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**THE NATIONAL IMPACT OF REGIONAL POLICY: POLICY  
SIMULATION WITH LABOUR MARKET CONSTRAINTS IN A TWO-  
REGION COMPUTABLE GENERAL EQUILIBRIUM MODEL**

**BY**

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**The National Impact of Regional Policy: Policy Simulation with Labour Market  
Constraints in a Two-Region Computable General Equilibrium Model \***

by

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## 1. Introduction

Throughout its present and previous sessions in office, the Labour government has promoted regional policy as a means of increasing national growth and productivity, and of reducing economic disparities across space. The key characteristic of this policy is a set of institutional arrangements, known as “constrained discretion”, that together make up a decentralised policy delivery system (HM Treasury, 2001; HM Treasury *et al*, 2003, 2004; McVittie & Swales, 2004).<sup>1</sup> In England, regional development policy is delegated to local Regional Development Agencies (RDAs), whilst in the rest of the UK it is devolved to the relevant local assembly or parliament. To deliver this policy, the government has put in place an institutional framework “... around targets, funding and central guidance, tied to stronger accountability and performance incentives” (HM Treasury *et al*, 2004, p. 2).

However, this decentralisation of power and responsibility takes place in a situation of general ignorance of the impact of local development policy outwith its immediate target area. In the UK there have been numerous evaluation of the effect of regional policy on the recipient regions (Taylor, 2002; Wren, 2003). However, studies identifying the effect of regional policies on either non-target regions and/or the economy as a whole are rare. As Taylor (2002, p. 204) states: “The “big” question is whether regional policy yields economic benefits for the economy as a whole. We need to know, for example, whether the *non*-assisted areas benefit from regional policy and, if so, to what extent”. In fact, recent government policy documents show little recognition of the regions’ operating as a coherent economic system. There is no rigorous discussion about how policy spillovers should be dealt with in the target setting or the other institutional arrangements for the Regional Development Agencies. Further there is no general consensus about how to assess the overall desirability of regional policy from a national

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<sup>1</sup> The term “constrained discretion” comes initially from the monetary policy literature (Bernanke & Mishkin, 1997) but has been extended by the present Labour government to cover other areas of policy and specifically the delivery of regional policy (Balls, 2002; McVittie & Swales, 2004).

perspective (HM Treasury *et al*, 2003; Learmonth, 2003; McVittie and Swales, 2004; Swales, 1997).

Until recently, the official Treasury position was that regional policy had no net aggregate impact on the UK economy as a whole (HM Treasury, 1997). This implies that policy-induced employment increases in geographical areas receiving regional assistance are matched by corresponding reductions in other areas. This position that regional policy has a purely spatial redistributive (or equity) roll was enshrined in evaluation practices. The government's position now is less clear cut (HM Treasury, 2003); national efficiency gains are acknowledged, though how they are to be identified and measured is not.

The first step in a comprehensive evaluation of regional policy is to identify its full spatial impact. This involves two tasks. The first is to determine the form and strength of inter-regional linkages. The second is to specify the national constraints within which the system of regional economies operates. In this paper we use simulation results from a two-region Computable General Equilibrium (CGE) model of Scotland and the rest of the UK (RUK) to investigate these issues. The inter-regional linkages incorporate trade and income flows, inter-regional capital mobility and migration. The constraint that we focus on is an overall national population constraint and its impact on regional wage determination. The paper is structured in the following way. Section 2 outlines the AMOSRUK modelling framework. Section 3 describes the alternative labour-market model configurations used in the simulations. Section 4 reports the results for the model simulation and Section 5 is a short conclusion.

## **2. AMOSRUK: A Computable General Equilibrium Framework**

AMOSRUK, the inter-regional version of the AMOS<sup>2</sup> simulation framework, is a computable general equilibrium model of the UK economy. The model structure includes two endogenous regions - Scotland and the rest of the UK (RUK) - and one exogenous region - the rest of the world (ROW). There are three transactor groups in each region – households, firms and government – and three commodities and activities – manufacturing, non-manufacturing traded and sheltered. There are four main components of final demand: household consumption, investment, government expenditure and exports to the rest of the world.

The basic data set is an inter-regional input-output table for 1999, which provides a ‘snapshot’ of the Scottish and rest of the UK’s economies for that year and highlights the linkages that exist between sectors and regions.<sup>3</sup> The input-output table is augmented in a Social Accounting Matrix (SAM) with transfer payments between economic agents and factors of productions. The SAM covers all intra-regional, inter-regional and international transactions in the economy over a year. Further, where econometrically parameterised relationships have been imposed, these have been determined using annual data. Each “period” in the model is therefore interpreted as equal to a year.

AMOSRUK is a flexible CGE model that offers a wide range of model closures corresponding to different time periods of analysis and labour market options. In this paper we focus on the national population constraint. The way in which alternative labour market closures are used to vary the operation and spatial impact of such a constraint is presented in detail in Section 3. In production, local intermediate inputs are combined with imports from the other region and the rest of the world via an Armington link (Armington, 1969). This composite input is then combined with labour and capital (value added) to determine each sector’s gross output. Production functions at each level

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<sup>2</sup> AMOS is an acronym for *A Macro-Micro Model Of Scotland*. Both AMOS and AMOSRUK have been developed at the University of Strathclyde. Harrigan *et al* (1991) gives a full description of early versions of the AMOS framework, and Gillespie *et al* (2002) and McGregor *et al* (1999) describe the inter-regional model AMOSRUK. Greenaway *et al* (1993) gives a general appraisal of CGE models and Partridge and Rickman (1998) reviews regional CGEs.

can be CES, Cobb-Douglas or Leontief. The simulations in this paper use CES production functions at the value-added and gross-output level, and Leontief production functions at the intermediate-inputs level.

Consumption demand is linear in real income and homogenous of degree zero in all nominal variables. Real government demand is exogenous. Both inter-regional and international exports are price sensitive. However, while non-price determinants of export demand from the rest of the world is taken to be exogenous, export demand to the other UK region is fully endogenous, depending not only on relative prices, but also on all elements of intermediate and final demand in the other region.

