

Employment and Inflation Responses to an Exchange Rate Shock in a Calibrated Model

COLIN BERMINGHAM*

Central Bank and Financial Services Authority of Ireland, Dublin

Abstract: Ireland has no ability to affect the exchange rate through interest rates following the adoption of the euro. This paper provides a theoretically transparent method for analysing the impact of an exchange rate shock on employment and the aggregate price level in this context. The split between the tradable and non-tradable sectors of the economy is highlighted. The model is used to examine a specific exchange rate shock. The results of this calibration suggest that a sustained increase of 15 per cent in the value of the euro would reduce employment by 1.5 per cent and the domestic price level by about 7.3 per cent.

I INTRODUCTION

The aim of this paper is to provide a theoretical model of the economy that is capable of explaining the effect of a change in the exchange rate on employment and the aggregate price level. The model emphasises the distinction between the tradable and non-tradable sectors of the economy, which is important from both a theoretical and empirical viewpoint. The model is then used to estimate the response of unemployment and inflation to a specific exchange rate change.

This paper first sets out the model formulated by Barry (1997) but with the tradable sectors defined differently. In this paper, prices can vary in all sectors and the desired level of pass-through can be specified. Using the same

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methodology but with fewer assumptions, an expression for non-tradable prices is derived. Furthermore, a distinction is drawn between long-run and short-run effects and an explicit time horizon is put on these effects. The paper goes beyond issues considered in Barry (1997) by considering the implications of an exchange rate change on the aggregate price level. It draws on a theoretical framework from Barry (2001), which considers the trade-off between price-level and employment responses to a nominal shock in an analogous two-sector model. The model is then used to estimate how employment and the aggregate price level will be affected by a 15 per cent rise in the value of the euro.

In order to measure the effect of the exchange rate on the price level, it is necessary to construct an open economy model. It is also necessary to identify how the exchange rate will influence the price level in the model. Several open economy models exist that relate the behaviour of the exchange rate and the inflation rate. These models differ considerably in terms of the importance that they place on the role of the exchange rate in determining inflation. At one end of the spectrum, Purchasing Power Parity (PPP) posits that the domestic inflation rate is determined entirely by changes in the exchange rate and foreign inflation rates. As such, it attaches great importance to the exchange rate in explaining inflation. There is complete pass-through from the exchange rate to the domestic inflation rate. Empirical support for this strict form of PPP in relation to consumer prices is quite weak in the short term. However, there is widespread evidence in favour of PPP as a long-run proposition. (See Froot and Rogoff (1995) for a survey on PPP.) This is particularly true in relation to tradable prices.

At the other end of the spectrum, some recent literature on “new open economy macroeconomics” uses an assumption called “pricing-to-market”, which attaches no importance to the exchange rate in the determination of consumer price inflation. (See Lane (2001) for a survey.) In this family of model, import price setters set the import price equal to the domestic price. This price fixing practice is maintained regardless of shifts in the exchange rate. There is no pass-through at all. Devereux and Engel (2002) have termed this as “exchange rate disconnect”. Neither of these polar-case models is appropriate to the Irish case.

It is necessary to consider an intermediate model that places partial but not absolute importance on the exchange rate in the analysis of domestic consumer prices. One such model is the “Scandinavian” model of inflation. This type of model advocates separate treatment for the tradable and non-tradable sides of the economy in recognition of the different price determination mechanisms in operation. Inflation in the tradable sectors of the economy is determined by PPP. In the non-tradable sectors, the inflation

rate is a markup over costs, wages or some other appropriate variable. Although the approach adopted in this paper is similar to the Scandinavian model of inflation, it differs in its treatment of non-tradable prices, to the extent that non-tradable prices are not modelled strictly as a mark-up on another variable. Furthermore, full pass-through is not assumed for tradable prices but can be specified using the pass-through parameter if desired. Fitz Gerald and Shortall (1998) examine pass-through from the Irish pound/sterling bilateral exchange rate and find that it varies from 8 per cent to 51 per cent at a two year horizon depending on whether the exchange rate change is consistent with an estimated long-run cointegrating relationship for UK prices. Anderton (2003) and Hahn (2003) consider the issue of exchange rate pass-through in a euro area context. They find a 50 per cent pass-through but over a shorter time horizon.

