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Interregional dispersion of impacts from regional economic shocks: A CGE explanation

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1. Introduction

The ultimate effects on regions of economic shocks are influenced by a variety of interregional factors such as changes in competitiveness with other regions, interregional input-output linkages and factor mobility, particularly via interregional migration. There are circumstances where some factors may have opposing effects, and elucidating which might dominate requires a numerical model of the underlying regional structure.

To investigate these issues we are conducting a number of simulations with a multiregional computable general equilibrium (CGE) model. Our aim is to carefully interpret the results, disentangling the effects resulting from the various mechanisms which link regions. As might be expected, we are finding that our results are a consequence of a number of key model characteristics; in particular, the type of shock, the model closure and the speed of lagged responses in wages and interregional migration.

In this paper we concentrate on just one shock, a change in relative regional amenities. Amenities have long been considered to be a major factor in the choice of regional location by households (Greenwood et al., 1991). We will use the term "amenities" in its widest sense. The regional science literature often refers to natural amenities and urban amenities. The latter may include cultural opportunities and the availability of health and recreational services, and also the absence of disamenities, such as high crime rates and pollution levels.[1] In our framework, we will take "amenities" to mean any features of a region outside purely economic ones.

In the next section, we briefly describe our CGE model, the MONASH Multi-Regional Forecasting (MMRF) model before describing our migration theory in some detail. In Section 3 we set out a stylised version of MMRF which we use to explain our results. We call this stylised model S-BOTE. In Section 4 we discuss the results using S-BOTE of a 1 per cent fall in amenities in the NSW region.

2. The MONASH Multi-Regional Forecasting Model (MMRF)

2.1 MMRF Overview

MMRF is a dynamic multi-regional CGE model. In its operational version, MMRF explicitly models the behaviour of economic agents within each of Australia's 8 states and territories and features a large number of industries and commodities. For this exercise, however, we have for expository purposes reduced the number of regions to 3 and the number of industries to eight. Neoclassical assumptions govern the behaviour of the model's economic agents.

[1] We take our examples from Herzog and Schlottmann (1993, p. 145).

Each of the 8 representative industries operating within each of the 3 regions is assumed to minimise costs subject to constant-returns-to-scale production technologies and given input prices. A representative utility-maximising household resides in each of the model's 3 regions. Investors allocate new capital to industries on the basis of expected rates of return. Units of new capital are assumed to be a cost-minimising combination of inputs sourced from each of the model's 4 sources of supply (the 3 domestic regions plus imports). Imperfect substitutability between the imported and 3 domestic sources of supply for each commodity are modelled using the CES assumption of Armington. In general, markets are assumed to clear and to be competitive. Purchaser's prices differ from basic prices by the value of indirect taxes and margin services. Taxes and margins can differ across commodity, user, region of source and region of destination. Foreign demands for each of the 50 commodities from each of the 8 regions are modelled as inversely related to their foreign currency prices. The model includes details of the taxing, spending and transfer activities of two levels of government: a regional government operating within each region, and a federal government operating Australia-wide. Inter-governmental transfer payments and personal transfer payments to households are also modelled. Dynamic equations describe stock-flow relationships, such as those between regional industry capital stocks and regional industry investment levels. Dynamic adjustment equations allow for the gradual movement of a number of variables towards their long-run values. For example, the national real wage is assumed to be sticky in the short-run, adjusting over a period of about five years to return the level of national employment to its base-case level following an economic shock. Equality of deviations in expected regional real consumer wages across regions is maintained through labour movements between regions. Regional economic linkages arise from inter-regional trade, factor mobility, the taxing and spending activities of the federal government, and long-run economy-wide employment and balance of trade constraints. The model also evaluates a full set of national and regional income accounts, and associated deflators. The reader is referred to Adams et al. (2003) for a detailed discussion of the model, and Narqvi and Peter (1996) for an overview of core equations. The model is solved with the GEMPACK economic modelling software (Harrison and Pearson, 1996).

2.2 Treatment of Interregional Migration

2.2.1 Approaches taken in the regional CGE literature

Regional and multiregional models have taken a variety of approaches to the treatment of interregional migration. Some regional CGE models assume that labour is immobile across regions (e.g. Hirte, 1998). This assumption is more likely to be the case when the study is just for the short run (e.g. Li and Rose, 1995). Other studies take the opposite long-run approach and allow for endogenous interregional migration to equalize wages (e.g. Morgan, et al., 1989) or utility (e.g. Groenewold, et al., 2003). Many other regional CGE models, however, allow for imperfect interregional labour mobility.

Whalley and Trela (1986) were the first to incorporate imperfect interregional labour mobility into a regional CGE model.[2] Their migration theory was developed from their observation that individuals have "direct associations with specific regions" (p. 74). They assume that there is a distribution of individuals within each region who differ only by their intensity of preference for remaining in the region. In making decisions about migration, individuals compare the utility they would receive from residing in each of the regions. The marginal individual (i.e. the individual indifferent to migrating or remaining) is assumed to treat utility as just coming from income, and (as they are the marginal individual) the income receivable is the same for each region of residence.[3] All other individuals face a utility penalty from relocating, with the penalty increasing with the intensity of their location preference. If out-of-region income were to increase following some shock, out-migration would occur - until for the new marginal individual, home region income would just equal the income they could receive outside the region less the location penalty from shifting. That is, individuals trade off the extra income they would receive by migrating against location preference. Thus, in the new equilibrium interregional wage differentials are consistent with zero migration.

The responsiveness of interregional migration to interregional income differentials depends on the parameterisation of location preferences. Jones and Whalley (1989, p. 386) point to difficulties in setting the value of this parameter to be consistent with econometrically estimated elasticities of out-migration. Other modellers use equations directly employing econometrically estimated parameters for net migration (e.g. Rickman, 1992, McGregor et al. 1995 and 1996, and Rutherford and Törmä, 2010). McGregor et al. model net migration to equalize a function of interregional differences in unemployment and wage rates; with gradual adjustment of regional wage rates to return populations to equilibrium (i.e zero net migration).[4]

McGregor et al. (1996) simulate an improvement in amenities in Scotland and finds it causes unfavourable shifts in both the real consumer wage rate and unemployment. The authors (p.

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[2] Their model is a multiregional CGE model of Canada. A description detailing the model's migration theory can also be found in Jones and Whalley (1989).

[3] "Income" is the sum of real incomes from labour, natural resource taxes, and federal government transfers to the region.

[4] See also Gillespie et al. (2001).

350) surmise that it would seem problematic to direct interventionist regional policy at regions which are ‘low-wage, high unemployment’, as this description might simply mean the region is ‘amenity rich’.

2.2.2 A new specification for interregional migration

In MMRF, we begin development of our migration theory by assuming that gross inter-regional migration flows respond to movements in per-capita regional income relativities. We call the measure of income that is relevant to the migration decision “migration income”. Equation (1) defines migration income in region *r* as the expected wage per worker:

(E1) $Y_r^{(M)} = W_r \cdot E_r$

where

$Y_r^{(M)}$ is migration income in region *r*;
W_r is the wage rate in region *r*; and
E_r is the employment rate (1 minus the unemployment rate) in region *r*.