An important feature of the model is the between-period updating of capital stocks and the labour force. For the capital stock, gross investment is given by an explicit capital-stock adjustment mechanism: in each period investment demand from each sector is a proportion of the difference between actual and desired capital stock, where desired capital stock is a function of commodity output, the nominal wage and the user cost of capital. For the labour force, it is assumed that there is no natural population increase and that international migration can be ignored. Therefore, the only means of adjusting the regional labour forces is through inter-regional migration. This is explained in greater detail in the next section.

For the simulations performed in Section 4, the key parameter values are as follows: the elasticity of substitution in the CES production functions is set at 0.3 (Harris, 1989) and the Armington assumption is applied to both inter-regional and international trade with an elasticity of substitution of 2.0 (Gibson, 1990). The parameter determining the speed of adjustment from actual to desired capital stock is set at 0.5, following econometric work on the determination of investment in the Scottish economy.

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<sup>3</sup> Constructing the two-region IO table is non-trivial. Although official IO accounts are available for Scotland and the UK, there are no compatible tables for recent years. Whilst an analytical IO table exists for Scotland for 1999, the latest version for the UK is 1995. For more details see Ferguson *et al.*, (2003).

### 3. Alternative Model Configurations

Population is a key constraint that can operate at the regional or national level. In the AMOSRUK model, its primary impact comes through its effect on wage setting. For example, where the regional real wage is determined by local bargaining, a tightening of the regional labour market leads to an increase in the regional real wage and a reduction in competitiveness. However, inter-regional migration can ease this labour market pressure. In this paper we look specifically at the four cases that are outlined in Table 1.

**Table 1: Simulation Set Ups**

	Model set up		Effective long-run population constraint	
	Population fixed	Regional wage setting	Regional level	National level
Quasi-IO	<b>Region</b>	<b>Fixed real wage</b>	✗	✗
Regional bargaining	<b>Region</b>	<b>Bargaining</b>	✓	✓
Wage spillover	<b>Region</b>	<b>Regional wage leadership</b>	✗/✓	?
Flow migration	<b>Nation</b>	<b>Bargaining</b>	✗	✓

#### 3.1 Quasi-IO

The first benchmark case involves no effective population constraints. This is where we impose fixed real wages in both the Scottish and RUK economies. In this case, regional employment is determined solely by regional labour demand, with increased employment met by increased regional labour market participation and reduced regional unemployment. Neither region suffers adverse competitiveness effects generated specifically through the labour market as export demand expands. Nominal wage might change but only in response to changes in the regional consumer price index (cpi). Capital fixity is responsible for supply restrictions, so that marginal costs and prices rise

in the short run as output expands, with some crowding out of exports. However, investment will optimally adjust capital stock over time, so that capacity constraints are eventually relaxed and the economy operates as an extended IO system (Batey, 1985; McGregor *et al*, 1996). We therefore label this as a “Quasi-IO” closure.

### 3.2 Regional Bargaining

The second simulation set-up involves a closure where population is fixed in each region and wages are determined by regional bargaining that takes the form of a regional wage curve (Blanchflower and Oswald, 1994). The particular bargaining function adopted is the econometrically-parameterised relationship identified by Layard *et al* (1991):

$$(1) \quad \ln \left[ \frac{w^I}{cpi^I} \right] = \beta^I - 1.113 \ln u^I$$

where:

$w$  is the nominal wage rate,

$cpi$  is the consumer price index,

$u$  is the unemployment rate,

$\beta$  is calibrated to ensuring that the model replicates the base year dataset, and the I superscript indicates the region.

In this closure the effective population constraint applies at the regional level, with regional real wages reflecting the tightness of the regional labour market, measured as inversely related to the regional unemployment rate. Given that the population constraint applies to both regions individually, we also interpret this as a national constraint. We refer to this as the “Regional Bargaining” case.

### 3.3 Wage Spillover



In the “Wage Spillover” case the RUK is the lead region and Scotland the follower. Real wages in the RUK are determined by regional bargaining, as in equation (1), whilst Scotland takes the nominal wage set south of the border. Again regional populations are held constant. This closure is consistent with early classic UK regional policy evaluation that was clearly set within a Keynesian frame of reference (Moore and Rhodes, 1973). However, wage flexibility across space remains a policy concern, so that the asymmetric wage rigidity identified here is still a relevant conceptual model.

In this set up the population in the RUK acts as an active constraint, in that the nominal national wage reflects the tightness of the labour market (and the  $cpi$ ) in RUK. However, in Scotland there is essentially no population constraint working through the regional labour market. This labour-market closure is difficult to classify in terms of population constraints. The RUK labour market is effectively population constrained but the Scottish labour market is not. The position for the national economy therefore seems ambivalent.

### 3.4 Flow Migration

In the final model configuration we impose bargaining at the regional level and flow migration to allow population adjustment. Migration flows in one period serve to update the population stock in the next period. The Scottish rate of immigration is positively related to the Scottish/RUK ratio of the real consumption wage; and negatively related to the Scottish/RUK ratio of unemployment rates (Treyz *et al*, 1993). The specific form of this equation is derived from the Leyard *et al* (1991) econometrically parameterised inter-regional migration function:

$$(2) \quad \ln \left[ \frac{m^S}{L^S} \right] = \zeta - 0.08 [\ln u^S - \ln u^R] + 0.06 \left[ \ln \left[ \frac{w^S}{cpi^S} \right] - \ln \left[ \frac{w^R}{cpi^R} \right] \right]$$

where:

$m$  is net in-migration,

$L$  is population,

$\xi$  is a calibrated parameter that ensures zero net migration (the equilibrium condition) for the base year data, and

$S$  and  $R$  indicate Scotland and the rest of the UK respectively.

In the long run, this flow migration re-imposes the original ratio of regional wage and unemployment rates. In effect, the introduction of flow migration allows a unified national labour market together with a national population constraint. Therefore an increase in demand in one region will equally affect the long-run real wage in both regions. This is the “Flow Migration” model configuration, where the population constraint applies at the national level, but can be eased at the regional level through migration.

