: different time horizons

	Case 1	Case 5	Case 6	Case 7
Public Deficit/GDP (%)				
1990	4.4	6.0	6.0	5.9
1994	3.9	3.4	5.8	5.5
1998	2.9	2.4	4.9	4.3
2002	1.6	1.1	1.1	3.3
2006	0.0	-0.6	-0.5	-0.9
Foreign Financing/GDP (%)				
1990	-7.1	-8.3	-7.8	-7.1
1994	-4.0	-3.8	-5.8	-4.7
1998	-1.9	-1.7	-5.0	-3.3
2002	-0.3	0.0	-1.4	-2.9
2006	0.8	0.8	0.0	1.2
Real Exchange Rate (1990=100.0)				
1990	100.0	100.0	100.0	100.0
1994	112.1	113.4	114.4	115.4
1998	120.3	121.7	122.9	124.7
2002	126.2	127.9	128.4	130.5
2006	131.6	133.9	134.5	135.6

Remarks:
Case 1: no structural funds
Case 5: structural funds in the period 1989-1993
Case 6: structural funds in the period 1989-1998
Case 7: structural funds in the period 1989-2003

Table 8
Effects of structural funds: different composition

	Case 2	Case 10	Case 11	Case 12
Welfare	109.9	112.6	106.1	106.1
GDP Growth (%)				
1990	3.4	3.6	3.1	3.6
1994	3.5	3.7	3.1	3.7
1998	3.4	3.6	3.1	3.6
2002	3.3	3.4	2.9	3.4
2006	3.0	3.1	2.6	3.0
GDP per capita (1990=100.0)				
1990	100.0	100.0	100.0	100.0
1994	118.9	120.2	118.2	120.0
1998	138.1	140.9	136.8	140.5
2002	157.4	162.0	155.9	161.4
2006	177.2	184.8	167.2	182.8
Private Investment/GDP (%)				
1990	22.3	23.3	22.3	24.1
1994	22.7	23.5	22.6	24.1
1998	22.2	22.8	21.7	23.4
2002	20.8	21.2	19.8	21.8
2006	17.9	18.1	17.3	18.6
Public Investment/GDP (%)				
1990	4.2	6.6	0.8	5.3
1994	5.6	8.7	1.4	7.1
1998	5.5	8.4	1.6	6.9
2002	5.5	8.3	1.5	6.8
2006	5.5	8.2	1.1	-6.7
Human Capital Investment/GDP (%)				
1990	7.6	7.7	7.6	7.7
1994	7.9	7.9	8.0	7.9
1998	7.8	7.7	8.1	7.7
2002	7.6	7.5	7.9	7.5
2006	7.3	7.2	7.8	7.1

Table 8 (continued)
Effects of structural funds: different composition

	Case 2	Case 10	Case 11	Case 12
Public Deficit/GDP (%)				
1990	5.6	6.9	5.3	6.1
1994	5.0	6.6	5.0	5.6
1998	3.4	4.9	3.8	3.9
2002	1.8	3.4	2.5	2.2
2006	0.3	1.9	0.8	0.6
Foreign Financing/GDP (%)				
1990	-6.0	-5.6	-7.5	-5.1
1994	-3.0	-2.4	-5.2	-2.3
1998	-1.0	-0.6	-3.2	-0.5
2002	0.4	0.5	-1.9	0.7
2006	1.2	1.0	-1.2	1.2
Real Exchange Rate (1990=100.0)				
1990	100.0	100.0	100.0	100.0
1994	116.8	117.1	118.0	116.7
1998	127.4	128.0	130.6	127.3
2002	134.2	135.4	140.9	134.6
2006	140.1	143.1	143.4	141.0

Remarks:

Case 2: structural funds - central scenario
Case 10: structural funds - no funds for private capital formation
Case 11: structural funds - no funds for infrastructure development
Case 12: structural funds - no funds for human capital formation