Models of this variety, which make the distinction between tradable and non-tradable prices, are useful in explaining the price determination process in an open economy. Kenny and McGettigan (1996) use multivariate cointegration analysis to demonstrate the empirical relevance of the distinction between tradable and non-tradable prices in Ireland. They show the strongest form of PPP to be consistent with the data on tradable prices in the long run. Slevin (2003) obtains the same result using the autoregressive distributed lag approach to cointegration. Slevin also finds that prices in the non-tradable sector are determined by wages and productivity growth. The empirical evidence from these studies demonstrates clearly that the distinction between tradable and non-tradable prices is warranted in the Irish case.

II MODEL DESCRIPTION

The model used is adopted from Barry (1997). The economy produces three types of goods: euro area tradable goods, foreign tradable goods and non-tradable goods. Variables are subscripted with E, F and N. The subscript E refers to euro area tradable goods, which are tradable goods consumed domestically that compete on euro area markets. The subscript F refers to foreign tradable goods, which are tradable goods consumed domestically that compete on international markets outside the euro area. Tradable goods can be produced domestically or abroad. The subscript N refers to domestically produced and consumed non-tradable goods. The superscript * denotes foreign variables.

Tradable goods prices are determined on international markets. The price of goods in the euro area sector is simply equal to euro area prices. In setting

euro area prices, euro area producers engage in a certain degree of pricing-to-market behaviour following an exchange rate change. The weight given to this behaviour is measured by σ . Exchange rate changes are the only source of price variation in this sector in the model. Prices in the foreign sector are determined by Purchasing Power Parity (PPP). The euro price of these goods is determined by the price on international markets, the exchange rate and the assumed level of pass-through, β :

$$p_e = p_e^* \quad (1)$$

$$p_e^* = e^\sigma \quad (2)$$

$$p_f = e^\beta (p_f^*)^\gamma \quad (3)$$

Obviously, the Law of One Price does not hold in practice but is being relied upon as a maintained assumption. In addition, p_f is constant so that the only source of price changes in the foreign sector is from the exchange rate but the model can allow for it to vary. The nominal value of the marginal product of labour is equal to the nominal wage rate:

$$w_i = p_i MPL_i \quad (4)$$

Total employment in the model refers to total private non-agricultural employment. Sectoral employment is a function of the real wage in each sector:

$$L = L_e(w_e) + L_f(w_f) + L_n(w_n) \quad (5)$$

where w_i refers to the real product wage in sector i ; ($w_i = w/p_i$). The derivative of labour employment in each sector with respect to the real wage in that sector is negative:

$$\frac{dL_i}{dw_i} < 0$$

The three-good utility function is specified as follows:

$$U = Y_f^\psi Y_e^\chi Y_n^\theta \quad (6)$$

The nominal demand for non-tradables is a fixed proportion of nominal income:¹

¹ See Internet Appendix, Section 1 for more details.

$$p_n Y_n = \theta M \quad (7)$$

Real output, Y , is expressed in terms of European prices:

$$Y = \frac{p_n Y_n}{p_e} + \frac{p_f Y_f}{p_e} + Y_e \quad (8)$$

Under the assumption that the utility function is log-linear, the fraction of income spent on non-tradable goods, θ , is also the elasticity of the consumer price index with respect to non-tradable goods prices. Similarly, the elasticity of the consumer price index with respect to the price of goods in the other sectors of the economy is equal to the exponent of that sector's good in the utility function. The equilibrium in the tradable sector of the economy is given by:²

$$p_n Y_n = \frac{\theta}{1 - \theta} (p_e Y_e + p_f Y_f) \quad (9)$$

As mentioned, non-tradable prices are not modelled as a mark-up on another variable.

III ANALYSING THE EXCHANGE RATE SHOCK

The equations in the model allow the effect of an exchange rate shock on employment and the aggregate price level to be examined. In this section, these effects are explained and the relevant equations are presented. However, the full derivations are contained in the Internet Appendix.

3.1 *Effect of a Shock to the Exchange Rate on Employment*

The level of employment in each sector is dependent on the real wage. In turn, the real wage is determined by the nominal wage and price. Two different levels of nominal wage adjustment will be considered based on alternative approaches. This means that knowledge of how the exchange rate will affect prices in each sector is necessary in order to determine the effects on employment. Prices in the euro sector vary with the exchange rate in accordance with the pass-through parameter and prices in the foreign sector obey a more traditionally framed PPP relationship with foreign prices. However, the effect of the change in the exchange rate on non-tradable prices is not immediately clear.

² See Internet Appendix, Section 2 for more details..