#### **4. Simulation Results**

In this paper we consider the indirect and induced effects on Scotland and the rest of the UK of a very straightforward direct policy impact: an increase the ROW exports in the Scottish manufacturing and non-manufacturing traded sectors. There are two reasons for choosing this particular stimulus. The first is practical: it replicates the direct impact expected from one of the policy priorities identified by Scottish Enterprise, Scotland’s Regional Development Agency. Expanding Scottish exports is an appropriate outcome under the Scottish Enterprise priority “Growing the Global Reach of Scottish Companies” (Scottish Enterprise, 2002), though the size of the direct impact chosen here is purely illustrative. The second is heuristic. The combined effect of the linkages and national constraints can be better appreciated in the context of a demand disturbance whose effect in conventional purely demand-driven single- and multi-regional Input-Output (IO) and Social Accounting Matrix (SAM) based models is familiar.<sup>4</sup>

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<sup>4</sup> The inter-regional impacts of a supply-side policy disturbance in the AMOSRUK model are discussed in Gillespie *et al* (2002).

The simulation strategy is relatively straightforward. In the initial period a 5% step increase in demand is entered for ROW exports for the Scottish manufacturing and non-manufacturing traded sectors. The model is then run forward for 50 periods with the values of all other exogenous variables and parameters held constant. This procedure is repeated for each of the model configurations outlined in Section 3, and the change from the initial base-period values reported for a number of key variables. In all cases, capital stock is updated between periods, and in the “Flow Migration” model configuration simulation the regional populations are similarly adjusted from period to period.

The model calibration process takes the economy to be initially in long-run equilibrium. This means that if the model is run forward with unchanged exogenous variables and parameters, the endogenous variables continuously take their initial values. Introducing a step change propels the economy towards a new long-run equilibrium, and it is the paths to these new comparative static equilibria that are reported here. The different model configurations generate both different long-run equilibria and different adjustment paths.

In all the configurations used here, the AMOSRUK model does not have natural rate properties. That is to say, an export demand shock will, in general, have an effect on aggregate activity and employment. Take, for example, the “Regional Bargaining” case. An increase in export demand improves the UK terms of trade, and increases the price of UK exports relative to imports.<sup>5</sup> This allows the real wage to rise and a general fall in the unemployment rate: employment and GDP will therefore rise. However, what is perhaps more important in the present context is that the size of the national impact will depend upon the regional configuration of the labour market; that is, the regional wage setting behavior, the extent of wage spillovers and the nature of inter-regional migration. Moreover the regional distribution of impacts is also affected by these effective population constraints.

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<sup>5</sup> This is precisely the mechanism that operates in the (one-good) aggregate Layard, Nickell and Jackman (1991) model. This model does not typically exhibit natural rate properties for an export demand stimulus, and the impact on the national economy is greater when the unwinding of the initial external balance surplus is complete.

#### *4.1 National GDP Impacts*

Figure 1 shows the projections for the change in GDP for the four model configurations. In all cases, national GDP increases over time towards a new stable equilibrium. This is greatest for the “Quasi IO” configuration, which is not surprising in that this represents a situation with no effective labour market constraints. We are effectively using this result as a benchmark. For the “Quasi-IO” variant, the long-run equilibrium exhibits IO characteristics: in each sector all inputs rise by the same proportionate amount, which equals the growth of output in that sector so that constant technical coefficients are maintained. Similarly, in long-run equilibrium all prices will have returned to their base-period level.

The model configuration that produces the second biggest GDP impact is the “Wage Spillover” labour market closure. Here labour market constraints in Scotland - the region that receives the demand injection - are low. However, demand spillovers to the RUK as a result of increased inter-regional imports to Scotland as activity rises, will lead to a rise in labour demand in the RUK. Bargaining will subsequently increase the real and nominal RUK wage, reducing competitiveness and increasing the linked Scottish nominal wage.

The introduction of bargaining in both regions, either with or without migration, further reduces national GDP growth, through strengthening negative competitiveness effects that operate through the labour market. With no migration, the increases in output demand generated directly in Scotland and indirectly in the RUK produce an increased derived demand for labour. In both regions real and nominal wages will be bid up with an associated increase in employment determined through the wage curve. We expect this increase to be associated with an increase in GDP in both regions, and for activity to increase over time as investment relaxes any existing capacity constraints.

An unexpected result is that the “Flow Migration” simulation generates a higher increase in national GDP than the “Regional Bargaining” simulation. These simulations are identical apart from the presence or absence of flow migration.<sup>6</sup> This result hinges on the initial SAM data, which are here taken to represent an equilibrium position. The base-year unemployment rate is much higher in Scotland than the RUK. In terms of the model, this difference is interpreted as reflecting inter-regional amenity differences. Also, the productivity per employee is lower in Scotland. The “Flow Migration” equilibrium therefore requires population to shift from a higher to a lower *per capita* productivity region, and once they move, the migrants take on the productivity and unemployment characteristics of the population in the destination region.

Finally, note that the move to long-run equilibrium is generally slow and this is particularly important for policy purposes. The time horizon for the evaluation of local regeneration policy is a 10-year maximum (HM Treasury, 1995). However, although adjustment is particularly protracted in the “Quasi-IO” case, in the other labour market closures, national GDP is close to its long-run equilibrium by year 10.

#### *4.2 Regional GDP Impacts*

Figures 2 and 3 give the change in GDP for the two regions, Scotland and RUK, for the different model configurations. For Scotland, all but the “Regional Bargaining” case have very similar long-run solutions. This confirms previous simulation results for bargaining with migration in both single region and two-region contexts (McGregor *et al*, 1996, 1999). A small region receiving a demand stimulus where flow migration is imposed will, in the long run, respond in a manner similar to conventional IO. The “Wage Spillover” result is similar, in that the negative supply-side effect from the wage increase in Scotland is small relative to the demand injection. However, where there is regional bargaining with no migration, significant labour market displacement effects are observed, with the long-run change in GDP less than 60% the value of the other three cases.