Table 9
Effects of structural funds: different funding requirements

	Case 2	Case 13	Case 14	Case 15
Welfare	109.9	112.9	110.3	110.0
GDP Growth (%)				
1990	3.4	3.4	3.1	3.5
1994	3.5	3.5	3.2	3.6
1998	3.4	3.5	3.2	3.5
2002	3.3	3.2	3.0	3.4
2006	3.0	2.5	2.6	3.0
GDP per capita (1990=100.0)				
1990	100.0	100.0	100.0	100.0
1994	118.9	119.0	117.9	119.8
1998	138.1	138.9	136.0	140.0
2002	157.4	160.5	154.4	160.5
2006	177.2	189.2	174.1	181.7
Private Investment/GDP (%)				
1990	22.3	22.5	21.6	23.6
1994	22.7	22.5	22.2	23.8
1998	22.2	21.5	21.5	23.1
2002	20.8	19.2	19.5	21.5
2006	17.9	14.0	16.4	18.4
Public Investment/GDP (%)				
1990	4.2	6.1	1.9	4.7
1994	5.6	8.2	2.6	6.2
1998	5.5	8.0	2.5	6.1
2002	5.5	7.9	2.5	6.0
2006	5.5	7.8	2.5	6.0
Human Capital Investment/GDP (%)				
1990	7.6	7.7	7.6	7.6
1994	7.9	7.9	8.0	7.9
1998	7.8	7.8	8.0	7.8
2002	7.6	7.6	7.8	7.5
2006	7.3	7.6	7.6	7.2

Table 9 (continued)
Effects of structural funds: different funding requirements

	Case 2	Case 13	Case 14	Case 15
Public Deficit/GDP (%)				
1990	5.6	7.3	5.2	6.0
1994	5.0	7.6	4.6	5.5
1998	3.4	6.4	3.2	3.8
2002	1.8	5.4	1.8	2.1
2006	0.3	4.2	0.6	0.5
Foreign Financing/GDP (%)				
1990	-6.0	-6.7	-7.3	-5.5
1994	-3.0	-4.1	-4.9	-2.6
1998	-1.0	-2.8	-3.1	-0.7
2002	0.4	-2.1	-1.9	0.5
2006	1.2	-2.0	-1.2	1.2
Real Exchange Rate (1990=100.0)				
1990	100.0	100.0	100.0	100.0
1994	116.8	116.0	117.1	117.0
1998	127.4	127.1	128.5	127.9
2002	134.2	137.2	137.0	135.3
2006	140.1	155.4	146.2	141.9

Remarks:

Case 2: structural funds - central scenario
Case 13: structural funds - no co-financing for private capital formation
Case 14: structural funds - no co-financing for infrastructure development
Case 15: structural funds - no co-financing for human capital formation

Table 10
Sensitivity analysis: initial values of stock variables

	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
(K+PK)/GDP	2.40		2.90		3.40	
GDP Growth (%)						
1990	4.2	4.5	3.0	3.4	2.0	2.6
1994	3.9	4.2	3.0	3.5	2.4	3.0
1998	3.6	3.9	3.0	3.4	2.6	3.1
2002	3.3	3.6	2.9	3.3	2.7	3.1
2006	2.8	3.2	2.5	3.0	2.2	2.8
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	121.8	125.6	114.5	118.9	112.8	117.7
1998	141.7	149.3	129.4	138.1	127.2	137.7
2002	160.4	171.3	144.6	157.4	142.4	159.5
2006	178.3	192.9	160.0	177.2	157.6	173.8
KT/KNT	1.0		1.25		1.5	
GDP Growth (%)						
1990	2.9	3.3	3.0	3.4	3.2	3.7
1994	3.0	3.4	3.0	3.5	3.2	3.7
1998	3.0	3.4	3.0	3.4	3.1	3.6
2002	2.8	3.3	2.9	3.3	3.0	3.4
2006	2.5	2.9	2.5	3.0	2.6	3.1
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	113.2	117.5	114.5	118.9	119.1	124.2
1998	126.9	135.2	129.4	138.1	138.5	149.6
2002	141.1	153.1	144.6	157.4	157.7	175.1
2006	155.6	171.6	160.0	177.2	176.8	201.7
K/PK	2.5		3.0		3.5	
GDP Growth (%)						
1990	3.5	4.0	3.0	3.4	2.5	2.8
1994	3.4	3.9	3.0	3.5	2.8	3.3
1998	3.2	3.6	3.0	3.4	2.9	3.4
2002	3.0	3.4	2.9	3.3	2.9	3.3
2006	2.6	3.0	2.5	3.0	2.6	3.0
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	118.7	123.3	114.5	118.9	114.2	118.8
1998	136.4	145.6	129.4	138.1	129.8	139.6
2002	153.6	166.8	144.6	157.4	146.4	161.5
2006	170.3	187.9	160.0	177.2	164.1	174.9