We define movements in per-capita migration income relativities via equation (2):

(E2) $$\frac{Y_d^{(M)}}{Y_o^{(M)}} = Y_{o,d}^{(Diseq)} \cdot \frac{F_d^{(M)}}{F_o^{(M)}}$$

where

$Y_r^{(M)}$ is migration income in region r;
$Y_{o,d}^{(Diseq)}$ is a measure of disequilibrium in migration income relativities between migration origin region *o* and migration destination region *d*;
$F_r^{(M)}$ is a shift-variable used for calibrating migration income ratios.

A plausible initial parameterisation of the right hand side of (2) is:

$Y_{o,d}^{(Diseq)}$ =1; and

$F_r^{(M)} = Y_r^{(M)Initial}$

where $Y_r^{(M)Initial}$ are the initial (base period) values for $Y_r^{(M)}$. With such a parameterisation of (2), we assume that the base period migration income relativities are consistent with trend regional gross emigration rates, and that the initial migration income relativities provide information about relative regional amenity values and the structure of regional compensating migration income relativities.

We assume that a rise, say, in $Y_{o,d}^{(Diseq)}$ will generate a rise in the gross emigration rate from region *o* to region *d* ($GEMR_{o,d}$), and a fall in the gross emigration rate from region *d* to region *o* ($GEMR_{o,d}$). That is, a rise in $Y_{o,d}^{(Diseq)}$ will cause region *d*'s net immigration rate to rise and region *o*'s net immigration rate to fall.

We adopt the inverse logistic function, used in Dixon and Rimmer (2002: 190-193) to model capital supply, to model the relationship between movements in $Y_{o,d}^{(Diseq)}$ and $GEMR_{o,d}$. For modelling a region's gross emigration rate, this function has the useful property of allowing us to limit the minimum and maximum rates of gross emigration.[5] The inverse logistic relationship is described in Figure 1. The equation describing this figure is:

(E3)

$$\begin{aligned} Y_{o,d}^{(Diseq)} &= 1 + F_{o,d} + (1/C_{o,d}) \\ &* \{ [\ln\left(GEMR_{o,d} - GEMR_{o,d}^{(MIN)}\right) - \ln\left(GEMR_{o,d}^{(MAX)} - GEMR_{o,d}\right)] \\ &- [\ln\left(GEMR_{o,d}^{(TREND)} - GEMR_{o,d}^{(MIN)}\right) - \ln\left(GEMR_{o,d}^{(MAX)} - GEMR_{o,d}^{(TREND)}\right)]\} \end{aligned}$$

where

$F_{o,d}$	is a parameter governing the vertical position of the function MM' in Figure 1;
$C_{o,d}$	is a positive parameter, governing the sensitivity of the gross emigration rate from region *o* to region *d* to movements in disequilibrium in the migration income ratio between region *o* and *d*;[6]
$GEMR_{o,d}$	is the gross emigration rate from region *o* to region *d*, expressed as a proportion of region *o*'s population;
$GEMR_{o,d}^{(MIN)}$	is the historically-observed minimum proportion of the region *o*'s population that emigrates to region *d* each year;
$GEMR_{o,d}^{(MAX)}$	is the historically-observed maximum proportion of region *o*'s population that emigrates to region *d* each year
$GEMR_{o,d}^{(TREND)}$	is the trend or normal rate of emigration from region *o* to region *d*.

[5] At the limit, the minimum and maximum gross emigration rates must be within the bounds 0 and 1 respectively. We choose minimum and maximum rates within these bounds by examining the historical data.

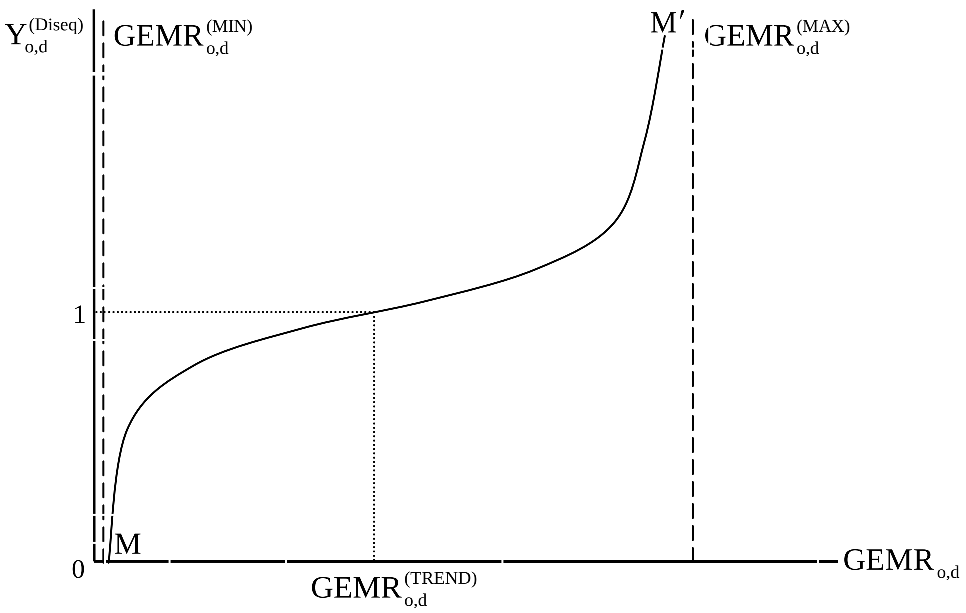
[6] We choose a value for $C_{o,d}$ that generates migration dynamics consistent with those described for Australia in Debelle and Vickery (1999). They find that net emigration from an Australian state following a relative downturn in its labour market occurs steadily over a number of years, with the bulk of the population adjustment having occurred by year four, and the process largely complete by year seven.

In year-on-year simulations, we treat $GEMR_{o,d}^{(TREND)}$ as a variable, and update its value each year according to the rule:

(E4) $$[100/GEMR_{o,d}^{(TREND)}]\times\Delta GEMR_{o,d}^{(TREND)} = q_d - q$$

(E4) ensures that the trend value for origin region *o*'s gross emigration rate to region *d* moves in proportion with region *d*'s share of the national population.

Figure 1: Relationship between gross regional emigration rates and disequilibrium in regional migration income.



To translate movements in $GEMR_{o,d}$ to movements in gross emigration numbers, we multiply the year *t* value of $GEMR_{o,d}$ by the year t population for region *o*. The resulting population flows affect start of year populations in year t + 1. Movements in $GEMR_{o,d}$ can thus be interpreted as changes in planned emigration in year *t*, with an average six month lag before the population movement occurs at the beginning of year *t* + 1.

3. Simulations and interpretation of multiregional model mechanisms

We use the MMRF model described in Section 2 to investigate a number of regional economic shocks. We have chosen these shocks on the basis that they describe the essential mechanics of a number of the research questions to which regional CGE models have been applied. An important purpose of the section is to explain our results in a way that can be readily understood by readers unfamiliar with a MMRF model. To do this we explain our results in terms of the miniature models, S-BOTE, which is a stylised back-of-the-envelope representation of the regional macroeconomy as modelled in MMRF. While S-BOTE is small and aggregated, it is sufficient to explain the major regional macroeconomic outcomes of the full-scale MMRF model. S-BOTE concentrates on the nature and direction of regional macroeconomic causation in the short-run and long-run.