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<sup>6</sup> A similar finding applies to employment.

The build up of Scottish GDP is initially most rapid in the “Wage Spillover” situation and slowest for “Flow Migration”. In period 5, the Scottish GDP change under “Flow Migration” is around 60% of the value under “Wage Spillover”, although by period 50 the results are almost identical. Concern over the speed with which the regional economy adjusts is important in practice for the evaluation of policy. Further, there might be legitimate concerns over policy decay, such that the initial direct impact of the policy stimulus declines over time so that the results in early time periods take on even greater significance (Gillespie *et al*, 2002).

For the RUK GDP change, reported in Figure 3, the differences are even more dramatic. For the RUK, the “Quasi-IO” results are much higher than the other three model configurations. In the “Quasi-IO” case, the impact on the RUK, in terms of the absolute change in GDP, is almost as large as the impact on Scotland itself. This simply reflects high trade linkages between the two economies. However, in the two cases where bargaining occurs with a fixed RUK population, “Regional Bargaining” and “Wage Spillover”, the rise in RUK GDP is much lower. In these cases, nominal wage increases reduce RUK competitiveness, leading to a fall in ROW exports and increasing import penetration. However, the most extreme reaction occurs under “Flow Migration” where, after period 4, RUK GDP falls below its initial level, as outmigration tightens the local labour market.

These results for the impact on the non-target region reinforce the concerns raised by Taylor (2002). Even if we have accurate estimates of policy impacts on the target regions, the impact on the rest of the economy can vary widely, depending upon regional wage setting and inter-regional migration. Given that poor regional data make reliable econometric work difficult, this important information required for effective regional policy making is at present missing.

#### 4.3 *Regional Wage Setting*

The differential impacts on regional GDP recorded in Figures 1, 2 and 3 are primarily the result of differences in the wage-setting outcomes under the various model set-ups. Figure 4 shows the change in average Scottish wage as a result of the export shock. Note that the average Scottish worker is best off under regional bargaining, where the real wage increases by over £80 per annum in the long run. The wage increase under “Flow Equilibrium” begins high but is eroded over time as in-migration reduces the bargaining power of local workers. In the long run, the proportionate wage-rate increase in Scotland must be close to that in RUK for population equilibrium to be restored. In the “Quasi-IO” simulations, the Scottish real wage is held constant throughout, registering a zero change. Finally, with the “Wage Spillover” case the Scottish real wage initially falls as the percentage increase in the RUK nominal wage is less than the percentage increase in the Scottish cpi. The initial fall in the Scottish real wage accounts for the associated rapid initial expansion in Scottish GDP for this model set up.

The change in the real wage for the rest of the UK is much less dramatic. Again, with the “Quasi-IO” case there is no change in the real wage. In all other model configurations the RUK real wage rises: the least under the “Regional Bargaining” set up, intermediate for the “Wage Spillover” and most for the “Flow Equilibrium”.

## **5. Conclusions**

In a UK context, at least, research into regeneration policy impacts has focused almost exclusively on the effects of the policy on the target region, with any consequences for other regions being largely ignored (Taylor, 2002). If the target region is the only region of interest to the policy making authorities, as it presumably is for devolved territories of the UK, this neglect may be defensible. For if, as is the case for each of the devolved territories, the target region is small relative to the rest-of-the-UK (RUK), then even if there are significant spillover effects to RUK, subsequent feedback effects to the target region are likely to be small. We have found the small open region assumption to be a reasonable approximation for Scotland, the biggest of the devolved regions, at least for demand disturbances (McGregor et al, 1999). We have also found

these own-region impacts to be sensitive to assumptions about regional wage-flexibility, though less so in the long-run than in the short-run, but to be especially sensitive to assumed migration behaviour.

Devolution is a recent phenomenon, which affects only three regions in the UK, so it hardly explains the long-standing, and virtual universal neglect of policy impacts on non-target regions. Decentralization of the RDAs in England and Wales may appear to add weight to the argument, but these authorities are delegated and, in principle, at least are concerned with achieving targets set by national policy authorities. Furthermore, the decentralization programme as a whole only dates from the 1997 Labour government. Certainly, regardless of their interest to regional authorities, the national effects of any regeneration policies must surely be of concern to national policy authorities, including the UK government. However, until the most recent version of the Green Book, the HM Treasury maintained that regional regeneration policy had no net positive impact on UK GDP or employment. Under this view, certainly in a two-region context at least, there is no need to seek to measure the impact of regeneration policy on the other region's employment, since it is presumed to be identical to that in the target region, but with the opposite sign.<sup>7</sup>

Perhaps researchers have been inhibited from searching for the national effects of regeneration policies under a policy regime in which the official view was that they could not exist. Any findings of such effects presumably would merely serve to demonstrate the inadequacy of the framework being used. In fact, of course, it was the traditional HM Treasury view itself that was problematic, as the most recent variant of the Green Book appears to acknowledge. National effects of supply-side policies should never have been dismissed on the basis of an appeal to natural rate theory (Gillespie *et al* 2002), and sophisticated, open-economy variants of that theory also recognise the potential power of export demands to exert a permanent influence on the real economy (Layard, Nickell and Jackman, 1991). Theoretical analysis alone is insufficient to establish the impact of

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<sup>7</sup> Even under this perspective, an interregional modelling framework would be required if there was interest in the distribution of crowding out effects across regions within RUK.



regeneration policies on the national economy, a conclusion that is only surprising for ever having been challenged.

In practice, there may, of course, be other factors contributing to the neglect of other-region and national effects of regeneration (and other regional) policies. However, there seems little doubt that the very strong position enshrined in official policy evaluation documents that national effects were non-existent must have been an inhibiting influence on research. The current Green Book, however, acknowledges the effects, and this immediately raises the issue of the scale, and in general, the direction of spillover effects on other regions, and their consequential impact on the national economy.