Table 10 (continued)
Sensitivity analysis: initial values of stock variables

	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
K/HK	**1.3**		**1.8**		**2.3**	
GDP Growth (%)						
1990	2.6	3.1	3.0	3.4	4.5	4.6
1994	2.7	3.2	3.0	3.5	4.9	5.1
1998	2.7	3.1	3.0	3.4	5.0	5.2
2002	2.6	3.0	2.9	3.3	4.9	5.1
2006	2.2	2.6	2.5	3.0	4.6	4.8
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	112.8	117.7	114.5	118.9	125.2	127.8
1998	125.9	135.7	129.4	138.1	152.0	157.2
2002	139.3	153.9	144.6	157.4	180.2	188.1
2006	153.0	172.7	160.0	177.2	210.6	221.5
LT/LNT	**1.0**		**1.1**		**1.2**	
GDP Growth (%)						
1990	3.0	3.3	3.0	3.4	3.0	3.4
1994	3.0	3.5	3.0	3.5	3.0	3.5
1998	3.0	3.4	3.0	3.4	3.0	3.4
2002	2.9	3.3	2.9	3.3	2.9	3.3
2006	2.5	2.9	2.5	3.0	2.5	2.9
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	114.5	114.6	114.5	118.9	114.5	118.9
1998	129.4	130.9	129.4	138.1	129.4	138.1
2002	144.6	148.0	144.6	157.4	144.5	157.4
2006	160.0	164.8	160.0	177.2	159.8	177.1

Table 11
Sensitivity analysis: technological factors

	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
β(trad,ntrad)	.50,.50			.55,.55		.60,.60
GDP Growth (%)						
1990	2.2	2.6	3.0	3.4	3.6	4.1
1994	2.6	3.0	3.0	3.5	3.5	3.9
1998	2.8	3.2	3.0	3.4	3.3	3.7
2002	2.8	3.1	2.9	3.3	3.0	3.4
2006	2.5	2.8	2.5	3.0	2.5	3.0
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	113.6	118.5	114.5	118.9	116.2	119.9
1998	128.4	138.2	129.4	138.1	132.1	139.5
2002	144.1	159.1	144.6	157.4	147.7	158.5
2006	160.9	182.8	160.0	177.2	162.6	177.1
β(trad,ntrad)	.60,.50			.55,.55		.50,.60
GDP Growth (%)						
1990	2.8	3.1	3.0	3.4	3.0	3.5
1994	2.9	3.2	3.0	3.5	3.2	3.7
1998	2.9	3.3	3.0	3.4	3.2	3.6
2002	2.8	3.2	2.9	3.3	3.0	3.4
2006	2.4	2.9	2.5	3.0	2.6	3.1
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	109.2	113.2	114.5	118.9	118.5	123.2
1998	120.1	127.6	129.4	138.1	137.3	147.5
2002	131.9	142.7	144.6	157.4	155.9	172.0
2006	144.1	158.5	160.0	177.2	174.7	197.9
ν(trad,ntrad)	.05,.05			.10,.10		.15,.15
GDP Growth (%)						
1990	2.7	3.3	3.0	3.4	3.3	3.4
1994	2.8	3.3	3.0	3.5	3.4	3.6
1998	2.8	3.3	3.0	3.4	3.4	3.6
2002	2.7	3.1	2.9	3.3	3.2	3.5
2006	2.4	2.8	2.5	3.0	2.8	3.2
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	114.0	118.5	114.5	118.9	116.2	119.4
1998	128.2	137.1	129.4	138.1	132.6	139.2
2002	142.9	155.9	144.6	157.4	149.3	159.1
2006	158.0	175.2	160.0	177.2	165.9	179.5