3.1 A stylised back-of-the-envelope representation of regional macroeconomic relationships

3.1.1 Equations of the S-BOTE model

Equations (S1)-(S23) (Table 1) describe a stylised representation of the key regional macroeconomic relationships relevant to the simulations we discuss in Sections 4. Hereafter we refer to these equations as the S-BOTE (stylised back-of-the-envelope) model.[7]

(S1) to (S19) describe variables *within* any given year of a dynamic simulation. (S20) to (S22) describe how key regional stock variables, capital, population and net foreign liabilities, move through time. These equations hold *between* any two adjoining years of a dynamic simulation. (S23) describes the lagged adjustment of real regional wages in the policy simulation. This equation is relevant to the process of regional wage adjustment in policy simulations only.

Equation (S1) is gross regional expenditure (GRE) in constant price terms.

$$\text{(S1)} \qquad GRE_r = C_r + I_r + G_r^{(S)} + G_r^{(F)}$$

where, C_r is real regional private consumption spending, I_r is real regional gross fixed capital formation, $G_r^{(S)}$ is real state government consumption spending in region *r*, and $G_r^{(F)}$ is real federal government consumption spending in region *r*.

Equation (S2) is the regional gross domestic product identity in constant price terms.

$$\text{(S2)} \qquad Y_r = GRE_r + (X_r^{(*)} - M_r^{(*)}) + (X_r^{(R)} - M_r^{(R)})$$

where $X_r^{(*)}$ and $M_r^{(*)}$ represent region r's foreign export and import volumes respectively, and $X_r^{(R)}$ and $M_r^{(R)}$ represent region r's inter-regional export and import volumes respectively.

7 In developing the S-BOTE model, we extend to the regional level distinctions used in the national macro BOTE model outlined in Giesecke and Schilling (2010) between: equations that describe variables within any given year of a dynamic simulation; equations that hold between adjoining years of a dynamic simulation; equations describing adjustment of variables in the policy simulation; and effective short-run and long-run closures.

Equation (S3) relates regional output to inputs of primary factors and technology via a constant returns to scale production function. A_r and A_r^L are variables describing regional technical efficiency. A_r describes the effectiveness with which regional inputs of primary factors are transformed into output. A_r^L describes the technical efficiency of labour inputs.

(S3) $Y_r = [1 / A_r]\, f(\{L_r/A_r^L\}, K_r)$

where L_r is regional employment and K_r is the regional capital stock.

Since (S3) is constant returns to scale, under our assumption of cost-minimising behaviour on the part of regional producers, we can relate the regional labour / capital ratio to the regional rental / wage ratio only, via equation (S4):

(S4) $K_r/\{L_r/A_r^L\} = g(\{W_r \cdot A_r^L\}/R_r)$

Equation (S5) defines regional employment as the product of regional population (Q_r), the regional participation rate (PR_r)[8], and the regional employment rate (ER_r)[9].

(S5) $L_r = Q_r \cdot PR_r \cdot ER_r$

Equation (S6) provides a stylized representation of the rates of return by regional industry and (S7) relates regional industry investment to rates of return.

(S6) $ROR_r = R_r / P_r$

(S7) $I_r = u(ROR_r/\Lambda_r)$

where ROR_r is average rate of return on capital in region *r* and Λ_r is a shift variable allowing for short-run autonomous movements in regional investment.

Equation (S8) defines the regional gross capital growth rate (Ψ_r) of regional real investment (I_r) to the regional capital stock (K_r).

(S8) $I_r/K_r = \Psi_r$

Section 2.2.2 introduced equations (E1) to (E3), which set out the relationship between expected regional wages and inter-regional migration. Equation (S9) is a stylised

[8] More generally, if we define L_r as employment in hours, then PR_r is the product of the regional participation rate, hours worked per worker, and the share of the regional population that is of working age.
[9] That is, (1 – the unemployment rate).

representation of these equations, describing a positive relationship between net inter-regional migration to region *r* (NIM_r) and the expected wage in region *r*.

$$\text{(S9)} \qquad NIM_r = b(W_r \cdot ER_r / F_r^{(SR)})$$

where $F_r^{(SR)}$ is a shift variable allowing autonomous movements in net inter-regional immigration to region *r*. (S10) calculates Υ_r, that part of region *r*'s population growth rate that is attributable to net inter-regional migration:

$$\text{(S10)} \qquad NIM_r \,/\, Q_r = \Upsilon_r$$

Equation (S11) defines $F_r^{(LR)}$, the ratio of the regional wage to the national wage:

$$\text{(S11)} \qquad W_r \,/\, W = F_r^{(LR)}$$

Equation (S12) determines the regional price level (P_r) as a function of the efficiency of regional primary factor usage (A_r), regional labour efficiency (A_r^L), and the prices of regional primary factors. More formally, it is the cost-minimising unit cost function that arises from (S3).

$$\text{(S12)} \qquad P_r = A_r \; u(\{W_r \cdot A_r^L\}, R_r)$$

Equation (S13) describes the regional consumption function. Regional real private consumption (C_r) moves with regional income under a given average propensity to consume (APC_r). In equation (S13) real regional income is simplified as real GDP at factor cost less interest payments on net foreign liabilities.[10] Foreign interest payments are represented by $NFL_r\ R$, where NFL_r is region *r*'s real (consumption price deflated) net foreign liabilities and R is the interest rate on net foreign liabilities.

$$\text{(S13)} \qquad C_r = APC_r \cdot [\, Y_r - NFL_r \cdot R \,]$$

Equations (S14) and (S15) describes the determination of regional and federal government public consumption spending at the regional level. Equation (S14) defines $\Gamma_r^{(S)}$,

[10] Readers familiar with the BOTE approach might be surprised at the absence of a terms of trade term in (S13). For example, (B13) might alternatively be written as $C_r = APC_r$ [{$PGDP_r/PC_r$}Y – NFL_r x R], where $PGDP_r$ and PC_r are the regional GDP deflator and consumption price deflator respectively. The ratio of these terms is a positive function of the terms of trade. By suppressing this ratio in (S13) and other relevant equations of S-BOTE, we do not wish to imply that terms of trade effects are absent at the regional level. However, regional terms of trade effects are not an important part of the explanations of results we present in Section 4. Hence, to keep S-BOTE simple, we do not include the terms of trade.

the ratio of state government consumption to private consumption in region *r*. Equation (S15) defines $\Gamma_r^{(F)}$, per-capita real federal government consumption in region *r*.

(S14) $G_r^{(S)}/C_r = \Gamma_r^{(S)}$

(S15) $G_r^{(F)} / Q_r = \Gamma_r^{(F)}$

Equation (S16) relates region *r*'s foreign export volumes ($X_r^{(*)}$) to the price of regional output (P_r) and a vertical (willingness to pay) scalar on the position of region-specific export demand schedules (V_r).