The results reported here suggest that spillovers may matter in practice as well as in principle. An increase in ROW exports, which is the kind of response that is expected from some aspects of Scottish Enterprise policy, clearly has national GDP effects. Even under the most neoclassical assumptions about the operation of regional labour markets, with no nominal inertia and fully flexible real wages in both regions and flow migration (“Flow Migration”), there are significant national effects. Admittedly, in this case there is indeed “crowding out” in RUK, but it is not 100%, and national effects remain. Under some configurations, positive spillovers arise, with obvious consequences for national effects. Indeed, even where spillovers are ultimately negative, in the short-run they tend to be positive as demand-side effects, operating through interregional trade linkages, dominate the supply-side consequences on real wages and migration. Our research also demonstrates that quite different national GDP changes can be associated with labour market set ups that have quite similar impacts on the target region. While own-region results prove sensitive to alternative visions of how regional labour markets function, other-region effects prove to be much more so.

The current Green Book’s acknowledgment that regional policy may have national effects in our view helps to clear the way for a proper investigation of such effects. From a national perspective this seems to us to necessitate the development of an

interregional model of the UK economy in which the impact of policies on all regions and on the national economy can be assessed. Detailed consideration is required of the economic interaction among regions and also the nature of the national constraints. As far as we are aware HM Treasury has developed no such framework, and without it we do not see how the current Green Book can actually be implemented. Furthermore, the models employed in this paper serve to illustrate how important it is within such a framework to capture the behaviour of regional labour markets appropriately, especially when there is interest in other-region effects, yet key aspects of this are still not well-understood. Additionally, the Government's regional decentralization and devolution programme appears to raise serious questions about the optimality of current regional policy design in the UK. While the presence of significant spillover effects is known to create the potential for policy-induced inefficiencies in a decentralized decision-making context (e.g. Gordon, 1983), there is no apparent recognition of this in current policy documents. There is, in our view, an urgent need for researchers and policy-makers alike further to explore the national impact of regional policies.

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*Appendix: A Condensed Version of the Period-by-Period AMOSRUK Model*

<b>Variable</b>	<b>Equation</b>
Value-added prices	$pv_i^x = pv_i^x(w_n^x, w_k^x)$
Commodity prices	$p_i^x = p_i^x(pv_i^x, \underline{p}_{j-i}^x, \underline{p}^y, \bar{p}^w)$
Consumer Price Index	$cpi^x = \sum_i \mathcal{G}_i^{xx} p_i^x + \sum_i \mathcal{G}_i^{xy} p_i^y + \sum_i \mathcal{G}_i^{xw} \bar{p}_i^w$
Capital Price Index	$kpi^x = \sum_i \gamma_i^{xx} p_i^x + \sum_i \gamma_i^{xy} p_i^y + \sum_i \gamma_i^{xw} \bar{p}_i^w$
Labour Demand	$N_i^x = N_i^x(Q_i^x, p_i^x, pv_i^x, w_n^x)$
Capital Demand	$K_i^x = K_i^x(Q_i^x, p_i^x, pv_i^x, w_k^x)$
Capital Rental Rate	$K_i^x = K_i^{sx}$
Household Income	$Y^x = \varphi_n^x N^x w_n^x + \varphi_k^x K^x w_k^x + L^x T^x u^x f$
Commodity Demands	$Q_i^x = C_i^x + J_i^x + I_i^x + G_i^x + X_i^{xy} + X_i^{xw}$
Consumption Demand	$C_i^x = C_i^x(\underline{p}^x, \underline{p}^y, \bar{p}^w, Y^x)$
Intermediate Demand	$J_i^x = J_i^x(Q^x, pv^x, \underline{p}^x, \underline{p}^y, \bar{p}^w)$
Investment Demand	$I_i^x = I_i^x(\underline{p}^x, \underline{p}^y, \bar{p}^w, \sum_j b_{ij}^x \Delta K_j^x)$
Government Demand	$G_i^x = \alpha_i^x \bar{G}^N$
Interregional Export Demand	$X_i^{xy} = X_i^{xy}(\underline{p}^x, \underline{p}^y, \bar{p}^w, \bar{G}^N, \underline{J}^y, \underline{Q}^y, Y^y)$
International Export Demand	$X_i^{xw} = X_i^{xw}(\underline{p}^x, \bar{p}^w, \bar{D}^w)$

<b><i>Wage setting</i></b>	
Bargaining	$w_n^x = w_n^x(u^x, cpi^x)$
Quasi IO	$w_n^x = \beta^x cpi^x$
Wage Spillover	$w_n^x = w_n^y$
Unemployment Rate	$u^x = \frac{L^x T^x - \sum_i N_i^x}{L^x T^x}$

<b><i>Between period updating</i></b>	
Desired Capital Stock	$K_{i,t}^{*sx} = K_{i,t}^{*sx}(Q_i^x, p_i^x, pv_i^x, ucc^x)$
User Cost of Capital	$ucc^x = ucc^x(kpi^x)$
Investment	$\Delta K_{i,t}^x = \lambda(K_{i,t}^{*sx} - K_{i,t}^{sx}) + \delta_i^x K_{i,t-1}^{sx}$
Capital Supply	$K_{i,t}^{sx} = (1 - \delta_i^x) K_{i,t-1}^{sx} + \Delta K_{i,t-1}^x$
National Population	$\bar{L}^N = L^s + L^r$
Regional Population	$L_t^s = L_{t-1}^s + m_{t-1}^s$
Migration	$m_t^s = m^s \left[ \frac{w_t^s}{cpi_t^s}, \frac{w_t^r}{cpi_t^r}, u_t^s, u_t^r, L_t^s \right]$

### **Notation**

Underlined variables are vectors whose elements are the sectoral values of the relevant variables. Where the subscript j-i is used this represents a vector of all sectoral values except sector i.

A bar over a variable indicates exogeneity.

A starred variable donotes desired value.