From the equilibrium condition above, non-tradable prices depend on prices in the other sectors and output in all sectors. The price effects in the other sectors have just been discussed but in order to determine the output effects it is necessary to make assumptions regarding how output is affected by the change in the exchange rate. Production is dependent on the level of capital and labour employed in each sector. Thus, in order to determine the change in output, it is first necessary to find how the assumed level of nominal wage adjustment in response to an exchange rate change affects labour and capital demand.

The change in the amount of labour employed as a result of a change in the wage is determined by the wage elasticity of labour demand in each sector. The response of capital employed to a change in the exchange rate is more difficult to determine. Two different assumptions regarding the level of capital adjustment are employed. Specifically, different values for these labour and capital elasticities are used to draw a distinction between long-run effects and short-run effects.

For simplicity, it is assumed that production technology is approximated by Cobb-Douglas production functions. It is initially assumed that capital stocks adjust fully so that the elasticity of capital demand with respect to wages equals 1 in each sector. This is viewed as a long-run assumption. In reality, it is unlikely that capital demand will be this sensitive to the wage rate but this assumption will be varied. It is also assumed that the elasticity of labour demand in each sector is not equal to -1 . Otherwise, changes in the real wage have no effect on sectoral output levels.³ With these assumptions, the response of output in each sector to the exchange rate change can be calculated. Barry (1997) derives his equations under the assumption that the economy starts from an equilibrium condition where all prices are equal. This assumption is not used to derive the equations in this version of the model. Accordingly, the total derivative of Equation (9) relates changes in non-tradable prices to changes in the nominal wage, euro area prices and foreign prices:⁴

$$\frac{dp_n}{p_n} = \left[1 - \frac{\varepsilon(L_f, w_f)}{\varepsilon(L_n, w_n)} \right] \frac{dw}{w} + \left[1 - \frac{\varepsilon(L_f, w_f)}{(1 - \theta)\varepsilon(L_n, w_n)} \right] \left\{ \chi \frac{dp_e}{p_e} + \psi \frac{dp_f}{p_f} \right\} \quad (10)$$

where $\varepsilon(L_i, w_i)$ is the elasticity of labour demand in sector i with respect to the real wage in that sector.

³ See Internet Appendix, Section 3 for more details.

⁴ See Internet Appendix, Section 4 for more details.

A restriction on the choice of labour demand elasticities is that the elasticity in the non-tradable sector cannot be equal that in the foreign sector. It can be seen from Equation (10) above that changes in the wage will have no effect on non-tradable prices if $\varepsilon(L_f, w_f) = \varepsilon(L_n, w_n)$. It is further assumed that the elasticity in the non-tradable sector is greater than in the tradable sectors. This is based on previous work by Bradley, Fitz Gerald and Kearney (1991), which finds that labour elasticities are higher in services sectors than in manufacturing.

Equation (10) is a long-run relationship because it is derived under the assumption that capital stocks adjust fully. If capital stocks are fixed, then the short-run relationship can be derived. In this case, the derivative of Equation (9) leads to the following non-tradable price equation:⁵

$$\frac{dp_n}{p_n} = \left[\frac{s_f \varepsilon(L_f, w_f) - s_n \varepsilon(L_n, w_n)}{1 - s_n \varepsilon(L_n, w_n)} \right] \frac{dw}{w} + \left[\frac{1 - s_f \varepsilon(L_f, w_f)}{(1 - \theta)[1 - s_n \varepsilon(L_n, w_n)]} \right] \left\{ \chi \frac{dp_e}{p_e} + \psi \frac{dp_f}{p_f} \right\} \quad (11)$$

where s_i represents the labour share in sector i . The calibrated parameters are substituted into this equation to determine the change in non-tradable prices.

Once the effect on non-tradable prices has been evaluated, the price effects in each sector will have been determined. In conjunction with the assumed level of nominal wage adjustment in the economy as a whole, this allows the level of real wage adjustment in each sector to be calculated. It can then be established what effects a change in the exchange rate has on the level of employment in the economy.

