February 2003
Preliminary, not for quotation

MACROECONOMIC ADJUSTMENT TO STRUCTURAL CHANGE [(*)]

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Abstract

In this paper we address the issue of macroeconomic adjustment to structural change for a small open economy catching up in the EU. The issue is particularly important for the EU new Member States. In fact, successful integration will mean, for these countries, that both nominal convergence (macroeconomic adjustment) and real convergence (structural change) will occur simultaneously and synergistically. We use a dynamic general equilibrium model with two sectors producing traded and non-traded goods. We consider an overlapping generation set-up and stickiness in wages and the price of non-traded goods. We focus on both the transitional and long-term effects of structural changes on the allocation of resources and ultimately on path of the real exchange rate. We consider a package of stylised structural changes, which include changes in total factor productivity in the traded goods sector, financial integration, and structural transfers. We show that this package generates a set of long-term effects and macroeconomic adjustments, in particular on the real exchange rate, which differ in important respects from the standard static Balassa-Samuelson type of effects. In particular, we find a sizeable front-loading of the effects due to wealth effects on consumption and labour supply. We then show that the presence of price and wage stickiness is crucial for the timing of macroeconomic adjustment to the structural changes. Finally, we show that a switch from a regime of fixed exchange rates to a regime of nominal exchange rate floating with the objective ensuring domestic price stability does not materially change the macroeconomic adjustment to structural change. We interpret this finding as illustrating the absence of a tradeoff between nominal convergence and real convergence.

Keywords: Macroeconomic adjustment, structural changes, nominal rigidity, exchange rate regimes.

JEL Classification: E60, F40, F43, O11, O24, and O41.

(*) This paper was prepared for presentation in the Conference organised by the National Bank of Hungary on "Monetary Strategies for Accession Countries" to be held in Budapest on February 27-28, 2003. The views expressed in this article are those of authors and do not necessarily reflect those of the institutions to which they are affiliated.

MACROECONOMIC ADJUSTMENT TO STRUCTURAL CHANGE

1. Introduction

Ten countries - Cyprus, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia - were accepted to become new members of the European Union on 1 May 2004. The historical agreement on EU enlargement was reached at the European Council, held in Copenhagen, on 12-13 December 2002. The Accession Treaty will be signed, in Athens, on 16 April 2003. Subsequently, the 10 accession countries and the 15 current members of the will ratify the Treaty. From 1 May 2004 on, the new members will be "Member States with a derogation" in the sense of article 122, paragraph 1, of the European Union Treaty.

According to the *acquis communautaire*, price stability should be the primary goal of monetary policy, in all Member States. Article 4 of the Treaty establishing the European Community, stipulates that, when conducting their economic policies, the Member States and the Community must follow the guiding principles of "stable prices, sound public finances and monetary conditions and a sustainable balance of payments". Gradual and sustainable disinflation towards low and stable inflation, as in the euro area, is normally referred to as nominal convergence. Such process of nominal convergence is accompanied by a downward adjustment in nominal long-term interest rates, to levels approaching those prevailing in the euro area, reflecting both declining inflation expectations and a diminution of risk premiums. Moreover, the new Member States will become, eventually, and in accordance with the timetables and procedures in the Treaty, members of the euro area.

All of these ten countries have GDP per capita well below the EU average. Specifically, they range from 30 per cent (Latvia) to 88 per cent (Cyprus), of the EU average, in terms of GDP per capita, valued in terms of purchasing power parity standards. Successful integration of the new entrants into the EU will be associated with a catching up process, defined as convergence in the levels of output per capita and productivity, reflecting a number of structural changes.

In the summary of the ECB Seminar on the Accession Process, held in Helsinki, in 12 November 1999, one of the key points underlined was that "nominal and real convergence should be pursued in parallel. By modifying their economic structures in line with those prevailing within the EU and by implementing appropriate structural reforms, accession countries will speed up the process of "catching up", whereby their living standards will progressively evolve towards levels closer to those of the EU (real convergence). Historical experience shows that this process should go hand in hand with the achievement and maintenance of price stability and sound public finances (nominal convergence). Progress towards fulfilling the Maastricht criteria as a condition for adoption of the euro is therefore fully compatible with structural reform."

The desired parallelism between nominal convergence and real convergence makes macroeconomic adjustment and structural change critical issues in the context of European integration. The ten accession countries have made considerable progress in terms of disinflation and most of them have experienced growth rates above the EU average. Furthermore, most of these countries have also experienced significant real appreciation of their currencies vis-à-vis the euro area. Their monetary and exchange rate policy regimes cover the full range of possibilities. From inflation targeting *cum* floating adopted in the Czech Republic and Poland, for example, to currency boards, followed, for example, in Estonia and Lithuania. Hungary, in turn, allows the exchange rate of the forint to float inside +/- 15 per cent fluctuation bands against the euro.

Structural change and real convergence in these countries will be associated with adjustments in relative prices. One relative price, which is particularly relevant in the context, is the real exchange rate, defined as the price of non-tradable goods relative to the price of tradable goods. The real exchange rate, as a relative price, adjusts to changes in relevant variables including conditions in the rest of the world, productivity trends, trade barriers, taxation, migration flows, financial flows, international transfers, institutional and behavioural characteristics of product and labour markets and much else. In fact, the list of factors potentially affecting the equilibrium real exchange rate and its adjustment path towards equilibrium coincides with the list of factors, which may affect relative prices in a dynamic general equilibrium context, for an open economy. It includes all factors influencing the relative supply and demand for non-tradable goods. Therefore, the real exchange rate is unlikely to be constant over time (see, for example, Neary (1988) and Edwards (1989)).

For the countries joining the EU, many of the above factors are likely to play a relevant role in determining the real exchange rate and its evolution over time. One popular explanation of trend real exchange rate appreciation is inspired in the Balassa-Samuelson effect (Balassa (1964) and Samuelson (1964)). The basic idea is very simple. Catching up implies convergence in productivity levels. The scope for productivity increase is much greater in the production of traded goods (e.g. manufacturing goods) than non-traded goods (e.g. services). Therefore, countries catching up will experience stronger relative productivity gains in the production of traded goods. With the interest rate determined in the world capital market and a competitive domestic labour market, this implies an increase in the relative price of non-traded goods. There are many estimates available of the actual and likely magnitudes of Balassa-Samuelson effects both for the euro area and for accession countries (see, for example, Pelkmans, Gros and Nunez-Ferrer, 2000, Bundesbank, 2001, Coricelli and Jazbec, 2001, Halpern and Wyplosz, 2001, Sinn and Reutter, 2001, Egert, 2002, Fisher, 2002, Mihaljek, 2002 and MacDonald and Wojcik, 2002).

In this paper we develop a two-sector dynamic general equilibrium model with price and wage stickiness. We consider an overlapping generation set up on the household side (see, for example, Blanchard, 1985, and Yaari, 1965). In the literature on open economies, this setup is usually preferred to the infinite horizon Ramsey approach, since it leads to a determinate steady-state level of foreign debt. The production side of the economy considers two final goods sectors: traded and non-traded goods sectors. The non-traded goods sector and the labour markets are characterised by monopolistic competition (see, for example, Dixit and Stiglitz, 1977). Furthermore, the accumulation of capital is subject to real adjustment costs while the price of the non-traded good and the wage rate are subject to nominal adjustment costs (see, for example, Kim, 2000).

We calibrate and numerically simulate this model using a stylised data and parameter set inspired in the cases of two of the euro area countries, which have undergone significant catching up, Ireland and Portugal. We do so to capture the main features of a typical country engaged in the process of catching up to the EU standards of living. Our reading of the experiences of Portugal and Ireland leads us to focus on productivity growth, financial integration, unilateral public transfers associated with EU structural policies. This is clearly a simplification. Nevertheless, it allows us to capture some main features of the structural changes associated with a catching up process in the EU.

In the context of the dynamic general equilibrium model, the equilibrium real exchange rate will be one of the relative prices to be determined in equilibrium. It will be shown that trend productivity differentials lead to trend relative price changes. However, in the short run the adjustment in relative prices is unlikely to follow productivity differentials closely and we find that there is a sizeable ‘front-loading’ of the impacts on the real exchange rate.

Structural change and macroeconomic adjustment are likely to interact in complex ways. It may be that price and wage stickiness will make adjustment towards equilibrium very slow. Indeed, Blanchard and Muet (1993). Their focus was on the length of time it would take for the real exchange rate to return to its equilibrium following a process of disinflation based on a fixed exchange rate regime. However, since they were focusing on the German mark versus the French franc, they, quite reasonably, assumed that the equilibrium real exchange rate that was constant over time. For accession countries the analysis of the behaviour of the economy under alternative price norms, when the real exchange rate changes endogenously seems to be a more relevant case to look at. An alternative view, is that, in the context of a model with forward looking agents, the impacts of anticipated structural changes on the real exchange rate and other macroeconomic variables will be ‘front-loaded’ as a result of immediate wealth effects on consumption and labour supply.

This paper is organised as follows. In the second section, we describe the dynamic general equilibrium model and we briefly address parameterisation and calibration issues, while leaving the full details for an Annex. In the third section, we simulate the model under specific structural changes to determine the relevance of price stickiness and exchange rate regimes on the long-term changes in the real exchange rate as well as on the transitional converge to such long-term changes. Finally, in the fourth section, we summarise the main results of the paper and highlighting their policy implications.

2. The dynamic general-equilibrium model

An overview of the model is presented in Chart 1 while details are provided in Table 1. All variables and parameters are defined in Tables 2 and 3, respectively. We consider a decentralized economy in a dynamic general-equilibrium framework. All private sector agents maximize utility or profits, taking, unless otherwise indicated, goods and factor prices as given. In addition, all agents have perfect foresight. This means that agents fully anticipate future prices and other exogenous variables. Therefore, their planned future actions are determined and implemented without the need for any changes.

The economy is inhabited by households, firms producing in two different sectors and a government. The two production sectors are a traded goods sector and a non-traded goods sector. The traded goods sector is competitive. The price of traded goods is the exogenous world price, adjusted for the nominal exchange rate, which, under a ‘small open economy’ assumption, is independent of domestic traded goods output. In contrast, the non-traded sector is characterized by monopolistic competition with firms acting as price setters.

As regards the households, we follow the conventional overlapping-generations specification of Yaari (1965), Blanchard (1985), Buiter (1988) and Weil (1989). Households, faced with a finite probability of death, maximise a utility function, which depends on consumption of both traded and non-traded goods and leisure. As regards the labour market, we introduce imperfect competition and a set of wage setting institutions (unions) into the framework.

The model also incorporates a highly simplified government sector. As regards links to the rest of the world, we assume a high, but not perfect, degree of capital mobility where the domestic interest rate equals the foreign rate plus exogenous and endogenous risk premiums, the latter depending on the stock of net foreign assets relative to output. In cases where the nominal exchange rate is allowed to float, we assume that a standard uncovered interest parity condition applies.

A notable feature of our framework, in contrast to much of the earlier literature exploring the impacts of long-run structural changes, is that we incorporate a number of important frictions into the model. We assume price stickiness in a context of monopolistic competition in the market for the non-traded goods and in the labour market. In regard to the labour markets this is achieved by including in the model a set of agents which act as wage setters, specifically trade unions. Our setup means that the price of non-traded goods and the wage rate are both subjected to price mark-ups and to nominal adjustment costs. Nominal stickiness in these markets is modeled in terms of quadratic adjustment costs, following Kim (2000) rather than the Calvo (1983) scheme, mainly for reasons of analytical convenience. Moreover, as shown by Rotemberg (1987), the two approaches yield equivalent price equations. An additional friction in both the traded and the non-traded goods sectors stems from investment adjustment costs which are again modeled by means of a quadratic adjustment cost term.

The general equilibrium is defined as paths for the endogenous variables such that budget constraints and the first order conditions of firms and households are satisfied simultaneously and at all points in time given the paths of the exogenous variables.

2.1 The traded goods sector

The traded good sector comprises a set of identical firms, each of which acts in a competitive manner in output and factor markets. On the basis of a "small open economy assumption", the price of traded goods is determined by the exogenous world price - which is independent of the levels of traded output of the individual firms and the economy as a whole - along with the nominal exchange rate. Output, YT_t, is produced with a Cobb-Douglas technology as in equation (T.1) in Table 1, exhibiting constant returns to scale in labour, L_t^d, and private capital, K_t, where q_{LT} is the labour share and *AT* is total factor productivity in the traded sector. Capital accumulation is characterized by (T.2) where physical capital depreciates at a rate of d_{KT}. Investment is subject to adjustment costs as in Christiano et al, (2001). These costs comprise learning and installation costs and are meant to reflect rigidities in the accumulation of capital towards its optimal level. These adjustment costs are internal to the firm and are modeled as a loss in capital accumulation and are, therefore, included in equation (T.2). Adjustment costs are assumed to be non-negative, monotonically increasing, and strictly convex. In particular, we assume adjustment costs to be quadratic in investment per unit of installed capital. The investment good in the traded sector comprises a Cobb-Douglas aggregation of traded and non-traded goods (as shown in T.7). At time *t*, the firms' net cash flow, $NCFT_t$, (see equation T.3), represents revenues from sales net of wage payments and investment spending.

Traded goods firms are assumed to maximise the discounted value of net cash flow by choosing paths for labour input and investement (broken down into traded and non-traded goods), subject to the production function and the capital accumulation equation. The first order condition for labour is given by equation (T.4), a standard condition whereby the marginal product of labour is equal to the real product wage. Because of capital adjustment costs, the first order conditions for capital and investment are more complex. The relevant terms of the Lagrangian are:

$$pt_t AT(LT_t^d)^{q_{LT}} KT_t^{1-q_{LT}} - w_t LT_t^d - pit_t IT_t + q_t^{KT}\{KT_t - (1-d_{KT})KT_{t-1} - IT_{t-1} + m_{IT}\frac{IT_{t-1}^2}{KT_{t-1}}\} +$$

$$\frac{q_{t+1}^{KT}}{1+r_{t+1}}\{KT_{t+1} - (1-d_{KT})KT_t - IT_t + m_{IT}\frac{IT_t^2}{KT_t}\} + \ldots$$

where q_t^{KT} is the shadow price of the installed private capital stock, which evolves according to (T.6), while r_t is the domestic nominal interest rate. Differentiating this expression with respect to IT and KT yields equations (T.5) and (T.6), the first of which expresses investment as a function of the shadow price (q ratio) while the second gives the law of motion for the shadow price.