(S16) $X_r^{(*)} = b(P_r / V_r)$

In MMRF the Armington (CES) assumption is used to model imperfect substitution possibilities across alternative sources of commodity supply to each region. In general functional form, this gives rise to equations (S17) – (S19). (S17) and (S18) relate region *r*'s foreign and domestic import volumes respectively to regional activity (represented here by Y_r), and the relative price of goods produced in region *r*. Similarly, (S19) relates region *r*'s inter-regional exports to the rest of the country to the relative price of region *r*'s output. (S19) also allows for the possibility of cost-neutral autonomous change in preferences in all regions away from (or towards) region *r*'s products, represented here by Ξ_r, the inter-regional sourcing twist term.[11]

(S17) $M_r^{(*)} = h(P_r/P, Y_r)$

(S18) $M_r = d(P_r/P, Y_r)$

(S19) $X_r = s(P_r/P, \Xi_r)$

(S20) to (S22) relate movements in three key regional stock variables to relevant flow variables. (S20) relates changes in the regional capital stock to regional investment. (S21) relates change in regional population to net inter-regional migration, and (S22) relates the change in net regional foreign liabilities to the excess of gross regional expenditure over regional income investment over savings.

(S20) $\Delta K_r = I_r$

(S21) $\Delta Q_r = NIM_r$

[11] See Horridge (2003) for a discussion of the derivation of these twist terms.

(S22) $\Delta NFL_r = GRE_r - Y_r$

Equation (S23) governs the path of real regional wages in the policy simulation. With (S23) activated in the policy simulation, the deviation in the real regional wage grows (declines) as long as the regional employment rate remains above (below) its basecase forecast level.

(S23) $$\left(W^{(Policy)}_{(t),r}/\mathbf{W}^{\mathbf{(Basecase)}}_{\mathbf{(t),r}} - 1\right) = \left(\mathbf{W}^{\mathbf{(Policy)}}_{\mathbf{(t\text{-}1),r}}/\mathbf{W}^{\mathbf{(Basecase)}}_{\mathbf{(t\text{-}1),r}} - 1\right) + \alpha\left(ER^{(Policy)}_{(t),r}/\mathbf{ER}^{\mathbf{(Basecase)}}_{\mathbf{(t),r}} - 1\right)$$

3.1.2 Short-run closure and operation of the S-BOTE model

We now discuss appropriate closures for equations (S1)-(S23). In doing so, we distinguish between equations that describe economic relationships within any given year (S1-S19), equations that describe movements in stock variables between years (S20-S22), and the equation describing sticky wage adjustment (S23). Within any given year of a year-on-year dynamic simulation, K_r, Q_r and NFL_r can be considered exogenous. The movement in these variables *between* years depends on investment, immigration and savings *within* years. These accumulation relationships are described by (S20)-(S22). (S23) governs the transition of the policy-case labour market closure from a short-run to a long-run environment. When operational in the policy simulation, (S23) gradually moves the regional labour market from a short-run situation of exogenous real wage / endogenous employment rate, to a long-run situation of exogenous employment rate / endogenous real wage. Recognising that (S20)-(S22) govern dynamics across years, our task of understanding model closure narrows to choosing appropriate short-run and long-run closures for equations (S1)-(S19).

In Table 1, model closure is described by rendering exogenous variables in bold. Two closures are presented: a short-run closure and an "effective" long-run closure. By "effective" long-run closure, we mean that while ROR_r, Ψ_r, ER_r, Υ_r and $F^{(LR)}_r$ are presented as long-run exogenous, no such exogeneity is actually imposed on these variables in the MMRF simulations reported in Section 4. Rather, in year-on-year dynamic simulations, (S8) and (S20), (S10) and (S21), and (S23) lead the economy to a long-run position that can be satisfactorily described by exogenous status of ROR_r, Ψ_r, Υ_r, $F^{(LR)}_r$ and ER_r.

(S1) to (S19) comprise 19 equations in 36 variables, requiring 17 variables be determined exogenously. A conventional short-run closure of (S1)-(S19) would have L_r, Y_r, GRE_r, C_r, I_r, $G^{(S)}_r$, $G^{(F)}_r$, $X^{(*)}_r$, $M^{(*)}_r$, $X^{(R)}_r$, $M^{(R)}_r$, R_r, P_r, ER_r, ROR_r, Ψ_r, NIM_r, Υ_r, and $F^{(LR)}_r$ determined endogenously, given exogenous values for A_r, A^L_r, K_r, W_r, Q_r, PR_r, Λ_r, $F^{(SR)}_r$,

W, P, APC_r, NFL_r, R, $\Gamma_r^{(S)}$, $\Gamma_r^{(F)}$, V_r and Ξ_r. Under this closure, each equation can be associated with the determination of a specific endogenous variable, allowing us to trace lines of short-run regional macroeconomic causation that will prove helpful in understanding the multi-regional CGE results we discuss in Section 4.

We begin by considering the regional price level, P_r, and the regional trade equations (S16) – (S19). With elastic foreign demand schedules, exogenous import prices, and flexible sourcing substitution possibilities via our settings for inter-regional and international Armington elasticities, we begin by noting that via equations (S16) – (S19) scope for significant short-run movements in P_r is constrained. We conjecture that a natural way to enter the system of simultaneous equations described by (S1) to (S19) is to begin with the idea that P_r is largely given.

We assume that short-run regional wages are sticky. In S-BOTE this is described by the exogenous status of W_r. With short-run movements in P_r constrained by the high price elasticity of demand of the regional traded goods sector, and with both primary factor productivity (A_r) and labour productivity (A_r^L) exogenous, we can identify (S12) with the short-run determination of capital rental rates (R_r).

With R_r determined by (S12), and with K_r, A_r, A_r^L and W_r exogenous, (S4) can be identified with the short-run determination of L_r. With K_r, A_r and A_r^L exogenous, and L_r known from (S4), Y_r is thus determined via (S3).

With Y_r determined equation (S13) determines C_r. With $\Gamma_r^{(S)}$ exogenous, this allows $G_r^{(S)}$ to be determined via (S14). Note that with the short-run regional population (Q_r) exogenous, the exogenous status of $\Gamma_r^{(F)}$ determines $G_r^{(F)}$ via (S15).

Together, (S13) – (S15) determine the regional consumption component of gross regional expenditure (GRE_r). Via (S1), we see that the remaining element of GRE_r is regional investment (I_r). I_r is determined by (S7) as a positive function of rates of return (ROR_r). In turn, ROR_r is determined by (S6), given that R_r is largely determined by (S12). With short-run movements in I_r determined by (S7), (S8) calculates short-run movements in the gross capital growth rate (Ψ_r).

With both regional investment, and regional private and public consumption determined, equation (S1) determines GRE_r. With Y_r determined by (S3), equation (S2) must determine the regional balance of trade: $(X_r^{(*)} - M_r^{(*)}) + (X_r^{(R)} - M_r^{(R)})$. The variable that adjusts to accommodate the required balance of trade movement is the regional price level, P_r. Note that the individual components of the regional balance of trade, $X_r^{(*)}$, $M_r^{(*)}$, $X_r^{(R)}$ and $M_r^{(R)}$ are determined by (S16) - (S19). In each of the equations (S16) - (S19), an important element is the relative regional price level, P_r / P. As argued earlier, $X_r^{(*)}$, $M_r^{(*)}$, $X_r^{(R)}$ and $M_r^{(R)}$ are elastic to movements in P_r / P. We view (S2) as determining the small movements in P_r necessary to generate outcomes for $X_r^{(*)}$, $M_r^{(*)}$, $X_r^{(R)}$ and $M_r^{(R)}$ via (S17) - (S19) that is compatible with the regional balance of trade deficit implicit in the difference between regional output determined by (S3) and regional expenditure determined by (S1).