3.2 Effect of a Shock to the Exchange Rate on the Overall Price Level

Next, the impact that a change in the exchange rate has on the aggregate price level is examined. It was mentioned that preferences are described using a Cobb-Douglas utility function. Thus, the exponent on the consumption of an individual sector's good in the utility function gives the elasticity of the HICP with respect to prices in that sector.

$$\varepsilon(P, e) = \psi e(p_f, e) + \chi e(p_e, e) + \theta e(p_n, e)$$

Using the definitions of elasticities:

⁵ See Internet Appendix, Section 5 for more details.

$$\frac{dP}{de} \left(\frac{e}{P} \right) = \psi \left(\frac{dp_f}{de} \right) \frac{e}{p_f} + \chi \left(\frac{dp_e}{de} \right) \frac{e}{p_e} + \theta \left(\frac{dp_n}{de} \right) \frac{e}{p_n}$$

Multiply both sides by de/e :

$$\frac{dP}{P} = \psi \frac{dp_f}{p_f} + \chi \frac{dp_e}{p_e} + \theta \frac{dp_n}{p_n}$$

From the price equations:

$$\frac{dp_f}{p_f} = \beta \frac{de}{e} + \gamma \frac{dp_f^*}{p_f^*} \quad \text{and} \quad \frac{dp_e}{p_e} = \sigma \frac{de}{e}$$

where β is the level of pass-through and σ is the pricing-to-market parameter. As a simplifying assumption, it is assumed that there is no change in p_f^* . In reality, when the value of euro increases against a foreign currency, this will lead to an increase in the demand for imports and should lead to some increase in foreign prices. However, the change in p_f^* would likely vary from country to country, making it a difficult effect to capture. It is for this reason that p_f^* is assumed to be constant. Consequently, employment losses and price reductions in the domestic economy are likely to be slightly overstated. The change in the price level due to an exchange rate shock can be expressed:

$$\frac{dP}{P} = (\psi \beta + \chi \sigma) \frac{de}{e} + \theta \frac{dp_n}{p_n} \quad (12)$$

This equation relates changes in the domestic price index to changes in the exchange rate and non-tradable prices. Changes in non-tradable prices are calculated using Equation (10).

IV ESTIMATING THE EFFECTS OF THE EXCHANGE RATE CHANGE

Having outlined the theoretical model and derived the necessary equations, the model is now used to estimate the effects of an exchange rate change. The parameters are calibrated based on data from 2002 and from parameter estimates in previous studies. Full details of how the parameters are calibrated can be found in Appendix 1 Table A1. In addition, the parameters that are used are in Table A1 at the end of the paper. The results of the model are sensitive to the chosen assumptions and calibrated parameters.

However, this means that the model is quite flexible in the sense that it can be easily calibrated to reflect different views of the structure of the economy.

In the employment scenarios, the effects of a change in the exchange rate on the level of employment are discussed. The first approach examines the level of wage adjustment necessary to keep employment fixed following the exchange rate change. The level of wage adjustment consistent with employment neutrality is that which preserves a constant real consumption wage. The second approach calibrates the level of nominal wage adjustment based on an ESRI analysis of a similar problem.

The long run for employment effects is considered to be 3-4 years in this paper. The majority of the adjustment in nominal wages takes place inside this time frame. Full capital stock adjustment is likely to take longer but for practical purposes the current time frame is adopted. The short run is more difficult to specify. The short run is usually defined as a period of time in which at least one of the factors of production is fixed. Given that employment responses are under consideration, and labour is consequently variable, the only other input specified in the production function is capital. Therefore, the short run is defined as the period in which capital remains fixed. It is possible to make this definition operational based on the equations in the last section. Non-tradable price equations were derived in the case of both fixed and fully adjustable capital stocks – these equations correspond to short-run and long-run equations respectively. We now have a theoretical and operationally consistent definition of the short run.

The employment effects in the tradable sector are based on the export shares of our trading partners. Consequently, from an employment perspective, the exchange rate shock is export weighted rather than a shock to the nominal effective exchange rate, which is based on overall trade figures.

4.1 Employment Scenario: Constant Real Consumption Wage in the Long Run

Following the exchange rate change, the level of price adjustment in the tradable sectors is determined by the price equations for those sectors. The level of price adjustment in the non-tradable sector and the level of nominal wage adjustment still need to be determined. However, if it is assumed the real consumption wage is constant in the long run following the exchange rate shock, this restriction allows the adjustment in these variables to be identified from the equations in the model.