Table 11 (continued)
Sensitivity analysis: technological factors

	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
ν(trad,ntrad)	.05,.15			.10,.10		.15,.05
GDP Growth (%)						
1990	2.9	3.3	3.0	3.4	2.8	3.3
1994	3.1	3.5	3.0	3.5	3.0	3.4
1998	3.1	3.5	3.0	3.4	3.0	3.4
2002	2.9	3.3	2.9	3.3	2.8	3.2
2006	2.6	3.0	2.5	3.0	2.5	2.9
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	114.6	118.3	114.5	118.9	114.2	119.6
1998	129.6	136.7	129.4	138.1	128.8	139.6
2002	144.7	155.2	144.6	157.4	143.9	159.6
2006	160.0	174.3	160.0	177.2	159.0	180.2
adj cost/inv	.08		.10		.12	
GDP Growth (%)						
1990	3.1	3.5	3.0	3.4	2.7	3.1
1994	3.1	3.6	3.0	3.5	2.9	3.3
1998	3.1	3.5	3.0	3.4	2.9	3.3
2002	2.9	3.3	2.9	3.3	2.8	3.2
2006	2.6	3.0	2.5	3.0	2.5	2.9
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	115.8	120.5	114.5	118.9	113.4	117.6
1998	131.1	140.2	129.4	138.1	127.6	136.1
2002	146.4	159.3	144.6	157.4	142.5	155.4
2006	161.9	178.6	160.0	177.2	157.8	175.5
δ of KT, KN	.055		.06		.065	
GDP Growth (%)						
1990	3.1	3.5	3.0	3.4	2.6	3.1
1994	3.2	3.6	3.0	3.5	2.9	3.3
1998	3.1	3.5	3.0	3.4	2.9	3.4
2002	2.9	3.3	2.9	3.3	2.8	3.3
2006	2.5	3.0	2.5	3.0	2.5	3.0
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	115.5	119.6	114.5	118.9	113.7	118.2
1998	131.0	139.3	129.4	138.1	128.0	137.0
2002	146.6	158.8	144.6	157.4	142.8	156.0
2006	162.2	178.7	160.0	177.2	157.8	175.8

Table 12
Sensitivity analysis: preference – related factors

	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
ρ	.95		.96		.97	
GDP Growth (%)						
1990	2.7	3.2	3.0	3.4	3.0	3.4
1994	2.9	3.4	3.0	3.5	3.2	3.6
1998	2.9	3.4	3.0	3.4	3.2	3.5
2002	2.8	3.2	2.9	3.3	3.1	3.4
2006	2.4	2.9	2.5	3.0	2.6	3.0
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	115.2	120.0	114.5	118.9	114.3	118.2
1998	125.4	138.9	129.4	138.1	130.2	137.8
2002	142.8	156.5	144.6	157.4	147.3	158.7
2006	155.2	173.4	160.0	177.2	164.8	180.7
α	.40		.44		.48	
GDP Growth (%)						
1990	3.0	3.3	3.0	3.4	2.8	3.3
1994	3.1	3.5	3.0	3.5	2.9	3.4
1998	3.1	3.5	3.0	3.4	2.9	3.4
2002	2.9	3.3	2.9	3.3	2.8	3.2
2006	2.5	3.0	2.5	3.0	2.5	2.9
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	117.8	122.1	114.5	118.9	111.4	116.1
1998	135.7	144.3	129.4	138.1	123.9	132.6
2002	153.2	166.2	144.6	157.4	137.1	149.5
2006	170.7	188.4	160.0	177.2	150.6	167.3
σ	.80		.90		1.00	
GDP Growth (%)						
1990	2.8	3.3	3.0	3.4	2.9	3.3
1994	3.0	3.5	3.0	3.5	3.0	3.5
1998	3.0	3.4	3.0	3.4	3.0	3.4
2002	2.9	3.3	2.9	3.3	2.9	3.3
2006	2.5	2.9	2.5	3.0	2.5	3.0
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	113.4	118.0	114.5	118.9	115.2	119.5
1998	127.5	136.4	129.4	138.1	130.7	139.2
2002	142.0	155.0	144.6	157.4	146.4	159.0
2006	156.8	174.1	160.0	177.2	162.1	179.3

Table 12 (continued)
Sensitivity analysis: preference – related factors

	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
r	.080		.085		.090	
GDP Growth (%)						
1990	3.0	3.4	3.0	3.4	2.7	3.2
1994	3.1	3.5	3.0	3.5	2.9	3.4
1998	3.1	3.4	3.0	3.4	3.0	3.4
2002	2.9	3.3	2.9	3.3	2.9	3.3
2006	2.5	2.9	2.5	3.0	2.5	3.0
GDP per capita (1990=100.0)						
1990	100.0	100.0	100.0	100.0	100.0	100.0
1994	115.8	119.7	114.5	118.9	113.5	118.1
1998	130.9	138.9	129.4	138.1	128.3	137.2
2002	145.5	157.3	144.6	157.4	144.1	157.5
2006	159.6	175.4	160.0	177.2	160.4	179.5