With L_r determined by (S4), the regional population (Q_r) sticky in the short-run, and regional participation rates (PR_r) exogenous, equation (S5) determines short-run movements in the regional employment rate (ER_r). Via equation (S9), this determines short-run movements in the net inter-regional migration rate (NIM_r), for given values of W_r and $F_r^{(SR)}$. With NIM_r determined by (S9), (S10) determines short-run movements in region *r*'s net inter-regional migration rate (Υ_r).

3.1.3 Long-run closure and operation of the S-BOTE model

Column (2) of Table 1 presents the long-run closure of S-BOTE. Our description of the model's long-run closure differs in three respects from the short-run closure described above.

First, (S23) ensures that the policy-case level of the regional employment rate (ER_r) is eventually returned to its base-case level via regional wage adjustment. In S-BOTE, this is represented by long-run exogeneity of ER_r and endogeneity of W_r.

Second, the short-run operation of (S7) and (S20) gradually drive rates of return towards base-case via capital adjustment. In (S7), Λ_r can be interpreted as a normal rate of return. Hence, via (S7), regional investment will be above (below) base-case so long as current rates of return (ROR_r) are above (below) normal rates of return. The annual capital accumulation process is described by (S20). Capital accumulation (depreciation) gradually drives convergence of actual and normal rates of return. In column (2) of Table 1, we describe the long-run outcome of this process as effective exogeneity of ROR_r and endogeneity of K_r.

Third, long-run changes in equilibrium regional capital stocks require long-run adjustments to the level of real regional investment in order to maintain the new level of capital. We describe this via the long-run exogenous status of Ψ_r in (S8). With (S8) determining long-run real investment, we describe (S7) as inactive in the long run via the endogenous status of Λ_r.

Fourth, the short-run operation of (S9) and (S21) generate movements in population that return expected inter-regional wage relativities to some independently given level. In S-BOTE, we represent this by the long-run endogenous status of Q_r and exogenous status of $F_r^{(LR)}$. Once long-run regional populations have adjusted to maintain independently determined inter-regional expected wage relativities, inter-regional migration rates return to independently established values. In S-BOTE, this is represented by the exogenous status of Υ_r. With the long-run annual value of NIM_r determined by (S10), we describe (S9) as inactive in the long run via the endogenous status of $F_r^{(SR)}$.

We now describe the path of long-run macroeconomic causation implicit in the closure described by column (2) of Table 1. This will prove helpful in interpreting the economic mechanisms responsible for the long-run simulation results discussed in Sections 4. We begin by noting that our long-run assumption of flexible regional capital and labour supply at given rates of return and inter-regional wage relativities effectively determines the long-run regional price level. This is clear from column 2 of Table 1 if we start by noting that with $F_r^{(LR)}$ exogenous, the long-run regional wage (W_r) is determined by (S11). With long-run rates of return (ROR_r) exogenous, the regional capital rental rate (R_r) is determined by (S6) for given movements in the regional price level (P_r). However, via (S12), for given levels of regional primary factor and labour productivity (A_r and $A_r^{(L)}$), we see that movements in the long-run regional price level follow movements in regional wages (W_r) and capital rental prices (R_r). But, as already noted, long-run values for W_r and R_r are determined via the exogenous status of ROR_r and $F_r^{(LR)}$. Together, (S6), (S11) and (S12) remind us that in the long-run, movements in a given region's factor prices, and with them, movements in a given region's price level, are all largely insulated from changes in regional economic conditions, barring movements in regional productivity.

With long-run movements in P_r determined by regional productivity and by long-run settings for regional factor markets, we now turn to explaining the long-run determination of the price-sensitive elements of regional GDP. Equations (S16) - (S19) describe region-specific foreign and inter-regional export and import volumes. All depend on, *inter alia*, the relative price of the region's output. If the regional price level were to fall, for example, then demand for the output of the region's traded good sector will rise. Via (S16) - (S19) this will be expressed as a fall in foreign and inter-regional import volumes ($M_r^{(*)}$ and $M_r^{(R)}$ respectively) and a rise in foreign and inter-regional export volumes ($X_r^{(*)}$ and $X_r^{(R)}$ respectively). Via (S2) this will cause regional activity (Y_r) to rise. Via (S3), the rise in Y_r requires inputs of K_r and L_r to rise. The relative proportionality of increase in K_r and L_r is governed by (S4). As discussed earlier, ceteris paribus, there is little long-run scope for endogenous movement in the regional wage / rental ratio. Hence, via (S4), we might expect that K_r and L_r will rise in proportion with the increase in Y_r.

With L_r determined by (S3) and (S4), and with the regional participation rate (PR_r) and employment rate (ER_r) exogenous in the long-run, the long-run regional population (Q_r) is determined by (S5). With the annual rate of net migration to region *r* (Υ_r) exogenous in the long run, with Q_r known, so too is the long-run annual net migration to region *r* (NIM_r) via (S9).

With K_r determined by (S3) and (S4), regional investment (I_r) is determined by (S8). With Y_r determined by (S2), real private consumption spending (C_r) is determined by (S13). With C_r determined, the long-run movement in regional public consumption spending ($G_r^{(S)}$) is determined via (S14). With Q_r determined by (S5), regional federal public consumption spending ($G_r^{(F)}$) is determined by (S15). With I_r, C_r, $G_r^{(S)}$ and $G_r^{(F)}$ thus determined, gross regional expenditure (GRE_r) is determined by (S1). Note that via the above streams of macroeconomic causation, we might generally expect that the individual components of GRE_r, and with them, GRE_r itself, to move broadly in line with movements in Y_r.

4. A change in regional amenity

We model a change in regional amenity via movements in $F_r^{(M)}$. For example, a fall in region *d*'s regional amenity, through say, heightened perceptions of risk of terrorism, natural disaster or industrial accident, requires a compensating increase in region *d*'s migration income relativity. Via (2), this can be implemented through an increase in the value of $F_d^{(M)}$. In the simulation below, we investigate the effects of a 1 per cent increase in the value of $F_{NSWACT}^{(M)}$ in the year 2012.

To understand the impact of a movement in $F_d^{(M)}$, we begin with S-BOTE. As discussed in Section 3.1.2, we assume that short-run regional real wages are sticky. In our short-run description of S-BOTE, this is represented by the exogenous status of W_r (column 1, Table 1). As discussed in Section 3.1.2, describing W_r as exogenous in the short-run is a shorthand way of describing the operation of equation (S23). (S23) relates the deviation in the regional wage rate to the lagged deviation in the regional wage and the deviation in the regional employment rate. Since none of the right-hand-side variables in (S23) respond immediately to NSW's regional amenity deterioration, the regional wage does not deviate from its basecase value in the first year of the simulation (Chart 1). Hence, via equation (S4), year 2012 regional employment is not affected by the movement in $F_d^{(M)}$ (Chart 1). Via (S5), there is thus no immediate (year 2012) impact on the regional employment rate (Chart 1).