Finally, the investment good in the traded sector is a Cobb-Douglas composite of traded and non-traded goods, ITT_t and ITN_t, respectively, given by equation (T.7), where *it* is the share of investment expenditures in traded goods and st is a scale factor. Accordingly, the firm faces a dual investment price index, pit_t which is given by equation (T.8). The optimal choice of ITT and ITN yields the standard condition by which the nominal expenditure share for traded goods in total traded-sector investment expenditure is equal to *it*.

2.2 The non-traded goods sector

The set-up in the non-traded goods sector differs in a number of respects from that of the traded goods sector. In particular, the non-traded goods sector is embedded in a monopolistic competition framework and the price of the non-traded goods is subject to nominal adjustment costs. These features mean that the first order conditions differ from those of the traded sector by incorporating terms in mark-ups and also terms reflecting costly price adjustment.

2.2.1 Firms in the non-traded goods sector and the aggregator

The model set-up we employ for the non-traded sector has now become standard in the "New Neoclassical Synthesis" literature (see, for example, Christiano, Eichenbaum and Evans, 2001, Erceg, Henderson and Levin, 1999, and Smets and Wouters, 2002). Specifically, we assume that the composite non-traded good is produced by a single firm, the non-traded goods aggregator. This single firm uses inputs supplied by an infinite number of firms located along a continuum in [0,1]. The introduction of the aggregator, which behaves in a competitive manner, into the setup is for reasons of analytical convenience. The alternative approach whereby the individual firms sell their output directly to consumers would not alter the properties of the model, but would increase the complexity of the solutions. Each intermediate good firm produces and supplies to the aggregator a differentiated good. In a context of monopolistic competition these intermediate goods firms are price setters in the market for their output but are price takers in the factor markets.

. The intermediate goods supplied by the different firms, $YN(s)$, where s ε [0,1], are assumed to be imperfect substitutes. The composite non-traded good, is produced by the aggregator using the following Dixit-Stiglitz technology:

$$YN_t = \left[\int_0^1 YN_t(s)^{(e_n-1)/e_n} ds\right]^{e_n/(e\ -1)} \quad \textbf{(1)}$$

where e_n is the absolute value of the elasticity of demand for the intermediate good produced by firm s, this elasticity being equal for all s.

Letting $pn(s)$ denote the price of the output of firm s, the aggregator's profit function is:

$$pn_t YN_t - \int_0^1 pn(s)YN(s)ds \qquad \textbf{(2)}$$

Assuming that the aggregator behaves competitively, i.e. acts as a price taker on both the purchasing and selling side, maximization of this expression with respect to each YN_t, yields the aggregator's demand for each intermediate good:

$$YN_t(s) = \left[pn_t(s) / pn_t\right]^{-e_n} YN_t \qquad \textbf{(3)}$$

Simple manipulations of the previous expressions and using the zero profit condition for the aggregator, yields the following expression for the price of the composite non-traded good supplied by the aggregator:

$$pn = \left[\int_0^1 pn(s)^{1-e_n}\right]^{1/(1-e_n)} \qquad \textbf{(4)}$$

2.2.2 Intermediate goods firms

Each intermediate goods producer (s) aims to maximise discounted cash flow by choosing a level of its output price and labour and investment subject to three constraints: 1) the production function (T.9), 2) the capital accumulation equation incorporating quadratic adjustment costs as in the traded sector (T.10), and 3) the demand function for their specific good (equation (3), above).

An important feature of our model is that intermediate goods firms' price setting is subject to nominal adjustment costs. This means that it is costly for the firm to adjust prices to the otherwise ideal level. Nominal adjustment costs for firm s are given, following Kim (2000) by a quadratic function of the percentage price change:

$$m(s)_p \left(\frac{pn(s)_t}{pn(s)_{t-1}} - 1 \right)^2 YN(s)_t \qquad \textbf{(5)}$$

where $m(s)_p$ reflects the degree of price stickiness for firm s or the cost of changing prices from the previous levels. (A value of zero for this parameter would correspond to perfect price flexibility). Notice that, nominal adjustment costs incurred by the firm depend on the amount of output which is actually supplied, which is in itself a function of the prevailing price. We have, therefore, modelled nominal adjustment costs as per unit costs.

Intermediate goods firms are therefore assumed to choose paths for pn(s), KN(s), IN(s) and LN(s) so as to maximise the expected discounted value of the firm:

$$\sum_{t=T}^{\infty} R(t)\{(pn_t - m_p\left(\frac{pn_t}{pn_{t-1}} - 1\right)^2)YN_t - w_t LN_t^d - pin_t IN_t\} \tag{6}$$

where R(t) is a discount factor defined in the usual way, e.g. R(t)=1, R(t+1)=1/(1/1+r_t), R(t+2)= 1/((1+r_t)(1+r_{t+1})) etc. The maximisation is subject to three constraints: the demand for the firms' output from the aggregator given by equation (3) above; the production function (T.9); the capital accumulation equation (T.10). The latter two equations are defined in an analogous way to the traded sector.

The first order conditions for this problem can be derived in a straightforward, if tedious, manner. To move from individual to aggregate behaviour, we note that firms are assumed to have identical technologies, budget constraints and demand functions for their output. Therefore, the equilibrium in this monopolistically competitive set-up will be symmetric. Thus, output levels, prices, investment, capital and labour inputs will be identical across firms. Imposing these conditions, using (1) and (4), yields a set of aggregate first order conditions for the non-traded sector which are shown in equations (T.13) to (T.19).

Equations (T.13) and (T.14) show the aggregate first order conditions for labour input. This differs from the standard case (e.g. as in the traded sector) in two key respects. First, it includes a mark-up term, reflecting the monopolistic nature of the market. Secondly, it includes terms in current and discounted future price changes, reflecting the impact of costly price output adjustment. Note that this would collapse to the standard marginal productivity condition for labour as e_n ? 8 and μ_p ? 0 (i.e. in the absence of market power and price adjustment costs). The same features apply to the marginal condition for capital (T.15). The investment equation (T.16) and the law of motion for the shadow price of non-traded capital stock (T.17) are, apart from the different definition of the marginal productivity of capital, the same as in the traded good sector. Finally, given the definition of the composite investment good in the non-traded sector (T.18) and its dual price index (T.19), the intratemporal choice of traded and non-traded goods in investment is determined by conditions identical to those in the traded sector.

2.3 The household sector

Population is normalised to be equal to 1 and assumed to be constant. Each household/generation faces the same utility function with identical intertemporal discount rates and survivor rates. Households are price takers in all markets. In addition, for reasons that will become apparent in the next section, we assume that each generation comprises an infinite number of workers distributed uniformly along a continuum [0,1] of skills or 'professions'. This implies that each generation comprises workers of different skills/professions with the 'proportions' of each profession equal across generations and that, further, the distribution of workers in each skill class (s) across generations is equal across skill classes.

A conventional overlapping generations specification following Yaari (1965), Blanchard (1985), Buiter (1988) and Weil (1989) was adopted here. See Frenkel and Razin (1996) for a detailed discussion of this type of household model. In this framework, the planning horizon is finite but in a non-deterministic fashion. A large number of identical agents are faced with a probability, $\gamma \in (0,1)$, of surviving through to the next period. The assumption that γ is constant over time and across age-cohorts yields the perpetual youth specification by which all agents face a life expectancy of $1/(1-\gamma)$, and the probability of being alive *j* periods ahead is simply γ^j. Since population is normalized to unity, *per capita* and aggregate values are equal.

The household, aged *a* at time *t*, has to choose present and future consumption and leisure streams that maximize utility, equation (T.21), subject to the consolidated budget constraint, equation (T.22). The objective function is lifetime expected instantaneous utility subjectively discounted at the rate of β. Preferences, $u_{a+v,t+v}$, are additive separable in private consumption and leisure, and take on the CES form where *B* is a size parameter and s is the constant elasticity of substitution. In practice, we will assume a Cobb-Douglas utility function (s =1). The effective subjective discount factor can be written as $\gamma\beta$ meaning that a lower probability of survival reduces the effective discount factor making the household relatively more impatient.

The budget constraint, equation (T.22), reflects the fact that the households' expected consumption expenditure stream discounted at the market real interest rate should not exceed the households' total wealth, $TW_{a,t}$, evaluated at time *t*. The market real interest rate is $1+r_{t+v}$, but the one-period loan rate at which households borrow and lend among themselves in a perfectly competitive market is $1/\gamma$ times greater. In effect, the probability of dying, $1-\gamma$, acts as a perceived default rate. To ensure a before-tax return of $1+r_{t+v}$ with certainty, creditors charge $(1+r_{t+v})/\gamma > 1+r_{t+v}$.

For the household of age *a* at time *t*, total wealth, $TW_{a,t}$, equation (T.23), is age-specific and is composed of human wealth, $HW_{a,t}$, net financial worth, $FW_{a,t}$, and the present market value of the firms, PVF_t. Human wealth, equation (T.24), represents the present discounted value of the household's future labour income minus lump sum taxes (LST) stream. Financial wealth comprises government debt minus foreign debt (T.25). Note that future labour earnings have to be discounted at a higher rate reflecting the probability of survival, since human wealth is household-specific and cannot be transferred at the time of death.

Income net of spending adds to net financial wealth, as in equation (T.25). Household's income is augmented by profits distributed by corporations, $NCFT_t$, and $NCFN_t$, international transfers such as emigrants' remittances, R_t, and public transfers such as old-age pensions, $TR1_t$. Loans among households cancel out upon the consolidation of households' financial assets, and are thus are omitted. On the spending side, debts to foreigners are serviced, taxes are paid and consumption expenditures are made. Under the assumption that no bequests are made, households are born without any financial wealth. Note also that total wealth is age-specific on account of age-specific labour supplies and consumption streams.

Assuming a constant real interest rate and that the consolidated budget constraint is binding, the household's intertemporal optimization problem can be formulated as a standard static program. Furthermore, under our simplifying assumptions, the marginal propensity to consume out of total wealth is age independent and aggregation over age cohorts is greatly simplified. Aggregate consumption demand as a function of the aggregate stock of total wealth is given by equation (T.27). In our setup, as explained in the next section, employment will be demand determined given the wage rates set by unions.

Finally, aggregate consumption spending is a Cobb-Douglas composite of expenditure in traded and non-traded goods, CT_t and CN_t, respectively, and is given by equation (T.28), where c, is the share of investment expenditures in traded goods and sc is a scale factor. Accordingly, the households face a dual consumer price index, pc_t which is given in equation (T.29).

2.4 Wage Stickiness and the Labour Market

The now standard way of introducing wage stickiness in to dynamic general equilibrium models is to use a setup where representative households themselves face a downward demand for their labour and act as wage setters (see Erceg, Henderson and Levin, 1999). In the current set-up, this approach cannot be applied directly since households in the present model are not homogenous. They are differentiated by levels of wealth (due to age effects) and accordingly differ in regard to their consumption. Labour market decisions, such as the setting of wages, would not, therefore, be identical across households if households themselves were wage setters. In addition, problems would arise in dealing with newly arrived households who previously would not have set a wage.

In order to incorporate wage stickiness in our set-up while overcoming this problem, the approach taken is to add an additional set of agents to the labour market. These additional agents – called for convenience unions – act as agents for the labour market decisions of households and set the wage rate charged to firms by their members so as to maximise the utility of a 'representative' union member. Given this wage, 'the right to manage model' applies, and the level of employment is determined by the firms' labour demand functions. A labour aggregator purchases labour inputs of different skill classes from unions/households and supplies a single composite labour to the traded and non-traded goods firms.

2.4.2 The labour aggregator

The specification of the behaviour of the aggregator is now relatively standard (see Erceg et al, 1999). It is assumed that a representative aggregator supplies a composite labour input L_t to firms by combining differentiated types of labour input, differentiated by professions/skills. The different labour inputs are supplied by unions located along a continuum, with unions representing household members of a specific skill type. The labour services supplied by the different unions, L(s), where s ε [0,1], are assumed to be imperfect substitutes. The composite labour supplied to firms is produced using the following Dixit-Stiglitz technology:

$$L_t = \left[\int_0^1 L_t(s)^{(e_w-1)/e_w} ds \right]^{e_w/(e_w-1)} \qquad \textbf{(7)}$$

Letting W(s) denote the wage rate for labour of type s and w the wage rate charged by the aggregator to the firms in the traded and non-traded sectors, the aggregator's profit function is:

$$w_t L_t - \int_0^1 w(s) L(s) ds \qquad \textbf{(8)}$$

Assuming that the aggregator behaves competitively, i.e. acts as a price taker on both the purchasing and selling side, maximisation of this expression with respect to each L(s), yields the aggregator's demand for each type of labour input:

$$L_t(s) = \left[w_t(s) / w_t \right]^{-e_w} L_t \qquad \textbf{(9)}$$

ε_w is the (absolute value of) the elasticity of demand for labour for the members of union s, this elasticity being equal for all s by virtue of (7). Substituting (9) into (8) and imposing the zero profit condition for the aggregator, yields the following expression for the wage rate for the composite labour supplied to firms:

$$w_t = \left[\int_0^1 w_t(s)^{1-e_w} \right]^{1/(1-e_w)} \qquad \textbf{(10)}$$

2.4.3 Unions

Each type of labour, L(s), is supplied exclusively to the aggregator by a union located along the continuum of unions. Unions act as agents for their members, setting a wage rate for its specific type of labour so as to maximise the utility of a representative member. Given this wage rate, the union (s) supplies as much labour of type (s) as is demanded by the aggregator. On the other side, members of the union agree that, in return for receiving the union wage, they will supply as much labour as required, with each member of the union working the same hours and receiving the same wage for its type of labour. Facing the downward sloping demand curve (9), each union chooses a wage rate for its type of labour so as to maximise the following

$$\left[\sum_{t=0}^{\infty} R(t) \left(U\{C_t(s), (L - L_t(s))\} - \frac{1}{2} m_w [\ \frac{w_t(s)}{w_{t-1}(s)} - 1]^2 +\ l(pc_t C_t(s) - w_t(s) L_t(s) \ldots .) \right) \right]$$

representative member welfare function:

(11)

Where R(t) is a discount factor defined in the usual way, e.g. R(t)=1, R(t+1)=1/(1+r_t), R(t+2)= 1/((1+r_t)(1+r_{t+1})) etc. The functional form of U(C,1-L) is the same as for the individual household.