Equation (10) is the long-run equation for non-tradable prices. Price changes in the sector are expressed as a function of the changes in nominal wages, euro area prices and foreign prices. If it is assumed that the pass-through and pricing-to-market parameters are both 0.5 ($\beta = \sigma = 0.5$) and the relevant parameters are put in the equation, it becomes a relation between

nominal wages and non-tradable prices. Substituting in all the relevant parameters yields the following equation:

$$0.379 \frac{dp_n}{p_n} - \frac{dw}{w} = 0.046757$$

Equation (12) relates changes in the aggregate price level to changes in the exchange rate and non-tradable prices. If the real consumption wage remains constant, the change in the nominal wage must be the same as the change in the aggregate price level. Making this substitution yields a second equation relating nominal wages and non-traded prices:

$$\frac{dp_n}{p_n} - 0.25 \frac{dw}{w} = -0.056249$$

Thus, imposing the restriction that the real consumption wage is constant in the long-run allows us to solve for the level of nominal wage adjustment. Solving the above equations simultaneously yields a value of -7.5 per cent for the change in the nominal wage. There is also a 7.5 per cent reduction in non-tradable prices. Together with the assumed 50 per cent pass-through and pricing-to-market parameters, the real wage remains constant in each individual sector. This means that the exchange rate shock is employment neutral in this case. This outcome is partly a result of the calibrated parameters. If a different level of pass-through or pricing-to-market were assumed, the exchange rate change would affect employment but to a small degree for any reasonable parameter choices. Similarly, different values for the labour demand elasticities would also impact on the employment response. The chief reason that a situation like this is unlikely to prevail following an exchange rate change is not due to the chosen parameter values but rather the fact that nominal wages are unlikely to be sufficiently flexible to preserve a constant real consumption wage. In the next scenario, the level of nominal wage adjustment chosen is less flexible and more reflective of reality.

4.2 Employment Scenario: Incomplete Nominal Wage Adjustment in the Long Run

As in the first scenario, the exchange rate shock that is considered is a 15 per cent increase in the value of the euro against all currencies simultaneously. The level of nominal wage adjustment for this second scenario is taken from Baker *et al.* (1996), an ESRI analysis of the likely implications for Ireland of participating in monetary union. As part of that analysis, the

response of Irish wages to a 20 per cent devaluation of sterling is calculated.⁶ The ESRI analysis suggests that nominal wages in Ireland should fall by slightly over 5 per cent in four years in response to a 20 per cent devaluation of sterling. Although this paper considers a 15 per cent devaluation of foreign currencies rather than 20 per cent, it is obviously a larger shock overall given that it is against all currencies. However, the level of nominal wage adjustment is still set at 5 per cent. The change in the level of employment in each sector is examined separately. The effects are summed to give the total change in employment in the economy as a whole.

Foreign sector: In the non-euro area tradable sector, prices fall by 7.5 per cent, assuming 50 per cent pass-through from the exchange rate to prices in the foreign sector ($\beta = 0.5$). In addition, wages fall by 5 per cent. Thus, the change in the real product wage w/p_f is an increase of 2.5 per cent. The impact of a 2.5 per cent rise in the real wage in the foreign sector on the total percentage employed in the economy is given by:⁷

$$\varepsilon(L_f, w_f) \left(\frac{L_f}{L_t} \right) \left(\frac{L_t}{L} \right) \left(\frac{dw_f}{w_f} \right) = -0.28 \text{ per cent}$$

The first term of this product is the elasticity of labour demand with respect to the real wage in the foreign sector of the economy. The second and third terms together give the fraction of the total labour market employed in the foreign sector of the economy. The final term is the percentage change in the real wage rate. Thus, the whole product expresses the reduction in the numbers employed in the foreign sector of the economy as a percentage of the total number employed. The increase in the real wage in the foreign sector leads to a 0.28 per cent reduction in employment, which is equivalent to 4,638 jobs lost.

Euro sector: Prices in the euro sector depend on the level of pricing-to-market. Anderton (2003) finds that extra-euro area producers assign a 30 to 50 per cent weight to shadowing euro area prices following an exchange rate change i.e., if the effective exchange rate of the euro decreases by 10 per cent, producers will reduce prices by 3 per cent to 5 per cent to maintain competitiveness. Assuming symmetry between pass-through and pricing-to-market behaviour, it is assumed that pricing-to-market has a 50 per cent

⁶ This is achieved in two steps. The NiGEM model of the UK economy is first used to calculate the wage and price effects in the UK. A quarterly economic model of prices and wages is then employed to determine the likely effects in Ireland.

⁷ The percentage change is generally displayed to two decimal places but calculations are based on six significant figures.

weight so that a 15 per cent rise in the exchange rate leads to a 7.5 per cent fall in prices. In conjunction with the 5 per cent fall in nominal wages, this means that the real wage in the euro sector also increases by 2.5 per cent. The change in the real wage in the euro sector leads to a 0.17 per cent reduction in employment. This amounts to 2,745 job losses.