The immediate (short-run) effect of an increase in $F_{NSWACT}^{(M)}$ is to decrease $Y_{o,NSWACT}^{(Diseq)}$ via MMRF equation (E2). Via (E3), this simultaneously raises the gross emigration rate from NSW to VIC and QLD, and lowers the gross emigration rate from VIC and QLD to NSW.[12] This causes NSW net immigration to fall, and QLD and VIC net immigration to rise (Chart 2). In S-BOTE, the joint operation of (E1) - (E3) is represented in a stylised way via (S9). (S9) recognises a positive relationship between region *r*'s net immigration numbers ($\mathrm{NIM_r}$), and region *r*'s migration income measure ($\mathrm{W_r \cdot ER_r}$) divided by the short-run representation of the amenity shift variable $\mathrm{F_r^{(SR)}}$. In (S9), a rise in $\mathrm{F_r^{(SR)}}$ lowers the value of $\mathrm{NIM_r}$ for any given value of $\mathrm{W_r \cdot ER_r}$. This is consistent with the short-run effect of $F_{NSWACT}^{(M)}$ in MMRF equations (E1) – (E3).

[12] The three regions in our model are: (1) NSW ACT; (2) VIC SA TAS; and (3) QLD WA NT. For convenience, we shall refer to each just by the acronym for the first mentioned state in each regional grouping.

Via the population accumulation equation (S21), the deviations in net regional immigration rates reported in Chart 2 translate through time into deviations in regional population (Chart 1). In NSW, the population falls 0.2 per cent below basecase in 2013. However, short-run movement in the NSW wage is constrained by (S23). Via (S4), this limits scope for movement in NSW employment. Hence, the NSW employment deviation in 2013, at -0.06 per cent, is less than the NSW population deviation (Chart 1). Via (S5), this requires the NSW employment rate to rise (Chart 1). The 2013 positive deviation in the NSW employment rate immediately begins placing upward pressure on the real consumer wage via (S23) (Chart 1). However, consistent with our assumption of regional wage stickiness, (S23) ensures that this pressure is not sufficient to immediately return the NSW employment rate to its basecase value (Chart 1).

The NSW capital stock adjusts gradually to the shock. In the short-run representation of S-BOTE, gradual short-run capital adjustment is described by exogenous determination of K_r. With short-run capital stocks adjusting slowly, as NSW's population declines, and with it, NSW employment (Chart 1), the NSW labour / capital ratio must fall **(**Chart 3). Via (S4), this causes a negative deviation in the NSW capital rental rate (Chart 3), which, via (S6), causes a negative deviation in the NSW rate of return on capital. In Chart 3, we report deviations in both the NSW average capital rental price and NSW investment price deflator. The short-run negative deviation in the NSW rate of return is manifested in Chart 3 as a large negative gap between the NSW average capital rental price and the NSW investment price deflator. Via (S7), the negative deviation in the NSW rate of return causes a negative deviation in NSW investment (Chart 3). Via (S20), this generates a growing negative deviation in the NSW capital stock **(**Chart 3).

The situation just described for NSW is reversed for the country's other regions. For example, via Chart 2 we see that the short-run net immigration deviation for QLD is positive. Via S-BOTE equation (S21), this generates a growing positive deviation in the QLD population (Chart 4). Via S-BOTE equation (S23), QLD's wages adjust with a lag to the regional labour market pressures generated by the positive population deviation. This constrains the short-run movement in QLD employment via (S4). Via (S5), this ensures that, as the QLD population deviation gradually increases over the short-run, the short-run deviation in the QLD regional employment rate is initially negative (Chart 4). This accounts for the short-run gap between the regional population and employment deviations in Chart 4. Over the medium run, the

QLD regional wage deviation decreases, allowing the regional economy to absorb the rising labour force through higher employment, and gradually returning the regional employment rate to its basecase level (Chart 4).

To understand the long-run implications of the amenity shock, we begin by considering equations (S9) – (S11) in the long-run representation of S-BOTE (column 2, Table 1). In the long-run, MMRF equations (E1) – (E3) operate to ensure that regional populations (and with them, regional labour forces) eventually adjust to ensure that regional wage relativities are little changed from independently determined levels, and that net immigration rates eventually return to levels that are little different from their long-run trend values. In S-BOTE, we begin the description of this long-run equilibrium by deactivating (S9), the short- to medium-run equation that gradually achieves long-run equilibrium in inter-regional migration. In S-BOTE, deactivation of (S9) is described by the endogenous determination of $F_r^{(SR)}$. In the long-run, we assume that the short- to medium-run immigration process described by (S9) in column 1 has returned wage relativities to exogenously determined values. In the long-run representation of S-BOTE, this is described by exogenous determination of $F_r^{(LR)}$ in (S11). Our long-run representation of the amenity shock in S-BOTE is a one percent increase in the value of $F_r^{(LR)}$. In our MMRF results, we see this as a long-run increase in the ratio of the NSW wage to wages in other regions (Chart 5).

The short- to medium-run operation of equations (S7) and (S20) gradually drive regional rates of return back towards their base-case values via regional capital adjustment. As discussed in Section 3.1.3, the end point of this process can be represented by long-run exogeneity of regional rates of return and endogeneity of regional capital stocks. In the long-run representation of equations (S6) and (S11), regional factor prices are effectively determined exogenously.[13] Hence, via (S12), so too are relative regional output prices. Via equations (S16) – (S19), relative regional output prices are the chief determinant of region-specific net exports. This ties down the long-run size of the regional macro economy via (S2). That outcomes for long-run regional macro outcomes following supply-side shocks hinge largely on movements in relative regional cost conditions has been noted previously (Giesecke et al.

[13] This is a useful approximation of the long-run condition holding in many MMRF models. Of course, it is only an approximation. For example, in (B9), the denominator in the rate of return equation is the regional GDP deflator at factor cost. However, in a true MMRF model, rates of return are calculated with reference to the regional cost of capital. Movements in regional capital costs can diverge from movements in average regional prices due to taxes (see for example Giesecke et al. 2008), sectoral differences in productivity change.

2008, Giesecke and Madden 2010, Giesecke et al. 2011). The long-run representation of S-BOTE makes clear the connection between user-specified assumptions about regional factor prices and the long-run size of the regional economy.

Chart 6 reports deviations in real GDP and GDP deflators for the three regional economies. The relationship between deviations in GDP deflators and deviations in real GDP predicted by S-BOTE are borne out in the MMRF results. Consistent with our positive shock to the relative NSW wage rate, in Chart 6 we find the NSW GDP deflator rising relative to our other two regions. By increasing the relative cost of goods sourced from NSW, this causes a negative deviation in NSW real GDP. A corollary of the rise in the relative NSW wage rate is a fall in the relative VIC and QLD wage rates (Chart 5). This accounts for the relative declines in the VIC and QLD GDP deflators (Chart 6). By reducing the relative cost of goods sourced from VIC and QLD, this causes positive deviations in the real GDP of these regions. Note that the ranking of the real GDP deviations corresponds with the ranking of the deflator deviations. The negative deviation in VIC's GDP deflator lies below that for QLD (**Chart 6**).[14] The slight relative cost advantage this affords the VIC economy causes its real GDP deviation to lie slightly above than that of QLD (Chart 6).