The consumption term entering the union's objective function (C(s)) is the average consumption of members. Given our earlier assumption that the distribution of union members across generations is identical, average consumption of the members of union (s), C(s), will in fact be equal to average consumption in the economy as a whole. It is interesting to note that in basing its choice on average consumption, the union is implicitly assigning a higher weight to older (and therefore richer) members, a type of seniority principle. In setting the wage, the union also takes into account the fact that hours worked by members will be determined by the labour demand function of the aggregator, (9). The quadratic term in change in the union wage in the welfare function reflects and assumed disutility of changing the nominal wage rate. This term, reflecting 'psychic adjustment costs', can be motivated by the idea that changing nominal wages involves considerable negotiating efforts in the union, reducing members utility. Finally, in choosing the wage rate, the union takes into account the budget constraint of its members and their decisions regarding the choice of consumption level. This is shown in the final term in the objective function above. Given the households first order condition for consumption, λ will equal the marginal utility of consumption of the representative member divided by the consumer price index. This term is taken as given in the union's optimisation problem.

Substituting the labour demand function (11), differentiating with respect to w_t(s) and substituting the marginal utility condition for consumption for λ, yields the following Euler equation for the wage rate of union (s):

$$\left[\begin{array}{l}\left(\dfrac{L_t}{pc_t}\right)(1-e_w)U_C - e_w\left(\dfrac{L_t}{w_t(s)}\right)U_{1-L} + \left\{\dfrac{m_w w_{t+1}(s)}{(1+r_t)w_t^{\,2}(s)}\right\}\left\{\dfrac{w_{t+1}(s)}{w_t(s)}-1\right\} \\ \\ -\left\{\dfrac{m_w}{w_{t-1}(s)}\right\}\left\{\dfrac{w_t(s)}{w_{t-1}(s)}-1\right\} = 0\end{array}\right] \tag{12}$$

In order to interpret this equation, note that along a zero wage growth steady state, the last two terms in the above expression will be zero. This implies that the steady state real wage rate of the union will be given by:

$$\left(\frac{w_t(s)}{pc_t}\right) = \left(\frac{e_w}{e_w-1}\right)\left(\frac{U_{1-L}}{U_C}\right)$$

(13)

The second term on the right of this equation is an expression for the real wage that would be satisfied under perfectly competitive labour market conditions. Thus the real wage charged by the union in the long-run is thus a mark-up on the wage that would have prevailed if the labour market had been operating under perfect competition, with the size of the mark-up depending on the elasticity of demand for the union's labour services. With this in mind, the first two terms of the Euler equation therefore represent a non-linear 'error-correction' term in the deviation of the current union wage from its long run equilibrium level. The remaining terms reflect a (forward-looking) adjustment to this long run level resulting from the quadratic term in the utility function. The Euler equation therefore has the usual interpretation, where the union balances the costs of being away from its 'equilibrium' against the costs of adjustment which arise when changing nominal wages.

To move from the wage rate of individual unions to the aggregate wage rate, we note that under our assumptions, a symmetric equilibrium will apply. Specifically, the elasticity of the aggregators demand for each type of labour (e_w) and all of the other parameters and functional form of the union's objective function are equal across unions. By our assumptions on the distribution of union members across generations, average consumption will also be equal across unions. This implies that the solution to the first order condition will be identical across unions. The equilibrium in the labour market will therefore be symmetric, implying that w(i)=w(j) and L(j) = L(i) for all i,j. This implies that the aggregate wage rate must satisfy an economy-wide Euler given by (T.20). From the aggregator's demand for labour function (9), hours worked per member will also be equal across unions. Since union membership is equally distributed across generations, this implies, in turn, that hours worked will also be the same across generations. Given the wage rates set by the unions, and the resulting aggregate wage rate (equation (10)), total labour input will be determined by firms' labour demand functions (equations T.4 and T.13).

2.5 Public Sector

The model includes a relatively simplified public sector. We assume that in all periods, a balanced budget rule is followed.. Accordingly, the budget for the public sector is given by equation (T.30). In this equation CGT_t and CGN_t, are public consumption of traded and non-traded goods, respectively, rPD_t, are interest payments on existing public debt, LST_t are lump sum axes levied on the households, and TR_t are public transfer to the households. Finally, FT_t are foreign transfers to the Government in foreign currency (e.g. EU transfers), which are converted into domestic currency using the nominal exchange rate of ner_t. The proceeds are spent immediately on additional non-traded goods, accounting for the appearance of this term on both sides of the budget constraint.

Government consumption is assumed to be exogenous in real terms. In particular, public consumption of traded and non-traded goods both grows at given rate. Naturally, to the extent that there are changes in the nominal exchange rates or in the price of the non-traded goods, government consumption changes in nominal terms. Lump sum taxes adjust according to the balanced budget condition above.

2.6 Further equilibrium conditions and the determination of prices and interest rates

In addition to the first order conditions and budget constraints discussed earlier, a number of whole economy constraints are satisfied. The intertemporal budget constraint for our open economy is given by equation (T.31). This states the balance of payments condition that the change in foreign debt (the financial account) is equal to the current account deficit (nominal spending on traded goods and interest payments on the foreign debt minus domestic production of traded goods and international transfers). In turn, the equilibrium in the non-traded goods market is given by equation (T.32). Here the only relevant point is that it is assumed that international transfers are, as mentioned in the previous section, exclusively spent on non-traded goods. Equation (T.33) shows that total labour input is the sum of labour inputs in the traded and non-traded sectors. Finally, the definition of household financial wealth is given by equation (T.34).

In this model, we assume that the domestic economy is a small open economy, i.e., a price taker in the traded good markets as well as the financial markets. This means that domestic agents take the price of the traded good and the interest rate as exogenous.

In the determination of the domestic price of traded goods we start by assuming a regime of fixed exchange rates. In this case, the nominal exchange rate and the international price of non-traded goods ptw_t, are exogenous. The domestic price of traded goods, pt_t, is given by (T.35). Alternatively, we assume a regime of flexible exchange rates in which the authorities target consumer price stability. In this case the nominal exchange rate will evolve so as to ensure a path for traded goods prices which generates a stable overall consumer price level. Via an uncovered interest parity term, this path will in turn determine the path of the domestic interest rate vis-à-vis the world risk free rate, ir_t, which is assumed to be constant over time

Apart from UIP considerations, we assume that the domestic interest rate also contains both exogenous and endogenous risk premiums. The exogenous risk premium, rp_t, is assumed to reflect a lack of integration into global financial markets and is a parameter which we change in some simulations. The endogenous risk premium is a function of the foreign debt to GDP ratio. The purpose of including this rather arbitrary element is to dampen down fluctuations in net foreign assets. Putting all these elements together, the domestic interest rate is given by equation (T.36).

We define the steady-state growth path as an intertemporal equilibrium trajectory for the economy in which all the flow and stock variables grow at the same rate while market prices and shadow prices are constant. There are three major types of restrictions imposed by the existence of a steady-state growth path. First, the existence of a steady state determines the value of critical production parameters, like adjustment costs and depreciation rates given the initial stocks of physical and human capital. These stocks, in turn, are determined by assuming that the observed levels of investment of the respective types are such that, the capital to GDP ratios do not change in the steady state. Second, the need for constant public debt and foreign debt to GDP ratios implies that the steady-state public account deficit and the current account deficit are a constant fraction of the respective stocks of debt that coincides with the growth rate of the economy. Finally, the exogenous variables, as public transfers or international unilateral transfers, etc., have to grow at the steady-state growth rate.

2.7 Calibration

The data and parameters that are used in simulating the model are presented in Tables 2 and 3, respectively, and the details of the calibration procedure are given in Annex 1. The calibration approach is to choose a set of model parameters so as to match a steady state data set which broadly corresponds to the stylised facts of the Irish and Portuguese economies. These features mainly relate to shares of traded and non-traded goods in output, employment and demand components. In addition, we take into account information of the functional distribution of income. The basis information sources are input-output tables and national accounts for both countries. On the basis of this information, a baseline data set was constructed and is shown in Table 3, where for convenience, GDP and all prices are normalised to unity. In deriving this data set from the raw data, we have assumed that the traded sector basically comprises agriculture and manufacturing while the non-traded sector comprises the remainder of GDP.

We choose the parameters of the model in way such that the model, when run on the baseline, reproduces this data set. This comprises four steps. First, some parameter values are assumed on the basis of available literature or educated guesses. These include investment adjustment costs as a percentage of investment and mark-up parameters. Second, the values of the share parameters (production function parameters, shares of traded and non-traded goods in investment and consumption) can be determined straightforwardly from the respective shares in the data. Third, some parameters, specifically the parameters for nominal stickiness and wages and non-traded prices, are chosen to match empirical evidence from other studies. A final subset of parameters, namely the discount rate, the depreciation rates in both sectors and the investment adjustment cost parameters are chosen so that the model reproduces the baseline data set.

3. Macroeconomic adjustment to structural change: simulation results

In this section we seek to characterise macroeconomic adjustment to structural changes using the model outlined in earlier sections. To do this we solve the model numerically using the stacked-time algorithm of Laxton and Juillard (1996). This involves stacking the equations for all periods (in our case 200 years) and solving them simultaneously subject to given initial and terminal conditions, the latter being set to the steady state values.

We examine the response of standard macroeconomic aggregates – prices, output and employment – as well as the allocation of resources between the two sectors. We focus especially on the long-term impact on the real exchange rate as well as on its dynamics of adjustment towards its long run equilibrium. We explore the extent to which the presence or absence of price and wage stickiness impacts on these adjustment processes. Finally, we consider how different exchange rate regimes affect the macroeconomic adjustment. In particular we examine the implications for macroeconomic adjustment of a policy of fixed nominal exchange rate regime as against a policy orientated to domestic price stability under floating rates.

3. 1 Simulation design

In our simulation experiments we consider the effects of three stylised structural changes, which, as emphasised in the introduction, are seen as the principal structural changes associated with integration into the EU on the basis of the experience of Portugal and Ireland.[1]

The ***first structural change*** corresponds to a protracted increase of productivity growth in the traded good sector. It is meant to reflect a standard source of real convergence connected with increased trade integration. The magnitude of the change is such that the shock in total factor productivity growth in the traded good sector when combined with the other two shocks (see below) accumulates to a level effect on total output of about 30% in 50 years. This implies an increase inhe traded sector TFP growth rate of about 1 percentage point a year for a period of 30 years. The ***second structural change*** reflects the process of financial integration. It corresponds to a reduction in the interest rate the domestic economy faces in the international markets. We consider a reduction of the exogenous risk premium of 150 base points spread over 0 years. The ***third structural change*** is associated with the Community's structural policies. It is modelled as a pure demand shock. We consider an increase in international transfers, reflecting access to EU structural funds, corresponding to 3% of the GDP. This change lasts for a 15-year period after which transfers return to baseline.

In terms of the different sets of simulations to be considered, we start by considering the effects of structural changes under price stickiness and a fixed nominal exchange rate and proceed to determine the role of both assumptions. In the ***first set of simulation results*** our objective is to establish that a plausible package of structural changes leads in our model to reasonable results which are not in contradiction with known stylised facts. In **the *second set of simulation experiments***, we consider the effects of the same structural changes in the absence of price and wage stickiness but still with a fixed nominal exchange rate to determine how the macroeconomic adjustment would change in absence of such stickiness. The point is to establish that nominal price rigidities in the context of monopolistic competition are important to produce the plausible results introduced before. Finally, in the ***third set of simulation results***, we consider the effects of structural changes under price and wage stickiness but with a policy orientated to domestic price stability under a flexible nominal exchange rate. The idea is to show the effects of the choice of monetary policy regime, associated with nominal exchange rate floating, on the macroeconomic adjustment process.

For the sake of brevity we will refer to short term effects as effects happening within a ten-year period, medium-term effects as those occurring between ten and twenty years, and long-

[1] See, Pereira (1999a,b) and Gaspar and Pereira (1995), for specific analysis of this type of structural changes in the context of these ands other countries.

term the effects thereafter. Furthermore, all the references to status quo refer to the model outcomes before the structural shocks are imposed and, therefore, refer to the values for our stylised economy that reflect the long term trends for the economy in the absence of such structural shocks.

3.2 Effects of structural changes under market rigidities and fixed nominal exchange rate

How does our stylised economy adjust to the structural shocks considered under price and wage stickiness when the nominal exchange rate is fixed? What are the effects on the long-term allocation of resources and real exchange rate? What are the properties of the adjustment to the new equilibrium allocation of resources and real exchange rate? These are some of the questions we address in this section. The simulation results for this case are presented in Chart 2.

The structural changes under consideration lead to a sharp increase of the real exchange in the short-term to up 25% above the status quo level followed by a relatively slow convergence to a new long-term steady-state level which is about 30% above the status quo. The nominal wage rate and the consumption price index follow a similar pattern with a sharp increase in the short term followed by smooth convergence to a level about 45% and 15% above the status quo levels, respectively. As a corollary, the effects of structural changes on consumer price inflation are front-loaded. Indeed they virtually disappear after a ten-year period.

The effects of the structural changes on nominal wages and consumption prices suggest that real wages increase sharply within the first five years and then converges slowly to a long-term increase of about 22%. The long-term evolution of the employment follows the corresponding pattern. It shows a long terms increase of about 12.5%, but in the short term the structural changes lead to an increased employment on impact. This increase, however, shrinks until it eventually turns into a decrease. The recovery toward the long-term increase starts around 15 years into the structural changes.