### **Endogenous Variables**

- cpi: consumer price index
- kpi: capital price index
- m: Scottish immigration
- p: commodity price



pv:	value added price
u:	unemployment rate
ucc:	user cost of capital
$w_n$ :	nominal wage rate
$w_k$ :	capital rental rate
C:	consumption
D:	foreign demand
G:	government expenditure
I:	investment demand
J:	intermediate demand
K:	capital demand
$K^s$	capital supply
$\Delta K$	capital stock adjustment
L:	population
N:	employment
Q:	output
X:	exports
Y:	household income

### **Parameters and exogenous variables**

b:	capital coefficient
f:	benefit payment per registered unemployed
D	rest of the world demand
T:	participation rate
$\alpha$ :	government expenditure coefficient
$\beta$	real wage coefficient
$\delta$ :	depreciation rate
$\varphi$ :	regional share of factor income
$\theta$	consumption weights
$\gamma$	capital weights

$\lambda$  capital stock adjustment parameter

### **Subscripts**

$i,j$ : sectors

$k$ : capital

$n$ : labour

$t$ : time

### **Superscripts**

$r$ : rest of the UK

$s$ : Scotland

$w$ : rest of the world

$x,y$ : generic regional identifiers

### **Functions**

$m(.)$  migration function

$p(.), pv(.)$ : cost function

$ucc(.)$  user cost of capital formulation

$w(.)$ : wage curve

$C(.)$ : Armington consumption demand function

$I(.)$ , Armington investment demand function

$J(.)$ , Armington intermediate demand function,

$K(.), N(.)$  factor demand functions

$X(.)$  Armington export demand function

**Note:** A number of simplifications are made in this condensed version of AMOSRUK

1. Income transfers are generally suppressed.
2. Taxes are ignored.
3. The participation rate is ignored.
4. There are implicit time subscripts on all variables. These are only stated explicitly in the capital updating equation (6).