Non-tradable sector: In the long run, non-tradable prices are related to foreign prices according to Equation (10). Based on the calibrated parameters:

$$\frac{dp_n}{p} = 0.25 \frac{dw}{w} + 0.5966 \frac{dp_f}{p_f} + 0.1534 \frac{dp_e}{p_e}$$

The reduction in tradable prices is 7.5 per cent and there is a 5 per cent fall in the nominal wage. We now have all the necessary figures to calculate the change in the real wage:

$$\begin{aligned} \frac{dw_n}{w_n} &= \frac{dw}{w} - \frac{dp_n}{p} \\ &= \frac{dw}{w} - \left[0.25 \frac{dw}{w} + 0.5966 \frac{dp_f}{p_f} + 0.1534 \frac{dp_e}{p_e} \right] = 1.88 \text{ per cent} \end{aligned}$$

This leads to the following change in the level of employment:

$$\varepsilon(L_f, w_f) \left(\frac{L_n}{L_t} \right) \left(\frac{dw_n}{w_n} \right) = -1.05 \text{ per cent}$$

A 1.05 per cent reduction in employment is equivalent to 17,262 jobs lost. The change in overall employment is given by the sum of the individual changes in each sector:

$$\Delta L = \Delta L_f + \Delta L_e + \Delta L_n = -24,645$$

In this scenario, with the baseline calibration and under the assumption of fully adjustable capital stocks, a 15 per cent rise in the value of the euro coupled with a 5 per cent reduction in nominal wages in the economy leads to a reduction in overall employment of 24,645. This is equivalent to a 1.5 per cent reduction. In an analysis of the employment effects of a 15 per cent fall in the value of sterling, Barry (1997) finds that job losses would amount to 30,000. One might expect more job losses here given that Barry's results relate to a shock to the euro/sterling exchange rate only. However, the labour demand elasticities are lower in this paper and there is not full pass-through from the

exchange rate to prices in the foreign sector. These factors are influential and indicate the sensitivity of the employment results to the parameters and assumptions.

A number of qualifications need to be made regarding the results in this section. One problem is that the analysis is a partial rather than general analysis. There are numerous other factors that are likely to influence the level of employment, particularly over the time frame considered. The Irish labour force is quite mobile internationally and, in adverse conditions, the level of unemployment could be less than expected due to migration. Baker *et al.* (1996) point out that adjustment to the exchange rate shock will also take place abroad so it can be misleading to focus solely on domestic factors. Government policies might also be implemented to boost job creation.

4.3 Short-run Employment Effects

The model can also be used to calculate short-run employment effects. Non-tradable prices are described using Equation (11) instead of Equation (10). Short-run labour demand elasticities are needed but using the econometric estimates of the short-run elasticities in the literature also leads to problems. In particular, there is little agreement on the appropriate value for these elasticities. (See Barry (1998) and Fitz Gerald (1998) for a more detailed discussion.) Sectoral distinctions in this paper are different from those in previous papers so that econometric estimates of the elasticities can only be used as a guide. It is also necessary to estimate the level of wage and price adjustment in the short run and this will differ from the amount of adjustment in the long run.

A numerical example of short-run calculations is not provided, as the method is identical to that in the previous scenario. However, the relative magnitude of the short-run effects in comparison to the long-run effects will depend largely on two factors – the amount of short-run adjustment in wages and prices and the short-run labour demand elasticities. In their analysis of the effects of a sterling shock, Baker *et al.* (1996) find that very little adjustment in wages or prices takes place in the first year. This means that the change in the real wage is likely to be small in this scenario. Economic theory also suggests that labour demand elasticities will be smaller in absolute value in the short run. These factors suggest that the employment response to the shock will be smaller in the short run in comparison to the long run.

4.4 Price Level Scenario: 15 per cent Rise in the Value of the Euro

The shock considered is a 15 per cent rise in the value of the euro against all currencies – identical to the employment scenarios. The effect of the

exchange rate change on the aggregate price level is calibrated by weighting the tradable goods in the HICP according to import shares. Thus, from the perspective of aggregate prices, the exchange rate shock is import weighted.