It is interesting to understand this short-term response pattern of employment to the structural changes under consideration. Although the real wage rate increases in the short-term, this is just one of the determinants of labour supply and, ultimately, employment. Indeed, these structural changes – because they are fully anticipated by forward-looking households - lead to a substantial increase in the total wealth of the households. Recall that total wealth includes in addition to financial wealth (the foreign debt position), the forward-looking stocks of human wealth and the value of the firms. The structural changes represent a substantial gain in the profitability of the production sectors as well as on the discounted wage income of households.

This being the case, the structural changes induce on impact a major increase in the wealth position of the households. They respond, in a standard fashion, by increasing consumption (more on this below) and leisure. Hence a short-term reduction in desired labour supply. As will be discussed in more detail below, however, the impacts are offset in the very short run by wage stickiness which prevents an immediate adjustment of wages to desired levels, resulting initially in a rise in employment due to a shift in labour demand.

This evolution in the supply of labour hides a very different evolution of employment in the traded and non-traded goods sectors. In fact, the structural changes lead to a substantial positive but declining effect on employment on the non-traded goods sector and a negative short-term effect in the traded goods sector, which however turns into a substantial long-term gain. This suggests that the structural changes induce a shift in the composition of employment to the non-traded goods sector in the short term but decisively to the traded goods sector in the medium and long term.

In terms of the capital accumulation we see that the structural changes lead to a long term increase in the shadow price of capital for both sectors of about 20% in both the traded and non-traded goods sectors. The transitional patterns, however, are very different between the two sectors. In the short and medium term the shadow price of capital in the traded goods sector increases smoothly to a level of 35% above the status quo thereby overshooting the new long-term level. In turn, the shadow price in the non-traded goods sector increases on impact to about 40% over its status quo level and then declines smoothly to the new steady state level.

The effects of the structural changes on the two stocks of capital follow a corresponding pattern. The stock of capital in the traded sector increases strongly initially and then smoothly converges to a new steady state level about 70% above the status quo. The stock of capital in the non-traded sector increases at a smooth but decreasing rate to the new steady-state level, which is about 22.5 above the status quo level. Again the structural changes induce a shift in the sector composition of capital. In the short run the composition shifts to the non-traded sector while in the long term it shifts decisively to the traded sector. It should be pointed out that this pattern of results is consistent with the fact that that investment in the non-traded goods sector is more dependent on non-trade goods and the price of these goods increases substantially in the long term.

Naturally, the evolution of output, both at the aggregate and the sector level, follow closely the evolution of employment and capital accumulation. In the short-term aggregate output is only very marginally affected. The increase in capital formation is matched by a decline in employment. In the longer-term however, as both employment and capital accumulation increase, so does aggregate output. Indeed, aggregate output ultimately increases to a level that is about 35% above the status quo. At the sector level, the decline in employment in the traded sector in the short term induces a decline in output in this sector. In the long-term however, output increases by up to 100% over its status quo level. In turn, output in the non-traded sector increases significantly in the short term but the long term gains are less impressive, i.e., just about 8%. This means that the structural changes induce a major shift in the output composition toward the traded goods sector in the long run.

Let us consider now the evolution of private consumption. The evolution of private consumption is conditioned by two main factors. The first is the evolution of the consumer price index. The structural changes under consideration induce on impact an increase of about 5% on the consumption price index. This increase continues and becomes more accentuated as the consumption price index reaches a new steady state about 15% above the status quo level. The corresponding inflation rate increases sharply on impact but the bulk of the effects are in place after a ten-year transition period.

A second factor affecting private consumption is the evolution of total wealth including human wealth, financial wealth and the value of the firms. The positive impact of structural changes on the long-term wages leads to an increase in human wealth while an increase of the profitability of the firms leads to an increased present value of the firms. We see, finally that financial wealth mostly reflected in foreign financing declines but only slightly. Overall, therefore, consumers experience an increase in total wealth. This increase operates in the opposite direction if the increase in the consumer price index discussed above but in real terms household wealth rises by about 25%.

Reflecting this increase of total wealth private consumption increases sharply on impact also by about 25%. Then it progressively declines to a gain of about 14% as the buildup in foreign debt diminishes total wealth. Finally, it rebounds somewhat to reach a long-term gain of about 18% versus the status quo.

We can, therefore, summarise these results as follows. The structural changes lead to a marked increase in the real exchange rate in the long-term. In the long term, there is an increase in output and both employment and capital formation, as well as private consumption but the composition of output, employment and capital, as well as consumption shift markedly to the traded good sector. In the short-term, however, the shift is toward the non-traded sector.

So far we have considered all the structural shocks simultaneously and we just summarised their combined effects. It is useful, however, to consider briefly the differential effects of the different shocks in the perspective of determining which ones seem to be more important for either the observed long-term effects or the macroeconomic adjustment leading to such effects.

In terms of the effects on the real exchange rate, the short term effects seem to be induced mostly by financial integration and to a lesser extent by structural transfers while the long terms effects are exclusively due to the total factor productivity shock in the traded goods sector. Indeed, the effects of financial integration are very small after a 10-year period while the effects of structural funds are always very small.

In terms of the intertemporal patterns of employment and capital accumulation, all shocks seem to contribute to the short and medium term reallocation toward the non-traded goods sector. Financial integration alone seems to be behind the long term level and composition effects in terms of employment while both the total factor productivity shock in the traded goods sector and financial integration seem to underlie the long-term effects on the level and allocation of capital accumulation. Finally, in terms of the evolution of private consumption, the productivity shock leads to a progressively increasing positive effect that clearly dominates in the long term while financial integration and structural transfers have important short-term effects that become only marginally relevant in the long term.

3.3 Effects of structural changes in the absence of market rigidities

The central feature of our model set up is the presence of nominal rigidities in both the market for non-traded goods and the labour market in a context of monopolistic competition. This feature, while standard in most current macroeconomic models which are used to assess the effects of persistent but temporary shocks, is rarely included in growth models, such as ours, which are used to study the impacts of permanent changes. Therefore it is worthwhile to highlight how the features of price and wage stickiness, which we have incorporated into the model, affect the macroeconomic adjustment to structural change.

Clearly, we do not expect nominal rigidities to have any material impacts on the long-term effects of the structural changes, as is confirmed by our results. This being the case we concentrate on the short to medium term differences between the macroeconomic adjustment to structural changes in the presence and in the absence of nominal price rigidities. The simulation results are presented in Chart 3.

The presence of nominal rigidities changes the short-term price dynamics in a very substantial fashion. In the absence of nominal rigidities, the wage rate would respond to the structural changes by jumping immediately to a level rather close to, but just below, its new long-term steady state level and then gradually converge to this level. In contrast, the price of non-traded goods exhibits an overshooting pattern, jumping initially to a level above its new long run equilibrium before gradually converging to this value. As a consequence the real exchange rate also shows a similar overshooting pattern.

The effects of structural changes in the labour markets are also greatly affected by the presence of nominal rigidities. The greater short-term increase in the real wage in the absence of nominal rigidities leads to a much greater reduction of employment in the traded sector and a much lower increase in the non-traded sector. Overall employment actually declines in the short term while it increases in the case of sticky prices. The reduction in short-term employment under flexible prices/wages, in contrast to the short-term rise, which occurs under sticky wages, is easily explained. In the absence of wage stickiness, the increase in consumer wealth leads to a decline in labour supply, driving up the wage and lowering employment. Under sticky wages, in contrast, this process is muted. Wages do not exhibit the same marked jump pattern since they can, under wage stickiness, only gradually adjust to the long-run level. With employment demand determined in this case, employment actually rises in the short-run as a result of a shift in the labour demand curve.

The effects of nominal rigidities on the pattern of capital accumulation are also important. This is because a significant part of the investment activities in both sectors is in the form of purchases of non-traded goods. Therefore, the fact that the price of the non-traded goods increases immediately in response to the shocks under price flexibility implies that investment demand shows a much lower short-term response to the shocks in this case. In fact, investment in the traded good sector decreases significantly in the short-term while investment in the non-traded good sector increases by much less than under price rigidities. Accordingly, the short term reduction in capital accumulation in the traded sector is much more marked while the increase in capital accumulation in the non-traded sector is less marked.

The differences in the equilibrium in the input markets reflects itself clearly in the differences in the short-term pattern of response of output to the structural shocks with and without nominal price rigidities. Reflecting a reduction in employment and a lower capital accumulation in the short term under price flexibility, total output actually declines in the short term. This is unlike the case of price stickiness, in which case output actually increases on impact. In terms of the sector composition of output the pattern of response changes also in the expected manner. Output in the traded sector actually decreases more sharply in the short term in the absence of price stickiness while output in the non-trade sector actually increases less sharply. Hence the combined effect of a reduction in aggregate output.

Finally, the increase in the consumption in the flexible price case is less sharp than in the case of sticky wages/prices. This primarily reflects the lower increase in real human wealth in the former case, since the effect of higher real wages (a difference of 6 percentage points) is offset by lower employment in this case (20 percentage points). An interesting corollary of these results is that the main effect wage and price stickiness seems to greatly diminish the short-run effects of wealth on labour supply, with the result that output is higher in the short-run.

3.4 Effects of structural changes under flexible nominal exchange rate

In the previous sections we have considered the effects of the structural changes under the assumption of a fixed exchange rate regime. In this section, we analyse the effects of the structural changes under the assumption that the exchange rate is allowed to adjust in order to maintain domestic consumer price stability. The simulation results are presented in Chart 4.

Since we have observed that the effects of the structural changes on consumer price inflation under a fixed exchange rate regime are front loaded, we would expect the efforts in the direction of nominal exchange rate management to be relevant mostly in the very short term. Indeed, the increase in the price of the non-traded goods induced by the structural changes is now matched by an offsetting reduction in the domestic price of traded goods through the nominal exchange rate management. While these changes in the price levels are permanent, the changes in the relative price of non-traded to traded goods are small and temporary. Indeed, the paths of the real exchange rate are indistinguishable across both cases.

Accordingly, and because the nominal changes do not have a substantial impact on the relative prices, the intertemporal allocation of resources does not change significantly with flexible nominal exchange rates. The reduction in overall employment in the short term is slightly stronger in this case while the effects on capital accumulation are only visible in the non-traded sector where a marginally lower path is observed. Therefore, the short-term change in aggregate output is slightly less pronounced under price stabilisation. This is due almost exclusively to a lower increase of output in the non-trade good sector.

More interesting is the change in consumption patterns. Since the short-term consumer price inflation effects observed in the fixed exchange rate case are now eliminated, private consumption actually increases by more in the very short term, i.e., the first five years or so, under flexible nominal exchange rates. After this, however, the trajectory of consumption is slightly reduced compared to the fixed exchange rate case. The general point of this discussion is that the change from a regime of fixed exchange rates to a regime of flexible exchange rate to pursue price stability does not seem to yield substantial changes in the macroeconomic adjustment. Ultimately even the effects on private consumption are relatively small and only positive in the short term.

This is an important point for two very different reasons. First, this goes very much in the line of the arguments expounded by Lucas to the fact that the long-term benefits from stabilisation policies are negligible when considered in the context of growth dynamics. Nevertheless, it may be argued that stability-oriented policies are a necessary pre-requisite for a sustainable growth convergence path. Here it makes sense to emphasise that sound macroeconomic policies are a key requirement of EU membership. Second, it seems to suggest that structural change does not provide, by itself, a case for postponing the achievement of price stability. There is not, in the model, a significant trade off between maintaining price stability and the adjustment of the economy to structural change.

4. Summary and Policy Implications

This paper addressed the issue of macroeconomic adjustment to structural change for a small open economy catching up in the EU. The issue is relevant for the ten countries set to become new members of the EU on 1 May 2004 - Cyprus, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia. Successful integration of these countries will require both nominal convergence, i.e., macroeconomic adjustment, and real convergence, i.e., structural change. To analyse macroeconomic adjustment to structural change we considered a two-sector, imperfect competition, dynamic general equilibrium model allowing for price setting in the non-traded goods sector and wage setting. We made use of a set-up including overlapping generations, real adjustment costs to capital accumulation and costs to nominal price and wage adjustment. The model is calibrated with data and parameter sets inspired by the cases of Ireland and Portugal, two euro area countries that have undergone a process of significant catching up.

The structural changes considered included an increase in total factor productivity growth in the traded goods sector, financial integration - a reduction in the interest rate faced by the domestic economy - and international public transfers from the EU. Under a regime of fixed exchange rates these structural changes induce a long-term increase in the real exchange rate which goes with a substantial increase in aggregate output and private consumption and a reallocation of resources from the non-traded sector to the traded sector. This means that the source of increase in aggregate output and consumption is the increase in the traded goods output and consumption.

The short-term effects of the structural changes, however, are markedly different from the long-term effects. In the short term, the allocation of resources tends to shift towards the non-traded goods sector and one may even witness an absolute reduction in employment and aggregate output. Moreover, under fixed exchange rates, real appreciation implies an increase in domestic inflation. Domestic inflation converges to the level prevailing in the rest of the world only as real appreciation fades.

An important point we bring forth is that the pattern of short-term macroeconomic adjustments to structural changes is strongly affected by the presence of nominal rigidities in the labour and non-traded goods markets. Indeed, in the absence of price stickiness the short-term effects of the structural changes on the real exchange rate, and therefore, on the real wages and the consumption price index, would be much greater and, indeed, much closer to the long lasting steady state effects. This changes the dynamics of real adjustment in that both employment and output may even decline in the short term as a result of the structural changes while consumption would increase by substantially less. In our example, the presence of nominal rigidities seems to smooth out in time the effects of the structural changes.

Finally, when the nominal exchange rate is allowed to adjust in order to guarantee consumer price stability there are no significant impacts on the response of real variables to the process of structural change. The patterns of resource allocation across sectors, overall economic activity, employment and consumption are not significantly affected. In other words, the quantitative features of macroeconomic adjustment to structural change stay the same. We interpret this finding as illustrating the absence of any significant trade-off between nominal and real convergence

This latter result clearly has policy relevance, in particular, for the EU accession countries, sincethe European Union Treaty indeed requires that economic policies in the Member States must obey the principles of stable prices, sound public finances and monetary conditions and a sustainable balance of payments. TAs part of the obligations of membership of the EU, he new members need to adopt policies consistent with the economic policy regime characterising the *acquis communuataire*. In particular, this requires that nominal and real convergence have to be pursued in parallel.