**Figure 1: UK GDP Impacts from a 5% ROW Export Demand Increase for Traded Sectors in Scotland (£M)**

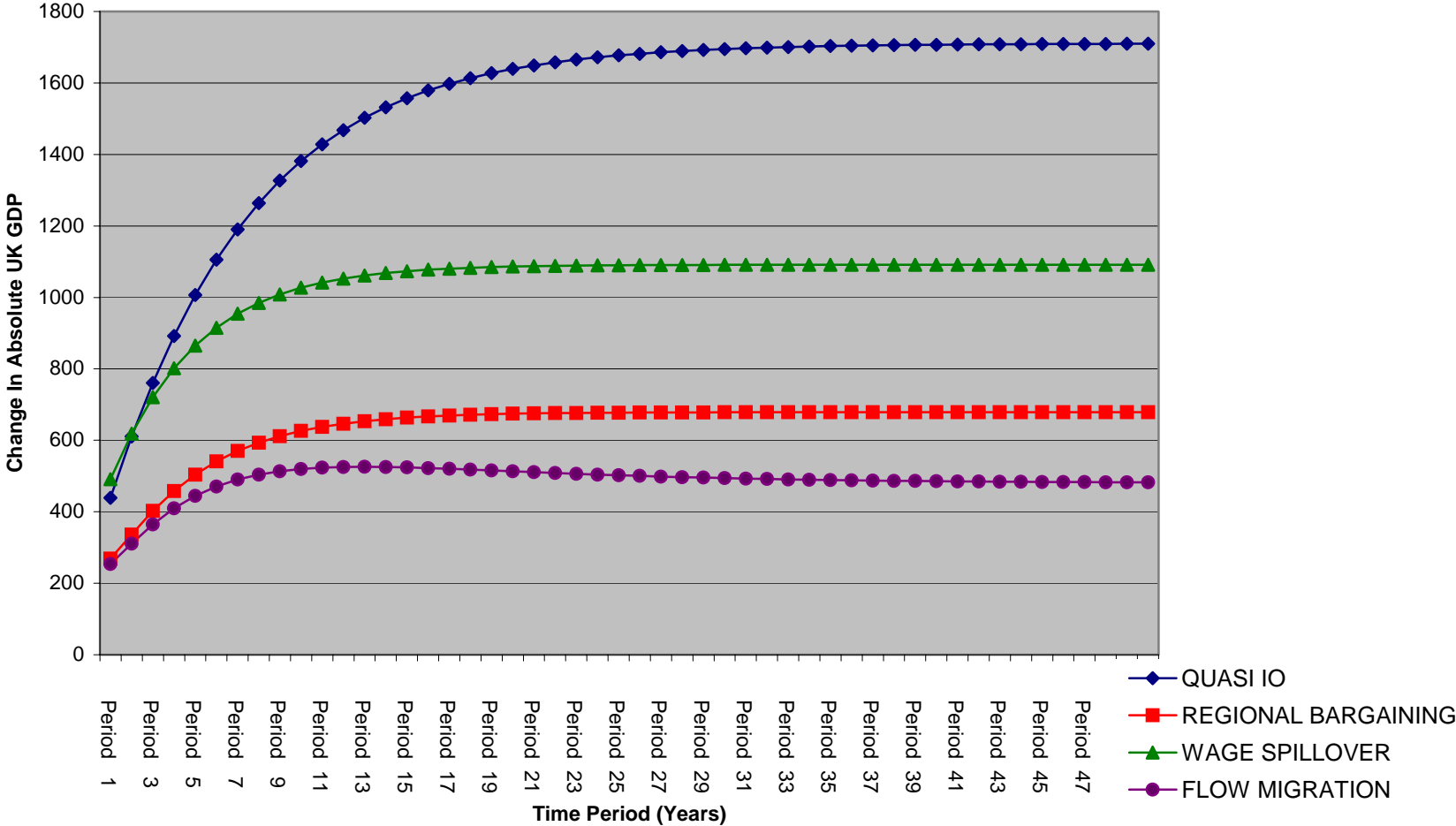
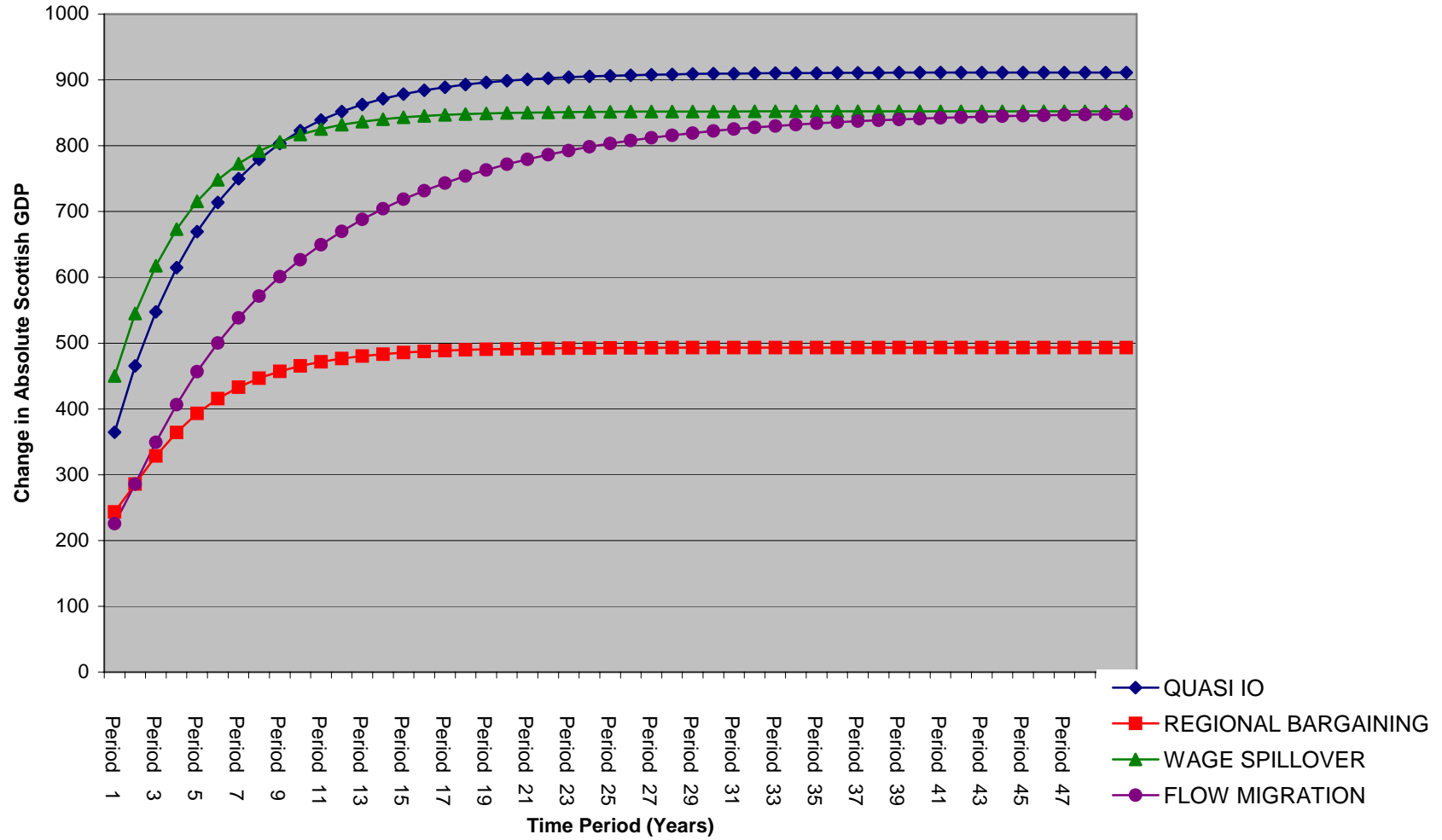
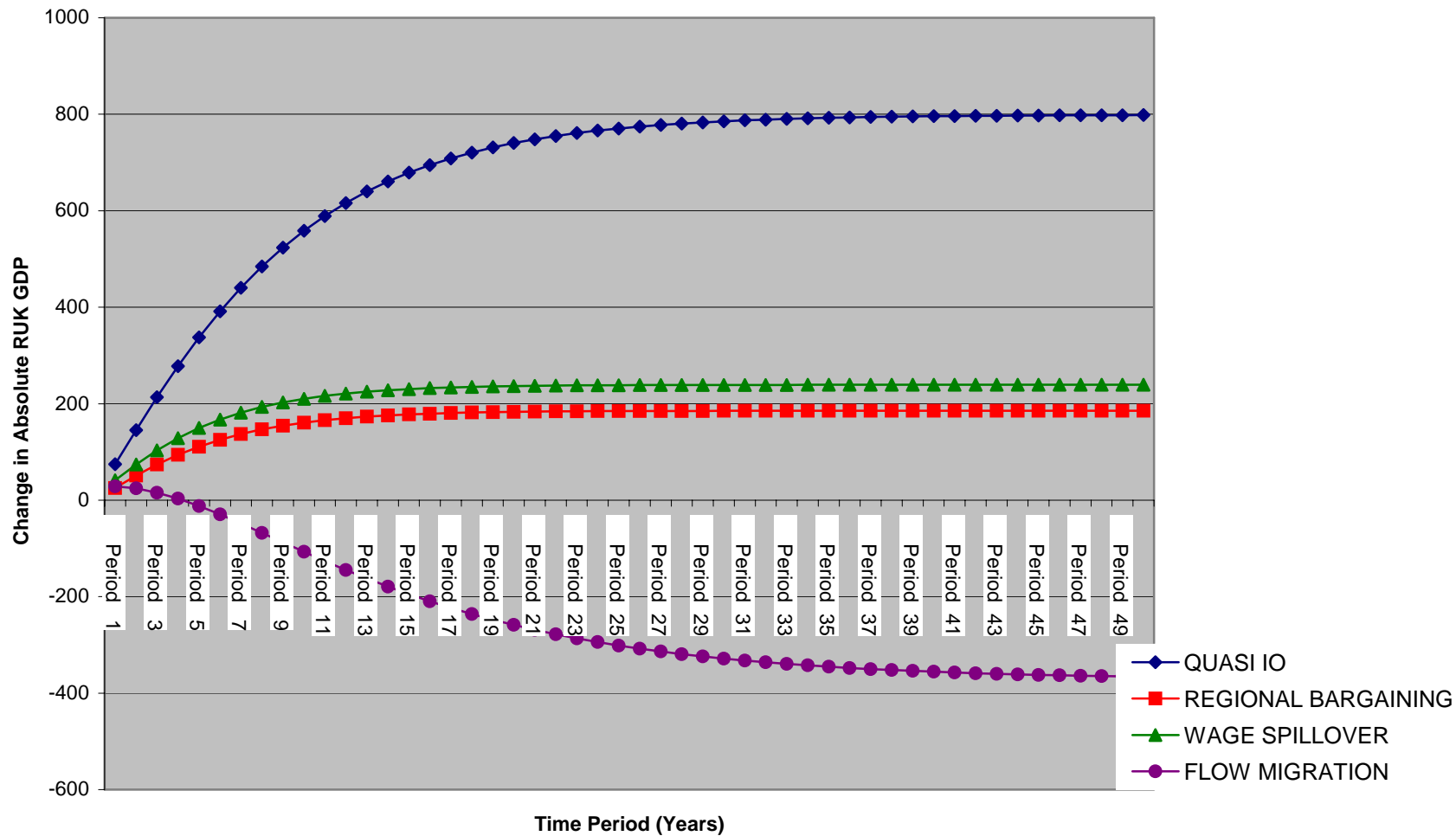