Via (S12), we can see that to explain the long-run movements in GDP deflators reported in Chart 6, we must explain long-run regional movements in wage rates and rental rates. Movements in long-run regional wage rates (Chart 5) were explained above by direct reference to our shock. To explain long-run movements in rental rates, we refer to our short-run investment and capital accumulation equations (S7 and S20) and our long-run rate of return equation (S6). Chart 7 reports MMRF results for regional rental prices and investment price deflators. In the short-run, Chart 7 reveals divergent deviations in region-specific capital rental prices and investment prices. In NSW, the deviation in the average capital rental prices initially lies below the NSW investment price deviation, implying a short-run negative deviation in NSW rates of return. In QLD and VIC, short-run average capital rental prices initially rise relative to investment prices, implying a short-run increase in rates of return (Chart 7). In NSW, the short-run negative rate of return deviation generates a short-run negative investment deviation (Chart 3). This accounts for the growing negative deviation in the NSW capital stock (Chart 3). Over time, this allows the deviation in the NSW capital

[14] The movement of labour out of NSW reduces wages in QLD and VIC by the same amount (Chart 5). However, VIC is more labour intensive than QLD. Hence, the negative deviation in wages generates a larger negative deviation in VIC's GDP deflator relative to QLD's GDP deflator.

rental price to gradually recover, so that by the end of the simulation period, we find it steadily converging on the NSW investment price deviation (Chart 7). In QLD and VIC, we find the reverse situation, with capital accumulation gradually driving down the short-run positive deviation in the capital rental rate, so that by the end of the period, we find it steadily converging on the long-run deviation in the investment price index. In S-BOTE, we represent the propensity of the long-run MMRF model to exhibit convergent deviations in capital rental prices and capital construction costs through the exogenous status of ROR in equation (S6). This long-run representation of (S6) models the fact that changes in the long-run cost of constructing regional capital must eventually flow into the long-run regional cost stream via changes in capital rental prices.

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Table 1: S-BOTE: a stylised back-of-the-envelope representation of the main macroeconomic relationships of a MRCGE model

	'Effective' short-run closure	**'Effective' long-run closure**
	Equations holding within any given year of the year-on-year basecase and policy simulations	
(S1)	$GRE_r = C_r + I_r + G_r^{(S)} + G_r^{(F)}$	$GRE_r = C_r + I_r + G_r^{(S)} + G_r^{(F)}$
(S2)	$Y_r = GRE_r + (X_r^{(*)} - M_r^{(*)}) + (X_r^{(R)} - M_r^{(R)})$	$Y_r = GRE_r + (X_r^{(*)} - M_r^{(*)}) + (X_r^{(R)} - M_r^{(R)})$
(S3)	$Y_r = [1 / \mathbf{A_r}]\, f(\{L_r/\mathbf{A_r^L}\},\mathbf{K_r})$	$Y_r = [1 / \mathbf{A_r}]\, f(\{L_r/\mathbf{A_r^L}\},K_r)$
(S4)	$\mathbf{K_r}/\{L_r/\mathbf{A_r^L}\} = g(\{\mathbf{W_r} \cdot \mathbf{A_r^L}\}/R_r)$	$K_r/\{L_r/\mathbf{A_r^L}\} = g(\{W_r \cdot \mathbf{A_r^L}\}/R_r)$
(S5)	$L_r = \mathbf{Q_r} \cdot \mathbf{PR_r} \cdot ER_r$	$L_r = Q_r \cdot \mathbf{PR_r} \cdot \mathbf{ER_r}$
(S6)	$ROR_r = R_r / P_r$	$\mathbf{ROR_r} = R_r / P_r$
(S7)	$I_r = u(ROR_r/\mathbf{\Lambda_r})$	$I_r = u(\mathbf{ROR_r}/\Lambda_r)$
(S8)	$I_r / \mathbf{K_r} = \Psi_r$	$I_r / K_r = \mathbf{\Psi_r}$
(S9)	$NIM_r = b(\mathbf{W_r} \cdot ER_r/\mathbf{F_r^{(SR)}})$	$NIM_r = b(W_r \cdot \mathbf{ER_r}/F_r^{(SR)})$
(S10)	$NIM_r / \mathbf{Q_r} = \Upsilon_r$	$NIM_r / Q_r = \mathbf{\Upsilon_r}$
(S11)	$\mathbf{W_r} / \mathbf{W} = F_r^{(LR)}$	$W_r / \mathbf{W} = \mathbf{F_r^{(LR)}}$
(S12)	$P_r = \mathbf{A_r}\ u(\{\mathbf{W_r} \cdot \mathbf{A_r^L}\}, R_r)$	$P_r = \mathbf{A_r}\ u(\{W_r \cdot \mathbf{A_r^L}\}, R_r)$
(S13)	$C_r = \mathbf{APC_r} \cdot [\ Y_r - \mathbf{NFL_r} \cdot \mathbf{R}\ ]$	$C_r = \mathbf{APC_r} \cdot [\ Y_r - \mathbf{NFL_r} \cdot \mathbf{R}\ ]$
(S14)	$G_r^{(S)}/C_r = \mathbf{\Gamma_r^{(S)}}$	$G_r^{(S)}/C_r = \mathbf{\Gamma_r^{(S)}}$
(S15)	$G_r^{(F)} / \mathbf{Q_r} = \mathbf{\Gamma_r^{(F)}}$	$G_r^{(F)} / Q_r = \mathbf{\Gamma_r^{(F)}}$
(S16)	$X_r^{(*)} = b(P_r / \mathbf{V_r})$	$X_r^{(*)} = b(P_r / \mathbf{V_r})$
(S17)	$M_r^{(*)} = h(P_r/\mathbf{P}, Y_r)$	$M_r^{(*)} = h(P_r/\mathbf{P}, Y_r)$
(S18)	$M_r = d(P_r/\mathbf{P}, Y_r, \mathbf{\Xi_r})$	$M_r = d(P_r/\mathbf{P}, Y_r, \mathbf{\Xi_r})$

(S19)	$X_r = s(P_r/\mathbf{P}, \mathbf{\Xi_r})$	$X_r = s(P_r/\mathbf{P}, \mathbf{\Xi_r})$

Equations holding between any two adjacent years of the year-on-year basecase and policy simulations

(S20)	$\Delta K_r = I_r$	$\Delta K_r = I_r$
(S21)	$\Delta Q_r = NIM_r$	$\Delta Q_r = NIM_r$
(S22)	$\Delta NFL_r = GRE_r - Y_r$	$\Delta NFL_r = GRE_r - Y_r$

Lagged wage adjustment in the policy simulations

(S23)
$$\left(W^{(Policy)}_{(t),r}/\mathbf{W^{(Basecase)}_{(t),r}} - 1\right) = \left(\mathbf{W^{(Policy)}_{(t-1),r}}/\mathbf{W^{(Basecase)}_{(t-1),r}} - 1\right) + \alpha\left(ER^{(Policy)}_{(t),r}/\mathbf{ER^{(Basecase)}_{(t),r}} - 1\right)$$

Bold denotes exogenous. Remaining variables are endogenous.