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Table 1 – The Dynamic General Equilibrium Model

Traded goods sector: Output, factor demands and pricing

$$YT_t = AT(LT_t^d)^{q_{LT}} KT_t^{1-q_{LT}} \tag{T.1}$$

$$KT_{t+1} = (1-d_{KT})KT_t + IT_t - m_{IT}\frac{IT_t^2}{KT_t} \tag{T.2}$$

$$NCFT_t = pt_t YT_t - w_t LT_t^d - pit_t IT_t \tag{T.3}$$

$$q_{LT}\, pt_t YT_t = w_t LT_t^d \tag{T.4}$$

$$\frac{q_{t+1}^{KT}}{1+r_{t+1}}(1-2m_{IT}\frac{IT_t}{KT_t}) = pit_t \tag{T.5}$$

$$q_t^{KT} = (1-q_{LT})\, pt_t \frac{YT_t}{KT_t} + \frac{q_{t+1}^{KT}}{1+r_{t+1}}\left[1-d_{KT} + m_{IT}\left(\frac{IT_t}{KT_t}\right)^2\right] \tag{T.6}$$

$$IT_t = stITT_t^{it} ITN_t^{(1-it)} \tag{T.7}$$

$$pit_t = \left(\frac{1}{st}\right)\left(\frac{pt_t}{it}\right)^{it}\left(\frac{pn_t}{(1-it)}\right)^{(1-it)} \tag{T.8}$$

$$\begin{aligned} & pt_t AT(LT_t^d)^{q_{LT}} KT_t^{1-q_{LT}} - q_t^{KT}\{KT_t - (1-d_{KT})KT_{t-1} - IT_t + m_{IT}\frac{IT_t^2}{KT_t}\} + \\ & \frac{q_{t+1}^{KT}}{1+r_{t+1}}\{KT_{t+1} - (1-d_{KT})KT_t - IT_{t+1} + m_{IT}\frac{IT_{T+1}^2}{KT_{t=1}}\} + \ldots \end{aligned} \tag{T.8a}$$

Non-traded goods sector: Output, factor demands and pricing

$$YN_t = AN(LN_t^d)^{q_{LN}} KN_t^{1-q_{LN}} \tag{T.9}$$

$$KN_{t+1} = (1-d_{KN})KN_t + IN_t - m_{IN}\frac{IT_t^2}{KT_t} \tag{T.10}$$

$$NCFN_t = (pn_t - m_p\left(\frac{pn_t}{pn_{t-1}}-1\right)^2)YN_t - w_t LN_t^d - pin_t IN_t \tag{T.11}$$

$$\Psi_t = (pn_t - m_p\left(\frac{pn_t}{pn_{t-1}}-1\right)^2)YN_t + (pn_{t+1} - m_p\left(\frac{pn_{t+1}}{pn_t}-1\right)^2)\frac{YN_{t+1}}{1+r_{t+1}} \tag{T.12}$$

$$w_t = \frac{\partial \Psi_t}{\partial LN_t} \tag{T.13}$$

$$\frac{\partial \Psi_t}{\partial LN_t} = \left\{ -\frac{1}{e_{pn}} \frac{pn_t}{pn_{t-1}} \left[1 - 2m_p \left(\frac{pn_t}{pn_{t-1}} - 1 \right) \right] + \left[pn_t - m_p \left(\frac{pn_t}{pn_{t-1}} - 1 \right)^2 \right] \right. \tag{T.14}$$

$$\left. - \frac{2}{e_{pn}} \frac{1}{1+r_{t+1}} \frac{YN_{t+1}}{YN_t} \frac{pn_{t+1}}{pn_t} m_p \left(\frac{pn_{t+1}}{pn_t} - 1 \right) \right\} q_{LN} \frac{YN_1}{LN_t}$$

$$\frac{\partial \Psi_t}{\partial KN_t} = \left\{ -\frac{1}{e_{pn}} \frac{pn_t}{pn_{t-1}} \left[1 - 2m_p \left(\frac{pn_t}{pn_{t-1}} - 1 \right) \right] + \left[pn_t - m_p \left(\frac{pn_t}{pn_{t-1}} - 1 \right)^2 \right] \right. \tag{T.15}$$

$$\left. - \frac{2}{e_{pn}} \frac{1}{1+r_{t+1}} \frac{YN_{t+1}}{YN_t} \frac{pn_{t+1}}{pn_t} m_p \left(\frac{pn_{t+1}}{pn_t} - 1 \right) \right\} (1 - q_{LN}) \frac{YN_1}{KN_t}$$

$$\frac{q_{t+1}^{KN}}{1+r_{t+1}} \left(1 - 2m_{IN} \frac{IN_t}{KN_t} \right) = pin_t \tag{T.16}$$

$$q_t^{KN} = \frac{\partial \Psi_t}{\partial KN_t} + \frac{q_{t+1}^{KN}}{1+r_{t+1}} \left[1 - d_{KN} + m_{IN} \left(\frac{IN_t}{KN_t} \right)^2 \right] \tag{T.17}$$

$$IN_t = snINT_t^{in} INN_t^{(1-in)} \tag{T.18}$$

$$pin_t = \left(\frac{1}{sn} \right) \left(\frac{pt_t}{in} \right)^{in} \left(\frac{pn_t}{(1-in)} \right)^{(1-in)} \tag{T.19}$$

Wage setting

$$(e_w - 1) \left(\frac{w_t (\bar{L} - \ell_t)}{pc_t C_t} \right) = e_w \left(\frac{(\bar{L} - \ell_t)}{\ell_t} \right) + m_w \left(\frac{w_{t+1}}{(1+r_t) w_t} \right) \left(\frac{w_{t+1}}{w_t} - 1 \right) - m_w \left(\frac{w_t}{w_{t-1}} \right) \left(\frac{w_t}{w_{t-1}} - 1 \right) \tag{T.20}$$

The household sector

$$U_{a,t} = \sum_{v=0}^{\infty} \gamma^v \beta^v \frac{\sigma-1}{\sigma}\left(c_{a+v,t+v}^{\frac{\sigma-1}{\sigma}} + B\ell_{a+v,t+v}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{T.21}$$

$$\sum_{v=0}^{\infty} g^v [1+r_{t+v}]^{-v} pc_t c_{a+v,t+v} \leq TW_{a,t} \tag{T.22}$$

$$TW_{a,t} \equiv HW_{a,t} + FW_{a,t} + PVF_{a,t} \tag{T.23}$$

$$HW_{a,t} = \sum_{m=0}^{\infty} \left(\tfrac{g}{1+r_{t+m}}\right) \cdot \left[W_{t+m}(\bar{L} - \ell_{a+m,t+m}) - LST_t \right] \tag{T.24}$$

$$FW_{a,t} = (1+r_{t-1})FW_{t-1} + NCFT_{t-1} + NCFN_{t-1} + \left[W_{t-1} \cdot (\bar{L} - \ell_{a-1,t-1}) \right] + TR_{t-1} + R_{t-1}$$

$$- pc_t C_{a-1,t-1} - LST_{t-1} \tag{T.25}$$

$$PVF_{a,t} = \sum_{m=0}^{\infty} \left(\tfrac{1}{1+r_{t+m}}\right)(NCFT_{a,t} + NCFN_{a,t}) \tag{T.26}$$

$$pc_t C_t = \left(1 - [1+r]^{s-1} gb^s\right)\left[HW_t + FW_t + PVF_t \right] \tag{T.27}$$

$$C_t = scCT_t^c CN_t^{(1-c)} \tag{T.28}$$

$$pc_t = \left(\frac{1}{sc}\right)\left(\frac{pt_t}{c}\right)^c \left(\frac{pn_t}{(1-c)}\right)^{(1-c)} \tag{T.29}$$

The public sector

$$pt_t CGT_t + pn_t CGN_t + rPD_t + TR_t + ner_t FT_t = LST_t + ner_t FT_t \tag{T.30}$$

Conditions for market equilibrium and price determination

$$FD_{t+1} = (1+r_t)FD_t + pt_t(CT_t + CGT_t + ITT_t + INT_t - YT_t) - ner_t(FT_t + R_t) \tag{T.31}$$

$$YN_t = CN_t + CGN_t + ITN_t + INN_t + ner_t FT_t / pn_t \tag{T.32}$$

$$LT_t^d + LN_t^d = L_t \tag{T.33}$$

$$FW_t = PD_t - FD_t \tag{T.34}$$

$$pt_t = ner_t ptw_t \tag{T.35}$$

$$r_t = rf_t + rp_t + rp\left(\frac{FD_t}{pt_t YT_t + pn_t YN_t}\right) + \log\left(\frac{ner_{t+1}}{ner_t}\right) \tag{T.36}$$

Table 2 – Parameter set

PARAMETERS	VALUE	TYPE
Household parameters		
Discount factor	0.03581	calibrated
Probability of survival	0.97500	data
Savings rate out of total wealth	0.94129	calibrated
Production scalars in traded goods sector		
Scale parameter	8.77966	scale
Labour share	0.55000	data
Capital share	0.45000	data
Depreciation rate	0.09596	calibrated
Adjustment cost as a percentage of investment	0.20000	assumed
Adjustment cost parameter	1.66733	calibrated
Production scalars in non-traded goods sector		
Scale parameter	12.12338	scale
Labour share	0.60000	data
Capital share	0.40000	data
Depreciation rate	0.08150	calibrated
Adjustment cost as % of investment	0.20000	assumed
Adjustment cost parameter	1.96320	calibrated
Expenditure shares of traded goods		
In private consumption	0.50000	data
Scale parameter for private consumption	2.00000	scale
In investment in traded goods sector	0.40000	data
Scale parameter for investment in the traded goods sector	1.96013	scale
In investment in the non-traded goods sector	0.35000	data
Scale parameter for investment in the non-traded goods sector	1.91066	scale
In public consumption	0.05000	data
Monopolistic competition and nominal adjustment costs		
Mark-up in non-traded goods sector	0.10000	assumed
Nominal adjustment costs for the price of the non-traded good	50.00	data
Mark-up in the labour market	0.10000	assumed
Nominal adjustment costs for the nominal wage rate	50.00	data
Interest rate parameters		
Responsiveness of the endogenous risk premium to foreign debt	0.4000	data

Table 3 – Data set

DATA	VALUE	TYPE
Domestic spending data		
GDP growth rate	0.00000	normalised
GDP	1.00000	normalised
GDP – traded sector	0.38000	data
GDP – non-traded sector	0.62000	data
Private consumption	0.57500	data
Private investment in the traded goods sector	0.10125	data
Private investment in the non-traded goods sector	0.12375	data
Public consumption	0.20000	data
Foreign account data		
Trade deficit	0.00000	normalised
Interest payments	0.00000	normalised
Unilateral public transfers	0.00000	normalised
Current account deficit (+)	0.00000	normalised
Public account data		
Public consumption	0.20000	data
Government transfers	0.15000	data
Interest payments on public debt	0.02500	data
Lump sum tax revenues	0.37500	data
Public deficit (+)	0.00000	normalised
Population		
Population / labour force	1.00000	normalised
Population growth rate	0.00000	normalised
Labour force in the traded goods sector	0.38327	calibrated
Labour force in the non-traded goods sector	0.61673	calibrated
Leisure	0.20000	assumed
Leisure scale parameter	-0.17320	scale
Stock variables		
Private capital in the traded goods sector	0.84409	calibrated
Private capital in the non-traded goods sector	1.21473	calibrated
Foreign debt	0.00000	normalised
Public debt	0.50000	data
Human wealth	4.51063	calibrated
Value of the firms	4.78406	calibrated
Prices		
Nominal exchange rate	1.00000	normalised
International price of traded goods	1.00000	normalised
Domestic price of traded goods	1.00000	normalised
Price of non-traded goods	1.00000	normalised
Price of private consumption	1.00000	normalised
Price of investment in the traded goods sector	1.00000	normalised
Price of investment in the non-traded goods sector	1.00000	normalised
Wage rate	0.54719	calibrated
Risk free interest rate	0.03500	data

Interest rate – exogenous risk premium	0.01500	data
Interest rate – endogenous risk premium	0.00000	normalised
Shadow price of capital in the traded goods sector	1.75000	calibrated
Shadow price of capital in the non-traded goods sector	1.75000	calibrated

Annex 1: Calibration and Parameterisation Procedures

The data and parameters used to simulate the dynamic general equilibrium model are presented in Tables 2 and 3, respectively. These data and parameters were obtained in two fundamentally different ways. First, some data and parameters are obtained directly from or are directly implied by data sources or the literature (referred in Tables 2 and 3 as Data). In this group we also include guesses for parameters for which there is no information (referred to as Assumed in the Tables), scale parameters (referred to as Scale in the Tables), and parameters and variables which, without loss of generality, we have normalised (referred to as Normalised in the Tables). Second, the remaining data and parameters were obtained by calibration of the model (referred to as Calibrated in the Tables). This means that they were obtained in such a way that the model replicates the observed data given the parameters obtained from the data sources, assumed, or normalised. We turn now to a detailed discussion of both parameterisation and calibration.

A.1.1 Parameterisation

In this sub-section we present the baseline dataset which is used in the simulations and for which the model should, when suitably calibrate, match in the steady state. The overall objective is to produce data and parameter sets that broadly match the ‘stylised facts’ of the Irish and Portuguese economies. The sources are mostly input/output tables and national accounting information but educated guesses of some values are frequently also used. Whenever relevant we attempt to use information for a relatively large time span. This is because we want the base case of the model to capture the stylised long-term trends for these economies while minimising the business cycle effects. This way the counterfactual simulations can be interpreted and pure deviations from the long-term trends.

We start by considering a zero growth steady state. For convenience, the baseline value of aggregate GDP is normalised at unity. Similarly, in the baseline all price indices are normalised to unity. Furthermore, we normalise the total time endowment to 3.0 and total hours worked in steady state to one-third of the total endowment, the standard value in the dynamic general equilibrium literature. Finally, we normalise all international flows (0.00) including foreign debt (0.00). All data is presented as shares of the normalised GDP.