Figure 2: Scottish GDP Impacts from a 5% ROW Demand Increase for Traded Sectors In Scotland (£M)



**Figure 3: RUK GDP Impacts from a 5% ROW Export Demand Increase for Traded Sectors in Scotland (£M)**



**Figure 4: Scottish Before Tax Real Wage Impacts from a 5% ROW Export Demand Increase to Traded Sectors in Scotland**

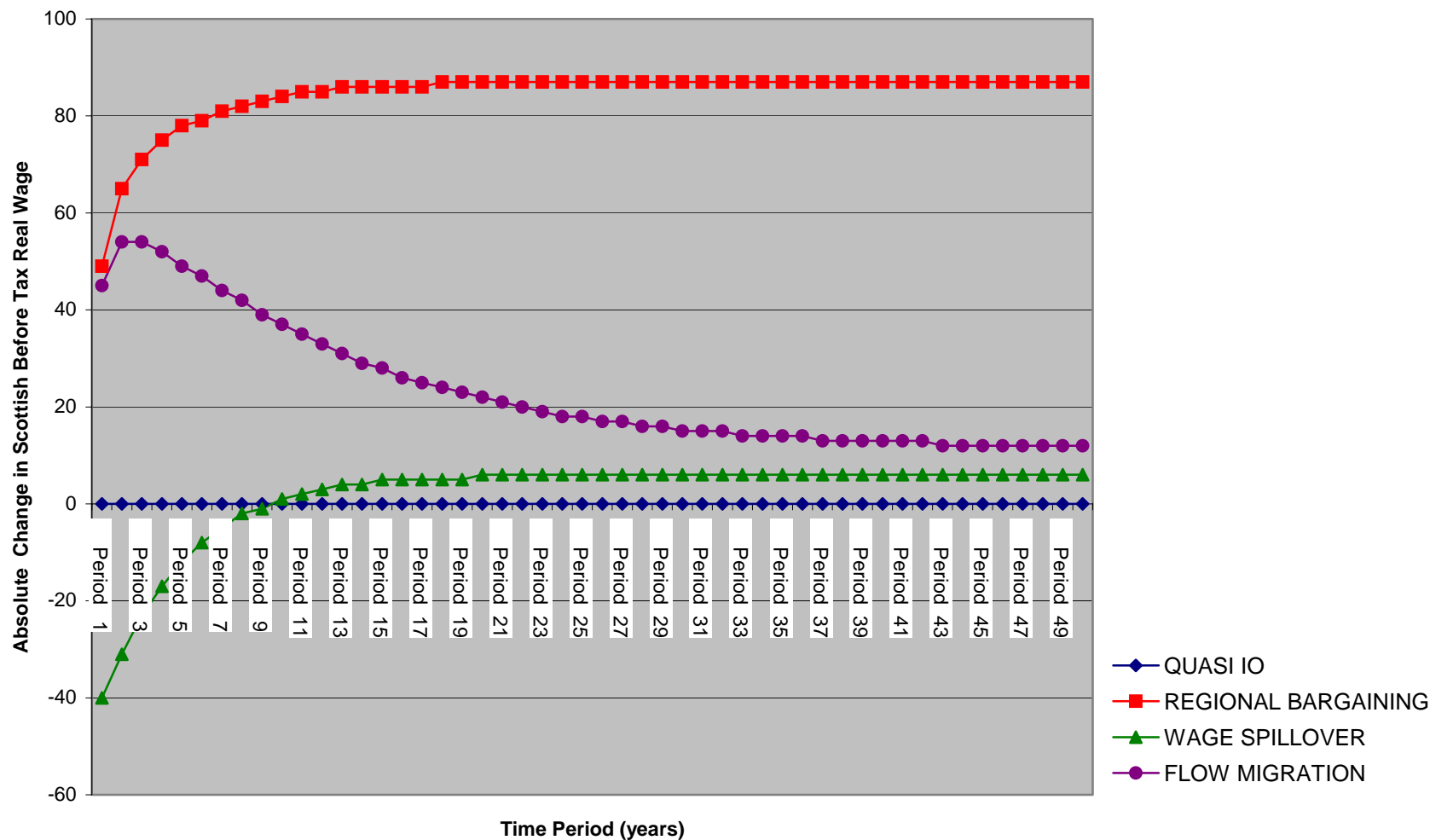


Figure 5: RUK Before Tax Real Wage Impacts from a 5% ROW Export Demand Increase for Traded Sectors in Scotland (£M)