The responsiveness of prices in the individual sectors of the economy with respect to the exchange rate is determined by the parameters of the model. The level of responsiveness in the foreign sector is set according to the pass-through parameter β , while responsiveness in the euro sector is determined by the pricing-to-market parameter, σ . In the non-tradable sector, the level of responsiveness is determined by the parameters in Equation (10). Calibrating Equation (10) with the appropriate parameters:

$$\frac{dp_n}{p} = 0.25 \frac{dw}{w} + 0.5966 \frac{dp_f}{p_f} + 0.1534 \frac{dp_e}{p_e} = -0.069$$

In this scenario, non-tradable prices fall by 6.9 per cent due to the strength of the euro. If this is substituted back into the expression for the HICP, the change in the aggregate price level is:

$$\frac{dP}{P} = 0.31(-0.15) + 0.38(-0.069) = -0.0727$$

Thus, in this scenario, a 15 per cent rise in the value of the euro leads to a 7.3 per cent reduction in the aggregate price level, suggesting a 48 per cent pass-through from the exchange rate to the aggregate price level. The reduction in prices in the tradable sectors and the reduction in the nominal wage put downward pressure on prices in the non-tradable sector of the economy.

V SUMMARY AND CONCLUSIONS

The aim of this paper has been to examine how the exchange rate impacts on the level of employment and the aggregate price level in the economy. The paper uses a simple framework in the form of a small, calibrated model adapted from Barry (1997). The equations in this paper are derived under less restrictive assumptions making them more widely applicable. Within the model framework, the distinction between the tradable and non-tradable sectors of the economy is of vital importance. A distinction between long-run and short-run effects is also drawn. The simplicity of the framework means that the parameters can be adjusted easily as the structure of the economy changes. This provides significant flexibility.

The results of the model vary according to the chosen assumptions and parameters. In the preferred case of incomplete nominal wage adjustment in the long run, a 15 per cent increase in the value of the euro leads to a 1.5 per cent reduction in employment. The sectoral breakdown shows that 70 per cent of the total jobs losses are in the non-tradable sector. The change in the real wage in the non-tradable sector is smaller than that in the tradable sectors but it employs the largest number of people and the calibrated labour demand elasticity is also higher than in the tradable sectors. The non-tradable sector is calibrated to represent the services sector of the economy. Economists often think of the manufacturing sector when considering the adverse effects of an exchange rate shock on employment but this analysis suggests the greatest cost could be to the services sector.

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APPENDIX 1
PARAMETER VALUES USED FOR CALIBRATION

The parameters in the model are calibrated based on data from the end of the year 2002. In some instances, the end of year figure was taken and in others, an annual average is taken. In many cases, it may be possible to calibrate the parameters using methods other than the ones presented here. However, this is one approach to the calibration process.

Table A1: *Parameters of Calibrated Model*

<i>Parameter</i>	<i>Value</i>	<i>Symbol</i>
Share of E-goods in the HICP	0.127	χ
Share of F-goods in the HICP	0.494	ψ
Share of N-goods in the HICP	0.379	θ
E share in tradable employment	0.323	L_e / L_t
F share in tradable employment	0.627	L_f / L_t
Tradable share in total employment	0.3	L_t / L
Non-tradable share in total employment	0.7	L_n / L
Total non-agricultural employment	1,644,000	L
Labour elasticity in E sector	-0.6	$\varepsilon(L_e, w_e)$
Labour elasticity in F sector	-0.6	$\varepsilon(L_f, w_f)$
Labour elasticity in N sector	-0.8	$\varepsilon(L_n, w_n)$

Share of Each Class of Good in the CPI

The distinction between tradable and non-tradable goods is, to a certain extent, arbitrary. Barry (1997) makes the distinction based on economic sectors. Services, housing and a certain proportion of wholesale and retail items in the CPI are classed as non-tradable. The remainder are classed as tradable. The drawback of such broad categories is that there are likely to be tradable goods being classified as non-tradable and visa versa. To address this shortcoming, the distinction between the tradable and non-tradable component of the HICP is made according to the methodology of Kenny and McGettigan (1997). Each individual item in the HICP is categorised as either tradable or non-tradable. The examination of the composition of the HICP in such detail allows the proportion of tradable and non-tradable goods in the HICP to be calculated as accurately as is possible.

Based on the expenditure weights of goods in the calculation of the CPI, tradable goods represent 59.4 per cent of the CPI with the remaining 40.6 per cent being accounted for by non-tradable goods, based on the method cited above. However, the HICP excludes certain items in both the tradable and

non-tradable categories that are not excluded in the CPI. Having accounted for these excluded items, tradable goods represent 62.1 per cent of the HICP and non-tradables represent 37.9 per cent. Thus, the elasticity of the HICP with respect to non-tradable goods prices, θ , is equal to 0.379. The tradable goods component is itself broken down further between the euro-area sector and the remaining foreign sector.