The decomposition of the GDP between traded and non-traded goods is always a difficult matter. To establish this decomposition we used input/output tables and ranked sectors of activity according to their share of exports in total final use (i.e. output minus intermediate sales). A cut-off point of 30% was used. On this basis, the non-traded sector comprises all services sectors plus building and construction. Manufacturing and agriculture are included in the traded goods sector. We determined that non-traded goods correspond to approximately 60% of total output in Ireland and about 63% in Portugal. We use a figure of 62% of the aggregate GDP in the simulations.

To determine the domestic composition of spending between the traded and non-traded sectors, we start from the aggregate private and public consumption and investment in both the traded and non-traded sectors from national accounting sources and re-scale their values to match the remaining assumptions. The values used for the simulations are 57.5%, 20%, 10.1% and 12.4%, of the aggregate GDP, respectively. These values together with the aggregate values for each expenditure category allow us immediately to obtain the scale parameters for the corresponding expenditure category.

The absence of a trade deficit in the baseline imposes restrictions on the values that can be assumed by the different types of domestic consumption and investment expenditure on both traded and non-traded goods. We assume that the shares of traded goods in private consumption, public consumption, private investment in the traded sector, and private investment in the non-traded sector are, 50%, 5%, 40% and 30%, respectively. These values are consistent with the zero trade balance assumption and some stylised facts about the composition of domestic expenditures based on input-output tables. Indeed, it is widely accepted that private consumption relies more heavily on traded goods than the other expenditure (the actual figures for Ireland and Portugal are between 45% and 50% of private consumption being purchases of non-traded goods). Also, public consumption spending is mostly on non-traded goods. Finally, the shares of traded goods in investment expenditures is greater in the traded goods sector than in the non-trade goods sector (the actual shares of traded goods in private investment in Ireland and Portugal are around 51% for the traded sector and 45% for the non-traded sector).

The public sector account assumes a balanced budget with a public debt of 50% of the GDP. Government transfers are 15% of the GDP and the total taxation consistent with the balanced budget assumption, and also accounting for interest payment on the public debt, is 37.5% of the GDP.

In terms of the parameter set, we use the input/output tables for Ireland and Portugal to determine the labour shares in both the traded and non-traded goods sectors. The clear indication is that the labour shares in value added are greater in the non-traded goods sector, a fact reflected in the stylised figures used for the simulations, 55% for the traded sector and 60% for the non-traded sector which are somewhere between the real figures for Ireland and Portugal.

Given the labour shares and the assumption of wage equalisation between the two sectors, we obtain the allocation of labour force between sectors using the first order conditions for labour for both the tradable goods sector and the non-tradable goods sector. The values we obtain are that 38% of the labour force is employed in the traded sector and the remaining 62% in the non-traded good sector. These values are very much in line with the data for both Ireland and Portugal, which suggests that the share of employment in the traded good sector are 36% and 38.5%, respectively.

In turn the nominal wage rate is obtained using the first order condition for labour for the tradable goods sector. It depends on the labour share parameters for both sectors directly and through the allocation of labour force. We obtain a value of .55, which means that wage income amounts to 55% of the GDP. This value is in line with the labour shares assumed for the two sectors and the fact that there is a mark-up in the non-traded sector. Finally, the scale parameter for leisure is obtained from the long-run version of the wage equation. It depends on the observed values for consumption, labour force participation, and the value obtained for the wage rate. It depends directly on the leisure as a fraction of the total labour force and on the mark up in the labour market.

The probability of survival is set at 97.5%, which corresponds to an active life of 40 years. In turn, the interest rate faced by the domestic economy is assumed to be 5%. This includes the risk free interest rate of 3.5% and the exogenous risk premium of 1.5%. The endogenous risk premium is normalised to 0.00 since it is a function of the foreign debt to GDP ratio which is itself normalised to 0.00. The responsiveness of this endogenous risk component to the foreign debt to output ratio is set at 0.4. This value is consistent with the estimates for the euro area that a one percentage point in the government debt to GDP ratio translates into an increase of 4 basis points in the government bond yield.

As to the real adjustment costs we assume that they are the same for both sectors and correspond to 20% of the investment observed in the baseline. This means that 20% of the observed investment is lost in terms of capital accumulation. This value is in line with the assumptions in the literature.

Finally, we need to consider the values for the nominal adjustment costs in the non-traded and labour markets as well as the degree of monopolistic competition in both markets. We assume that the price mark-ups in both markets are 10%. As to the nominal adjustment cost parameters we choose these parameters to match available evidence on price on wage stickiness in the euro area. As noted earlier, there is a symmetric relationship between the price equations generated by Calvo contracting and our quadratic adjustment formulation. Using the Calvo approach, estimates of the average length of time over which prices remain fixed in the euro area range from 4 quarters (Gali et al, 2001) to 10 quarters (Smets and Wouters, 2002). These estimates, however, relate to the whole economy. In our framework, 40% of output is accounted for by the traded goods sector, which we assume to be a flexible price sector. These aggregate estimates would thus imply an average duration of prices in the non-traded sector of between 8 and 20 quarters. Taking as our starting point, the midpoint of this range, namely 14 quarters, would lead to a value of the nominal price adjustment cost of 50 in our baseline steady state. As to wage stickiness, the evidence for euro area countries is relatively thin. We calibrate our nominal wage adjustment cost parameter so that the dynamic response of wages to consumer prices of our equation matches that of the estimated wage equation of Smets and Wouters (2002). This leads to a value, at baseline steady state, of 50.

A.1.2. Model Calibration

We calibrate the model to capture long-term trends in the economy, in particular the calibrated values are such that the model replicates the long-term data and other information we presented above. This means that the calibration conditions are based on the model steady state conditions, i.e., on the fact that in the long term the ratios of all the relevant variables to GDP are constant. In addition, the calibration procedures recognise that the steady state restrictions imposed on the model depend on the presence of price and wage setting as well as on the effects of monopolistic competition in the non-traded sector as well as the labour market.

By definition, the calibrated variables and parameters cannot be set independently in that they depend on the values assumed by the parameters and variables introduced in the previous section. The plausibility or lack thereof of the calibrated values is, accordingly, in itself an indication of the plausibility or lack thereof of the parameters and data presented in the previous section. The details of the calibration strategy are discussed below and are presented in a recursive manner and highlighting the dependency of the calibrated values on the parameters and date introduced in the previous section..

We start with the determination of human wealth. Human wealth is obtained from the corresponding equation of motion. It depends on the wage rate and therefore on the labour share parameters for both sectors. In addition, it depends on the interest rate, the growth rate for the economy and on the survival probability. The calibrated value is 451% of the GDP.

The steady state profits for the firms for each sector are obtained from the corresponding equations in the model. They depend on the wage rate and therefore on the labour share parameters for both sectors. The value of the firms in both sectors is obtained from the corresponding equation of motion. It depends on the wage rate and therefore on the labour share parameters for both sectors. In addition, it depends on the interest rate and the growth rate for the economy. The calibrated value is 478% of the GDP.

The subjective discount rate is obtained from the consumption equation given the observed consumption, foreign debt, and public debt and the calibrated human wealth and value of the firms. It is therefore, affected by all the parameters that enter in the calibration of human wealth and the value of the firms. In addition it depends on the probability of survival. The value calibrated is 3.6%, which is in line with the risk free interest rate in the economy.

The savings rate out of total wealth depends on the probability of survival and the subjective discount rate and indirectly on everything used to determine the subjective discount rate. The calibrated value is 94.1%.

The shadow price of capital in the traded goods sector is obtained from the corresponding variational condition and using the assumptions about the determination of adjustment costs (see below). It depends on the interest rate and adjustment costs as a share on observed investment in the sector. The calibrated values are 1.75 and are the same in both sectors since the real adjustment costs are assumed to be equal and the nominal rigidities in the non-traded sector are zero in the context of the calibration.

The depreciation rate in the tradable goods sector is obtained from equalising the variational condition for the shadow price of capital and the equation of motion for the shadow price of capital as well as the assumptions about the determination of adjustment costs (see below). It depends on the observed values of output and investment in the sector as well as the calibrated value of the shadow price of capital. In addition it depends on adjustment costs as a share on observed investment in the sector, the share of capital in production and the growth rate of the economy. Indirectly it depends on the interest rate through the shadow price of capital. The calibrated value is 9.6%, which implies an average life of the capital assets of just over 10 years.

The capital stock in the traded good sector is obtained from the corresponding equation of motion. It depends on the observed level of investment in the sector as well as on the assumptions about the determination of adjustment costs (see below). In addition it depends on the rate of growth of the economy as well as the depreciation rate and everything implicit in its determination. The calibrated value is 84.4% of the aggregate GDP.

The adjustment cost parameter for investment is obtained from the definition of adjustment costs assuming that total adjustment costs are a given share of the observed investment in the sector. It depends on the observed investment in the sector as well as the calibrated stock of capital and all parameters involved in its determination. The calibrated value is 1.67.

The scale parameter for the tradable goods sector is obtained from the production function given observed output, labour and capital shares in production, and the calibrated labour input and capital stock. The calibrated value is 8.8.

The calibration procedure to obtain the depreciation rate, the capital stock, the adjustment cost parameter, and the output scale parameter for the non-traded good sector is similar to the procedure for the traded sector. In addition to the factors identified above for the tradable goods sector, the calibration for the non-traded good sector depends also on the mark-up parameter. The calibrated value for the depreciation rate is 8.2%, which implies a life of about 12 years for the capital assets. The calibrated stock of capital is 121%, of aggregate GDP. Finally, the calibrated values for the adjustment cost and the scale parameters are 1.96 and 12,1, respectively.

It is important to note that the calibrated values for the depreciation rates in both sectors are in line with the figures commonly used in the literature. Furthermore, they are consistent with the evidence for Ireland and Portugal that the depreciation rate in the traded good sector is higher than in the non-traded good sector. As to the values for the capital stocks they imply an aggregate capital output ratio of 2.1. Furthermore, consistent with the observed output and investment patterns in Ireland and Portugal, the capital stock is greater in the non-traded good sector in absolute value but the capital intensity is greater in the traded goods sector, 2.2 versus 1.9.

A few final remarks are due on the role of nominal rigidities and monopolistic competition in the calibration procedure. Changes in the nominal rigidities do not affect the calibrated values since it is assumed that prices grow at the appropriate steady state growth rate (in this case zero) and only deviations from this growth rate are subject to nominal adjustment costs. This implies that in the steady state by design there are no nominal adjustment costs in either the non-traded goods market or the labour market. In turn, changes in the degree of monopolistic competition in the labour markets only affect the scale parameter for leisure. The rest of the variables are not affected. Changes in the degree of monopolistic competition in the non-traded goods market affect many of the calibration values. This is because it affects the calibrated allocation of labour between the two sectors and therefore the calibrated wage rate and everything that depends on it in the calibration process.

Charts 1 to 3 show percentage differences from base in the levels of the variables for all variables except:

- **Output growth, Inflation and Interest rates (percentage point difference from base)**

- **Foreign debt (difference from base in GDP points)**

Chart 1:

The red line shows the effect of the interest rate shock
The blue line shows the effect of the traded TFP shock
The green line shows the effect of the international transfers shock
The black line shows the combined effect of all 3 shocks

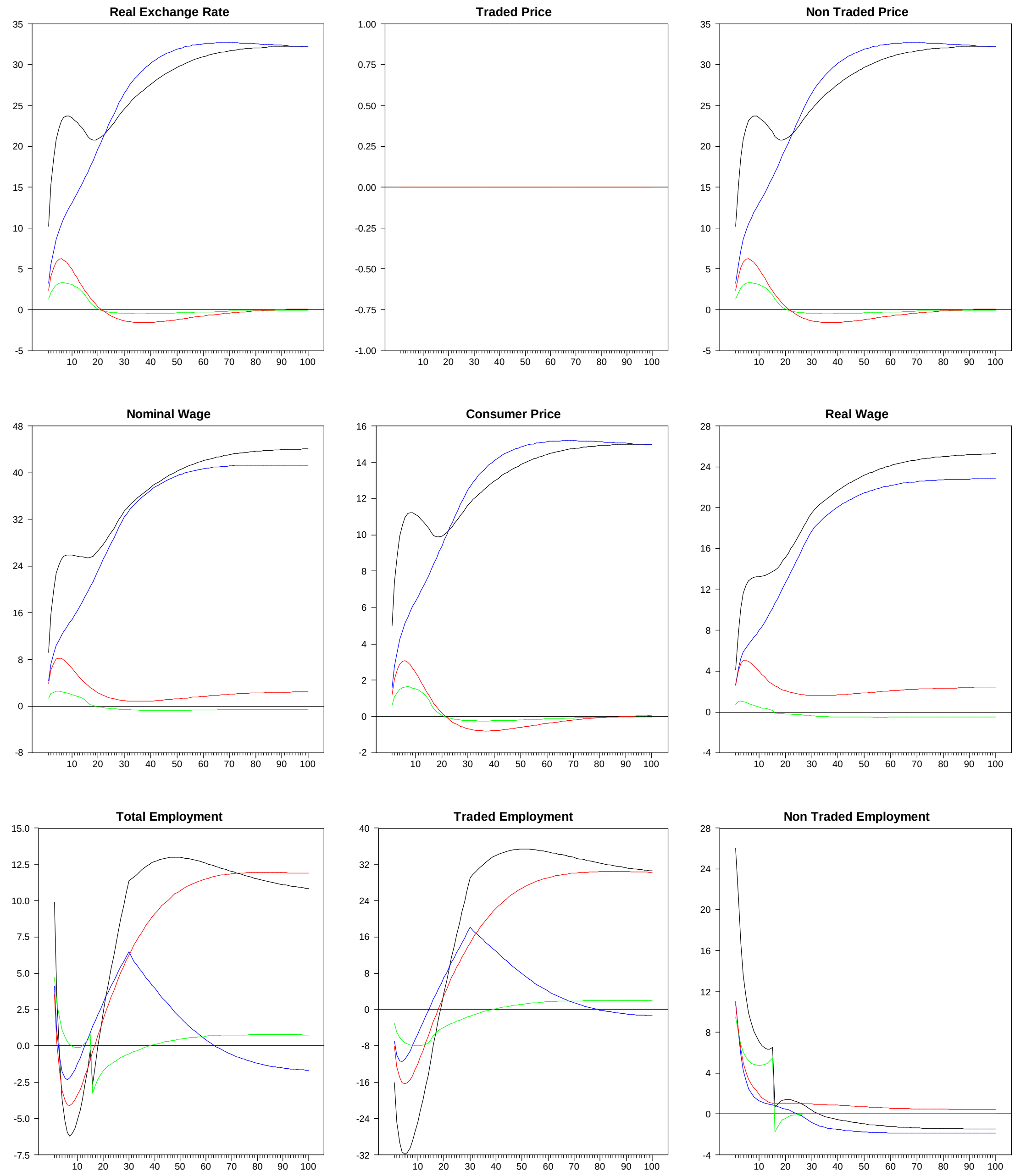
Chart 2:

The solid line shows the effect of all 3 shocks under sticky non-traded prices and wages
The dashed line shows the effect in the absence of price and wage stickiness

Chart 3:

The solid line shows the effects of the three shocks under a fixed exchange rate
The dashed line shows the effects of the same shocks under floating exchange rates

Chart 1. All 3 Shocks - Fixed Exchange Rate



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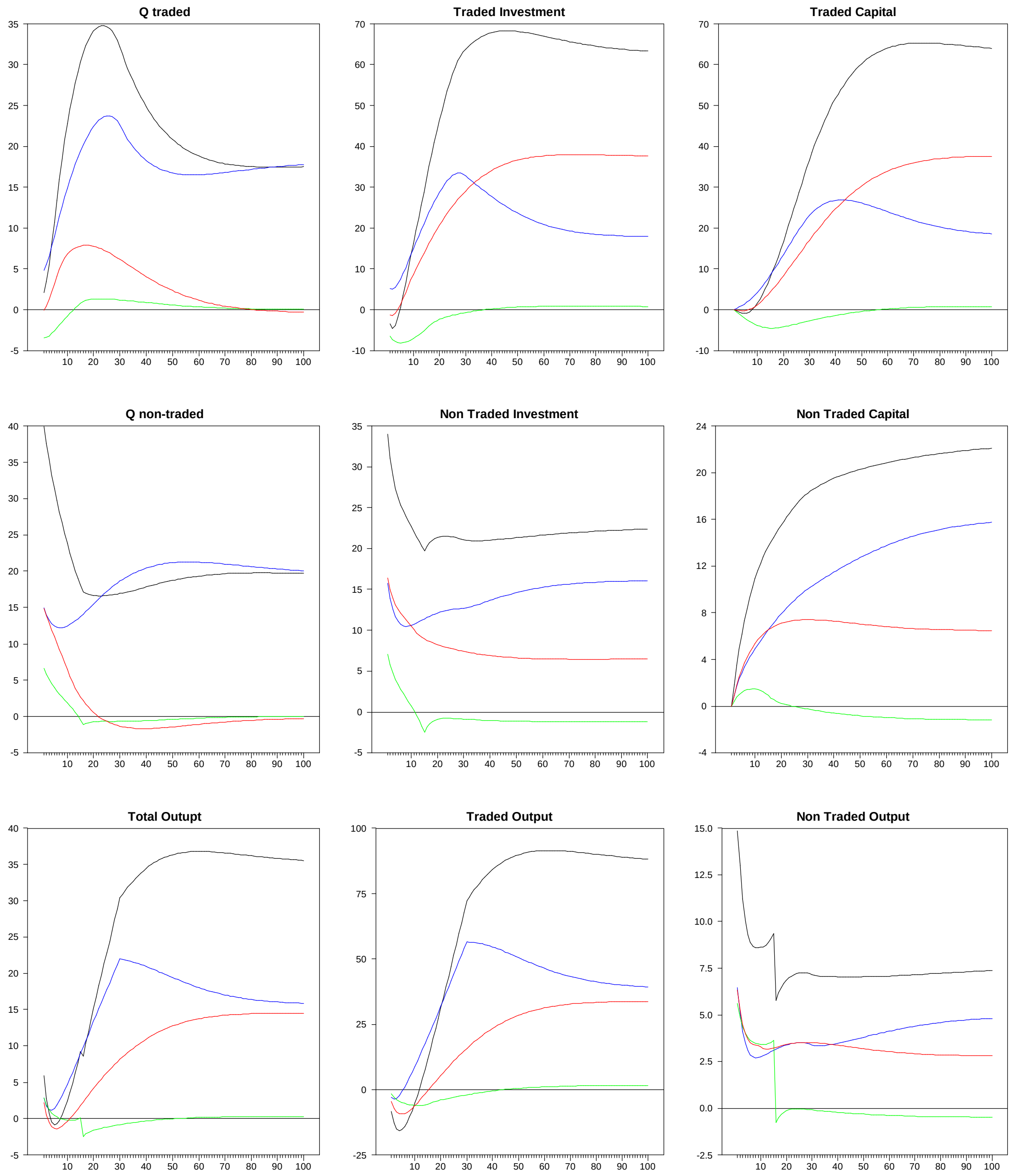

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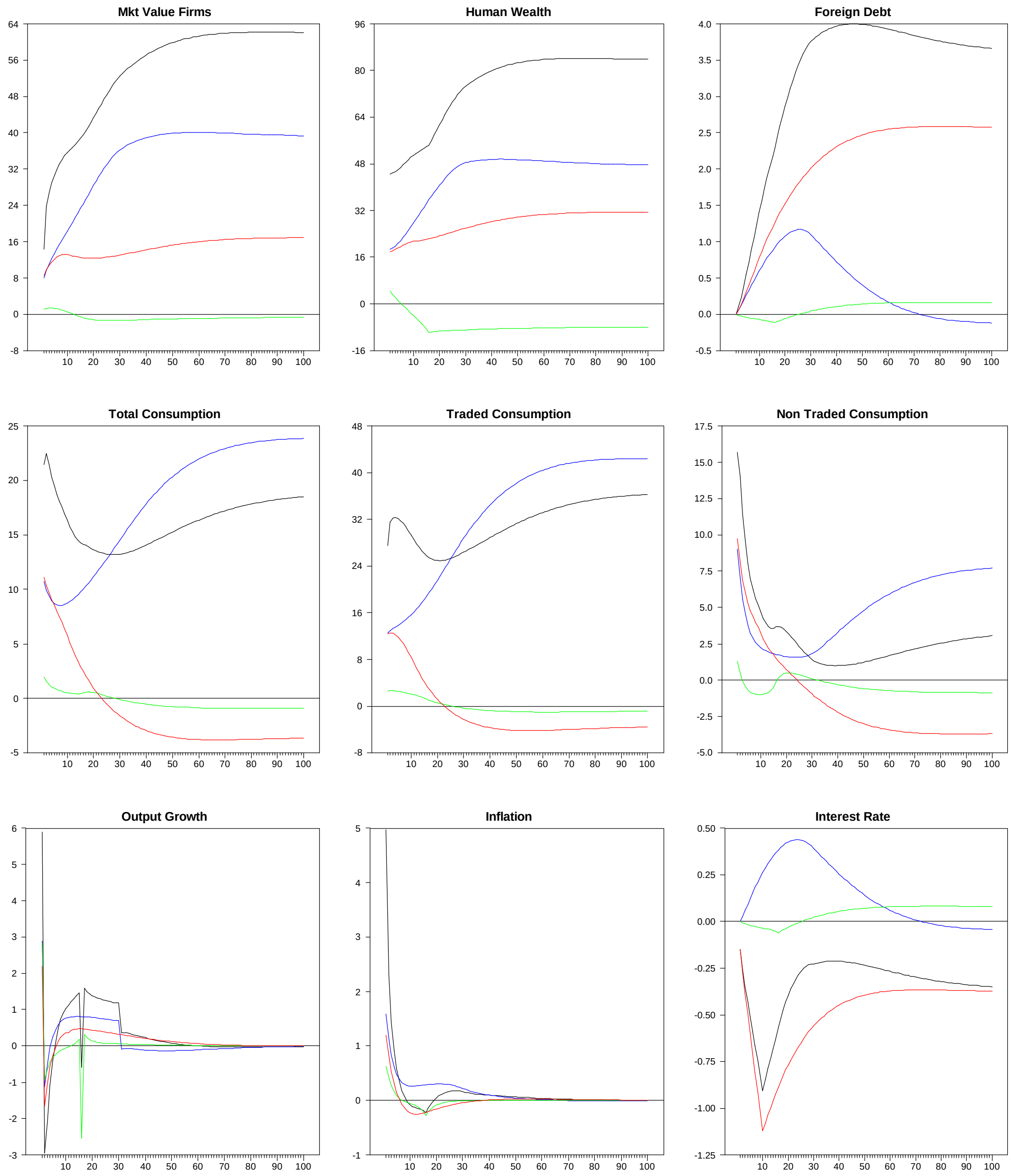
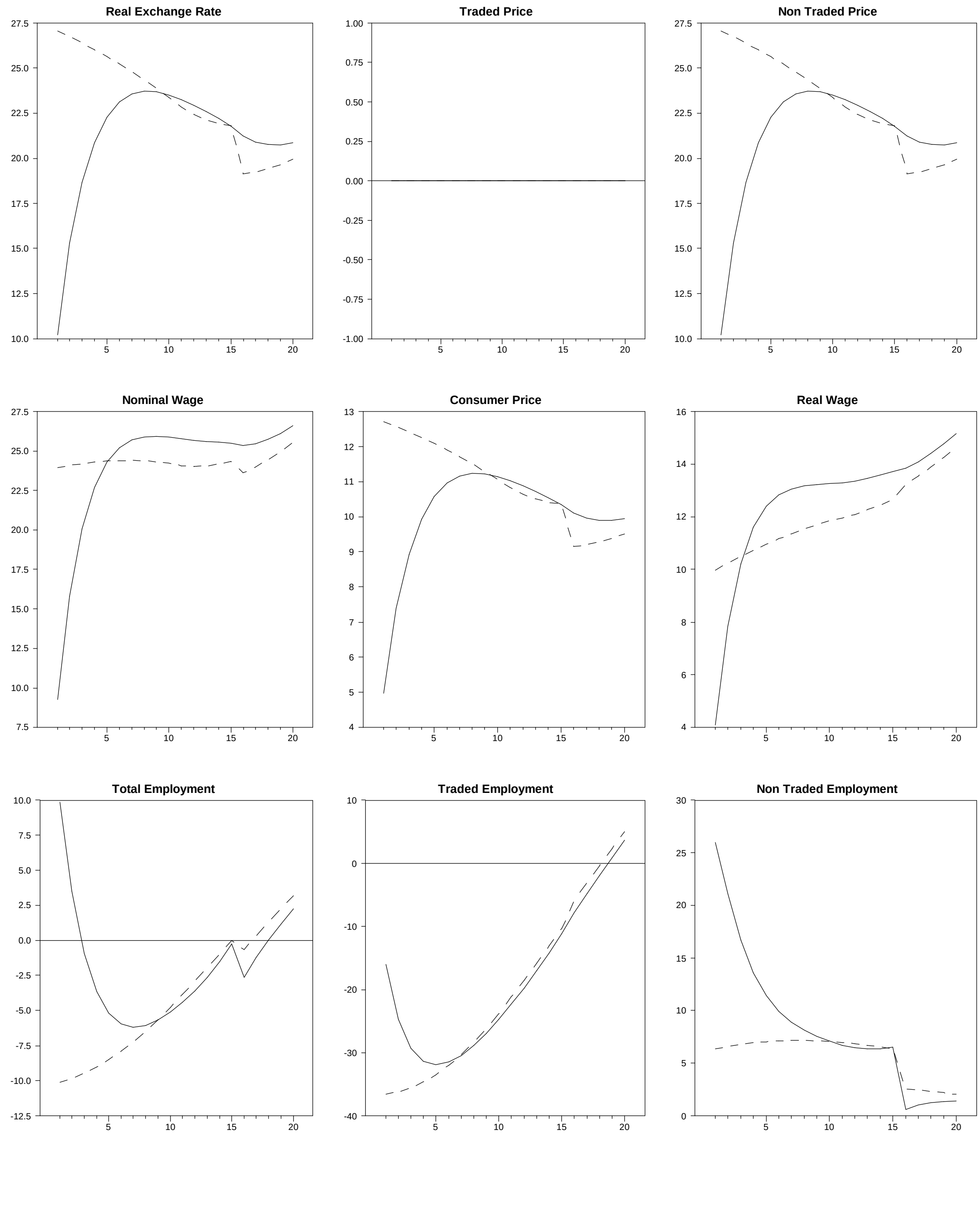


Chart 2. All 3 Shocks - Stickiness versus Non-Stickiness



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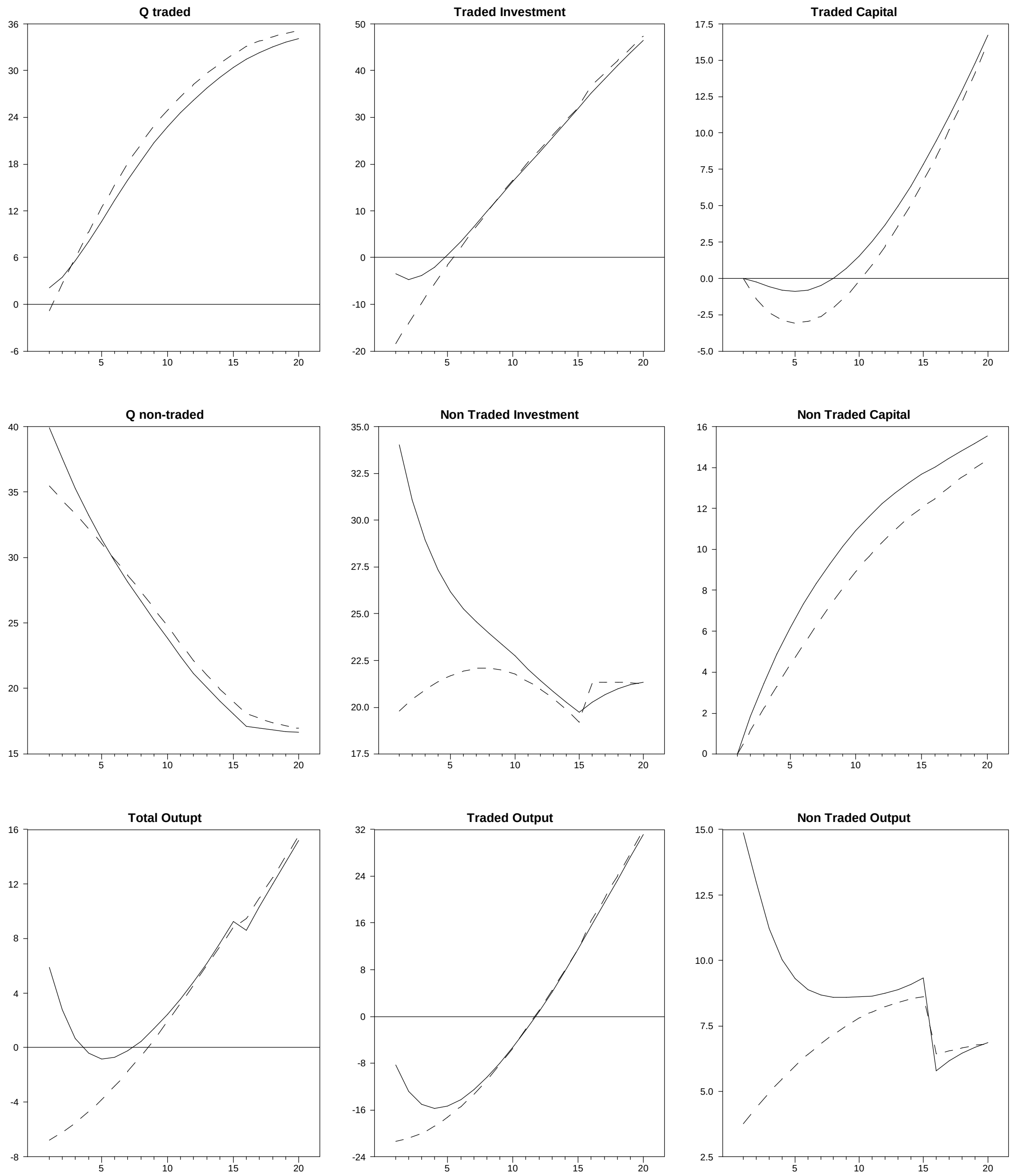

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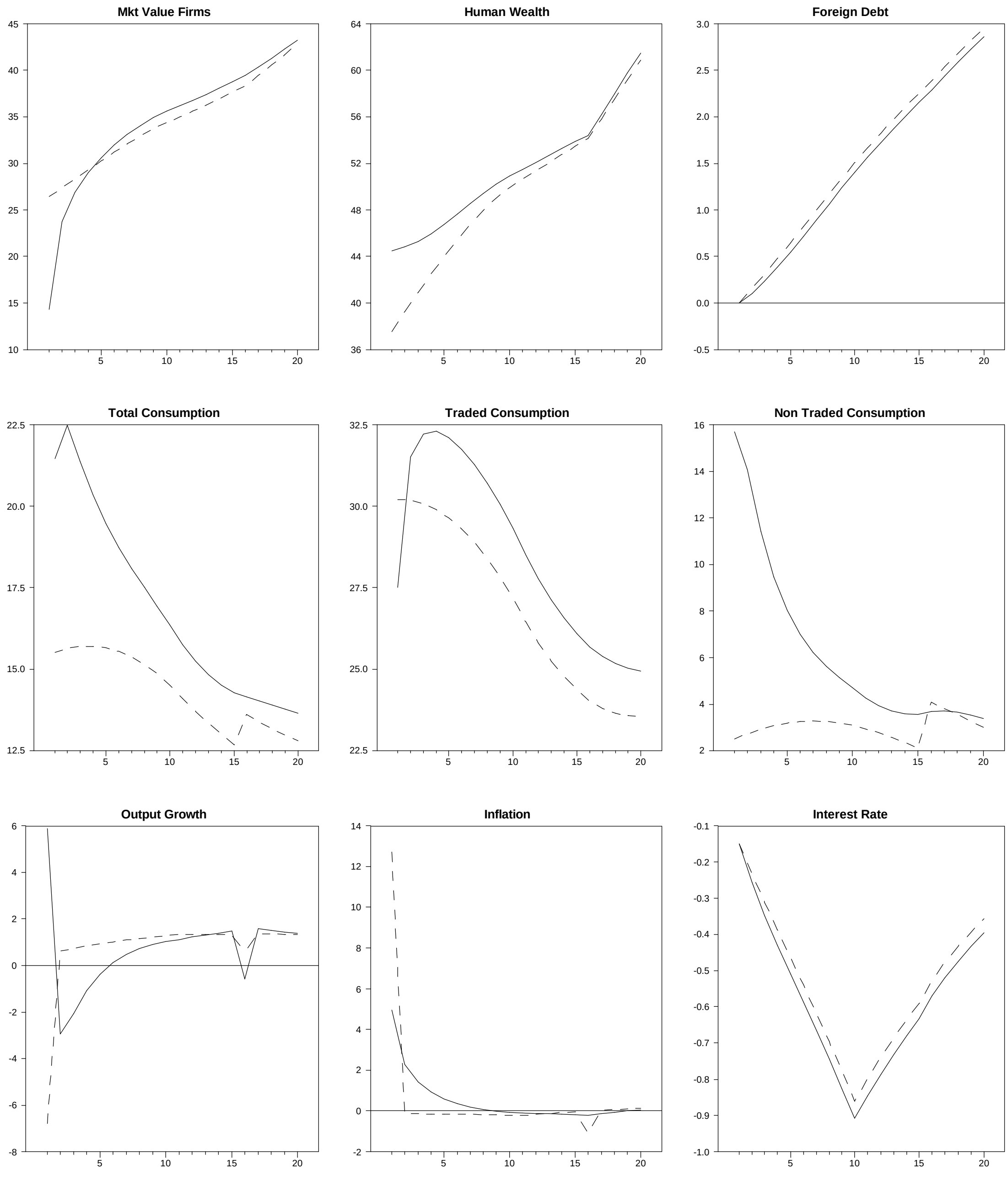
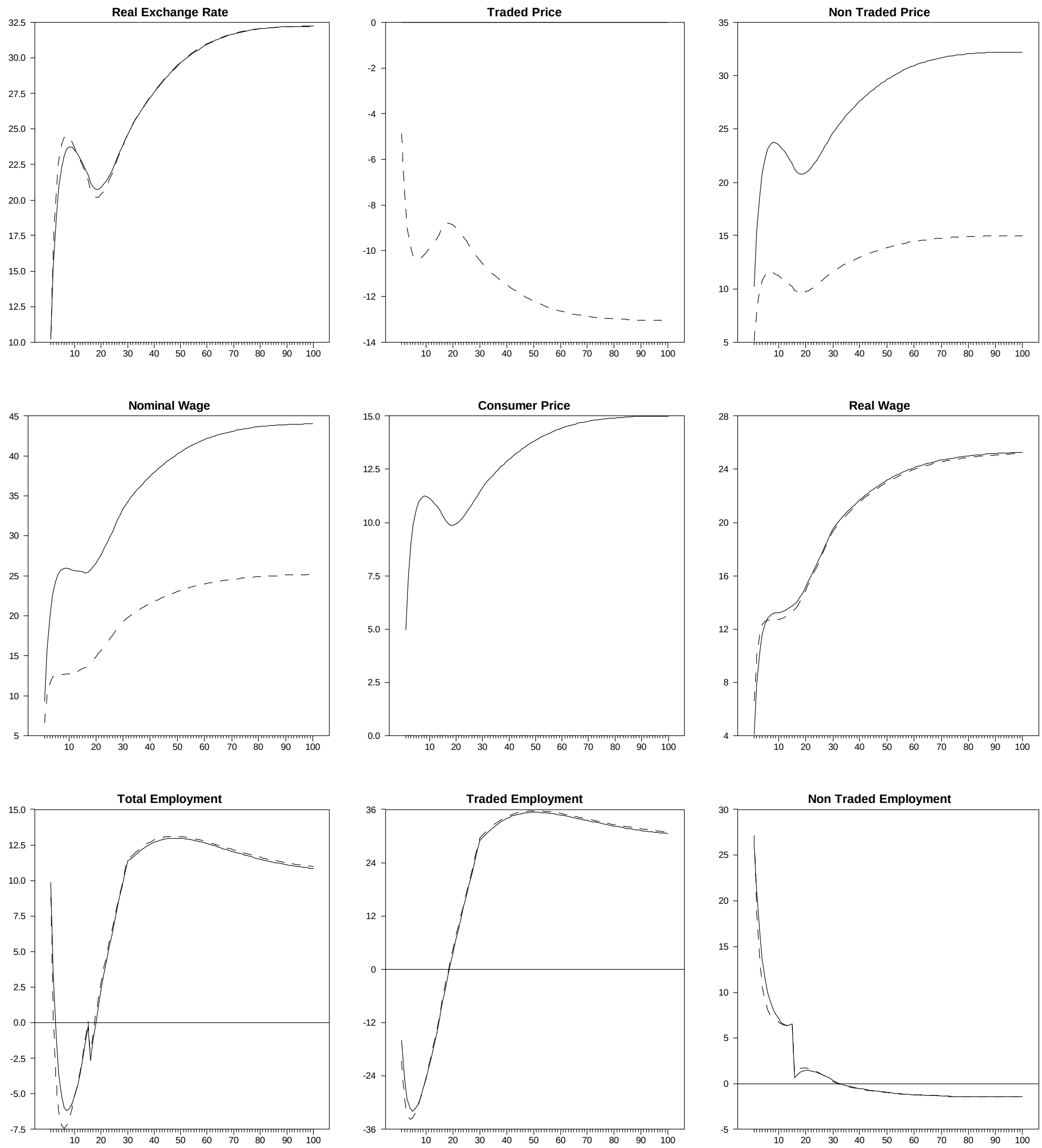


Chart 3. All 3 Shocks - Fixed versus Floating Exchange Rate



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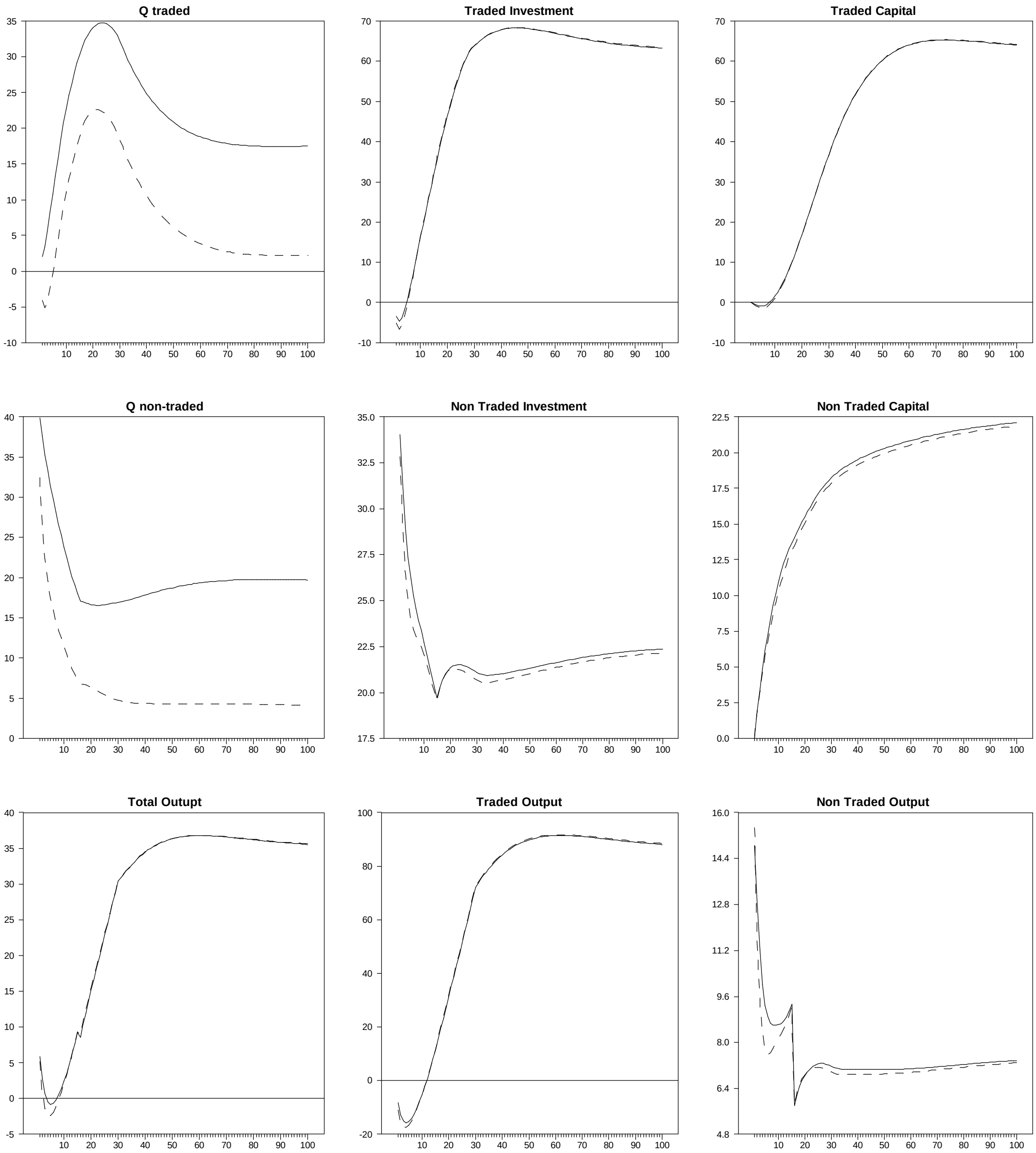

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