In order to assess the proportion of the tradable goods component of the HICP determined by euro-area and other foreign prices, the tradable component of the HICP is weighted according to our share of imports from these areas. According to *Budgetary and Economic Statistics 2003*, published by the Department of Finance, imports from the euro area in 2002⁸ accounted for 20.5 per cent of overall imports. This means that goods produced and consumed domestically that compete with euro area goods together with imported euro area goods account for 12.7 per cent of the HICP. Thus, the elasticity of the HICP with respect to euro area goods prices, χ , is equal to 0.127. This implies that goods produced and consumed directly that compete in other foreign markets together with imports from these markets comprise 49.4 per cent of the consumer price index. Thus, the elasticity of the consumer price index with respect to foreign goods prices, ψ , is equal to 0.494.

The use of import shares to weight the tradable component of the HICP suffers from the drawback that the tradable components that this paper aims to identify consist of not only imports but also domestically produced goods that compete on foreign markets. However, it is difficult to ascertain which items in the tradable component of the HICP were produced by domestic companies that compete on international markets. Consequently, the import shares were used as weights.

Share of Labour Employed in each Sector

The share of labour employed in the tradable and non-tradable sectors of the economy was obtained from the Quarterly National Household Survey (QNHS). Following the methodology in Barry (1997), agricultural employment was excluded in the analysis on the basis that it is largely constrained by the Common Agricultural Policy. Tradable employment is defined as employment in industry, where industry is defined as NACE economic sectors C-F, as outlined in Tables 2a and 2b of the QNHS. This is the definition of industry employed by the CSO. This definition includes the construction industry. It may be more appropriate to classify employment in the construction industry as non-tradable employment. However, in the current calibration, employment

⁸ Figures apply to the period from January to November 2002.

in the construction industry is treated as tradable employment, consistent with the CSO definition of industry employment in general. With this methodology, 30 per cent of the workforce is classified as being in tradable employment. Excluding the construction industry would obviously reduce this percentage but it is reasonable to assume that a certain amount of employment in services is more appropriately classified as tradable. Therefore, there should be some counter-balancing forces at work. As mentioned, the calibration process is open to interpretation.

Non-tradable employment is defined as employment in services, where the services industry is defined as NACE economic sectors G-O, also outlined in Tables 2a and 2b of the QNHS. According to these definitions, employment in the tradable sector accounts for 30 per cent of total non-agricultural employment with the remaining 70 per cent accounted for by employment in the non-tradable sector.

The percentage of tradable employment in the euro area sector is taken to be equal to the volume of euro area exports as a percentage of total exports. The data on exports is taken from the *Budgetary and Economic Statistics 2003*, published by the Department of Finance. According to export volumes, tradable employment in the euro area sector accounts for 37.32 per cent of total tradable employment. The remaining 62.68 per cent of tradable employment is accounted for by the foreign sector. An alternative approach to determining whether employment is dependent on euro area exports is to use data from the Census of Industrial Production on exports broken down by destination. This might be more consistent with the classification of tradable goods as goods from the industrial sector of the economy.

Sectoral Labour Demand Elasticities

Bradley, Fitz Gerald and Kearney (1991) estimate various sectoral elasticities. They find that labour elasticities in the services sector are generally higher than in the manufacturing sectors. Based on this evidence, Barry (1997) uses a value of -1 for the labour elasticity in the non-tradable sector and one of the tradable sectors. A value of -0.6 is assigned to the remaining tradable sector. Labour elasticities in the tradable sectors differ in his paper due to differences in the level of production technology employed. These differences are not necessarily preserved in the definition of the tradable sectors in this paper. For that reason, the labour elasticities in the tradable sectors are assumed to be equal in this paper and both are assigned a value of -0.6 . In addition, the elasticity in the non-tradable sector is set equal to -0.8 rather than -1 on the basis that a value of -1 means that wage changes have no effect on output in the fully adjustable capital stock case.

In terms of the labour shares, it is assumed that the labour share in the



tradable sectors is equal to 0.5, implying an equal split between labour and capital in the production process in the tradable sector. This seems to be a reasonable assumption for the production of commodities in an aggregate sense although it will obviously vary from sector to sector. In the non-traded sector, which has been calibrated based on the services side of the economy, the labour share is assumed to be 0.7, reflecting the fact that the provision of services is more labour intensive than the production of commodities.