Variables of the S-BOTE model

Variables in equations holding within any given year of the basecase and policy simulations (Equations **B1** – **B19**)			
GRE_r	Real gross regional expenditure	N	N
C_r	Real regional private consumption spending	N	N
I_r	Real regional gross fixed capital formation	N	N
$G^{(S)}_r$	Real state government consumption spending	N	N
$G^{(F)}_r$	Real federal government consumption spending	N	N

Y_r	Real gross regional product	N	N
$X_r^{(*)}$	Foreign export volumes	N	N
$M_r^{(*)}$	Foreign import volumes	N	N
$X_r^{(R)}$	Inter-regional exports	N	N
$M_r^{(R)}$	Inter-regional imports	N	N
A_r	Primary factor augmenting technical change	X	X
A_r^L	Labour saving technical change.	X	X
L_r	Employment	N	N
K_r	Capital stock.	X	N
W_r	Average regional wage	X	N
R_r	Average rental rate on capital	N	N
P_r	Regional GDP at factor cost deflator	N	N
Q_r	Regional population	X	N
PR_r	Regional participation rate	X	X
ER_r	Regional employment rate	N	X
ROR_r	Average rate of return on capital	N	X
Λ_r	Shift in investment/rate of return schedule	X	N
Ψ_r	Investment / capital ratio	N	X
NIM_r	Net inter-regional migration to *r*	N	N
$F_r^{(SR)}$	Shift in migration / wage schedule	X	N
Υ_r	Net inter-regional immigration rate	N	X
$F_r^{(LR)}$	Regional wage / national wage ratio	N	X

W	National wage	X	X
P	National price level	X	X
APC_r	Average propensity to consume	X	X
NFL_r	Net foreign liabilities	X	X
R	Interest rate on net foreign liabilities	X	X
$\Gamma_r^{(S)}$	State government / private consumption ratio	X	X
$\Gamma_r^{(F)}$	Per-capita real federal government consumption	X	X
V_r	Shift in export demand schedule	X	X
Ξ_r	Inter-regional sourcing twist	X	X
Variables in equations holding between any two years of the year-on-year basecase and policy simulations (Equations **B20** – **B22**)			
ΔK_r	Change in K_r between years *t* and *t* + 1	N	N
ΔQ_r	Change in Q_r between years *t* and *t* + 1	N	N
ΔNFL_r	Change in NFL_r between years *t* and *t* + 1	N	N
Variables of the lagged wage adjustment equation (Equation **B21**)			
$W_{(t)\,r}^{(Policy)}$	Wage at time *t* in the policy simulation	N	N
$W_{(t-1)\,r}^{(Policy)}$	Lagged value of the wage in the policy simulation	X	X
$W_{(t)\,r}^{(Basecase)}$	Wage at time *t* in the basecase simulation	X	X
$W_{(t-1)\,r}^{(Basecase)}$	Lagged value of the wage in the basecase simulation	X	X
$ER_{(t)\,r}^{(Policy)}$	Employment rate at time *t* in the policy simulation	N	N
$ER_{(t)\,r}^{(Basecase)}$	Employment rate at time *t* in the basecase simulation	X	X

Chart 1: Simulating a fall in NSW & ACT amenity. Population, employment, real wage & employment rate for the NSW & ACT region (percentage deviation from basecase)

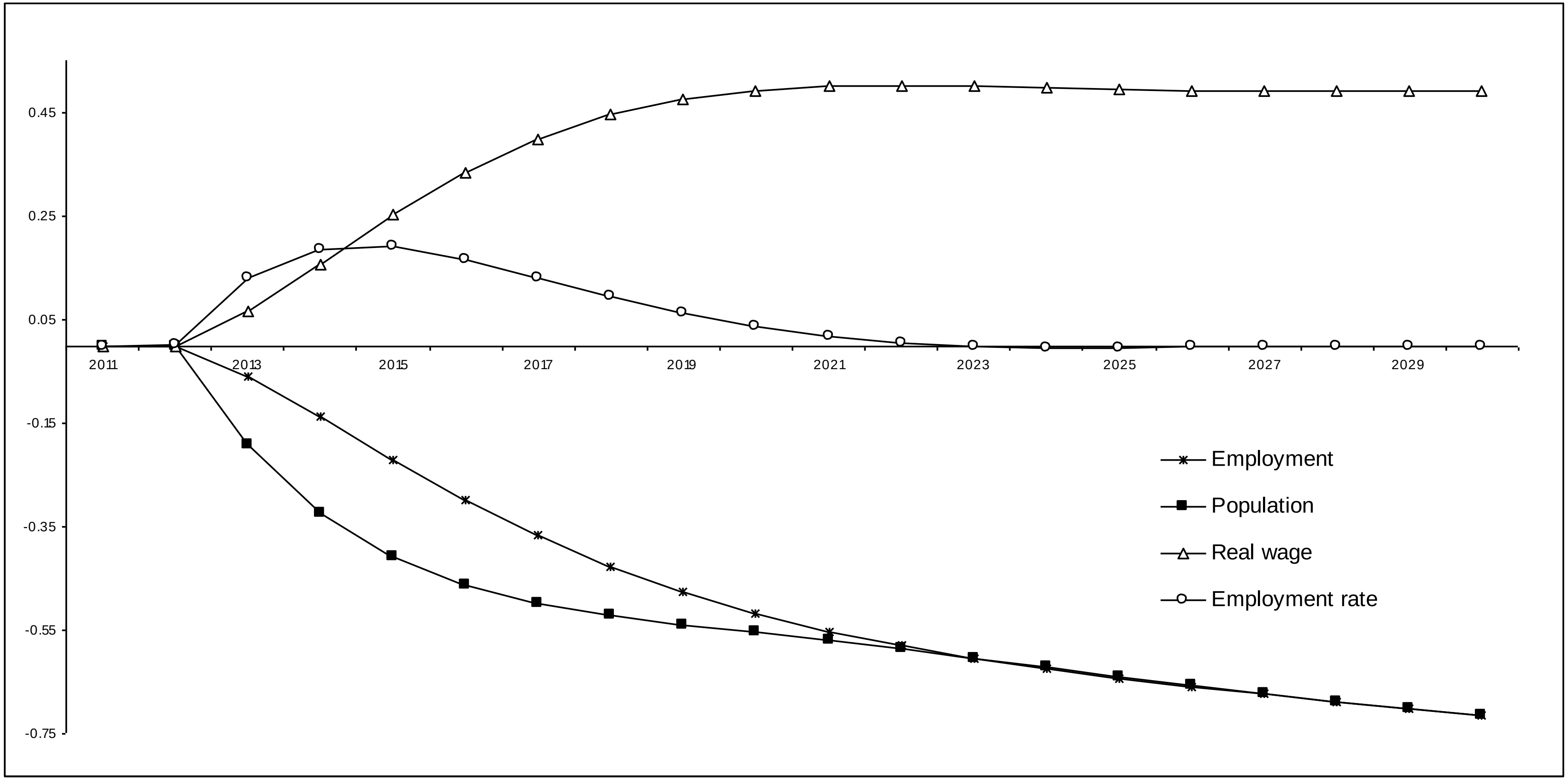

Chart 2: Simulating a fall in NSW& ACT amenity. Net regional immigration by region (change from basecase)

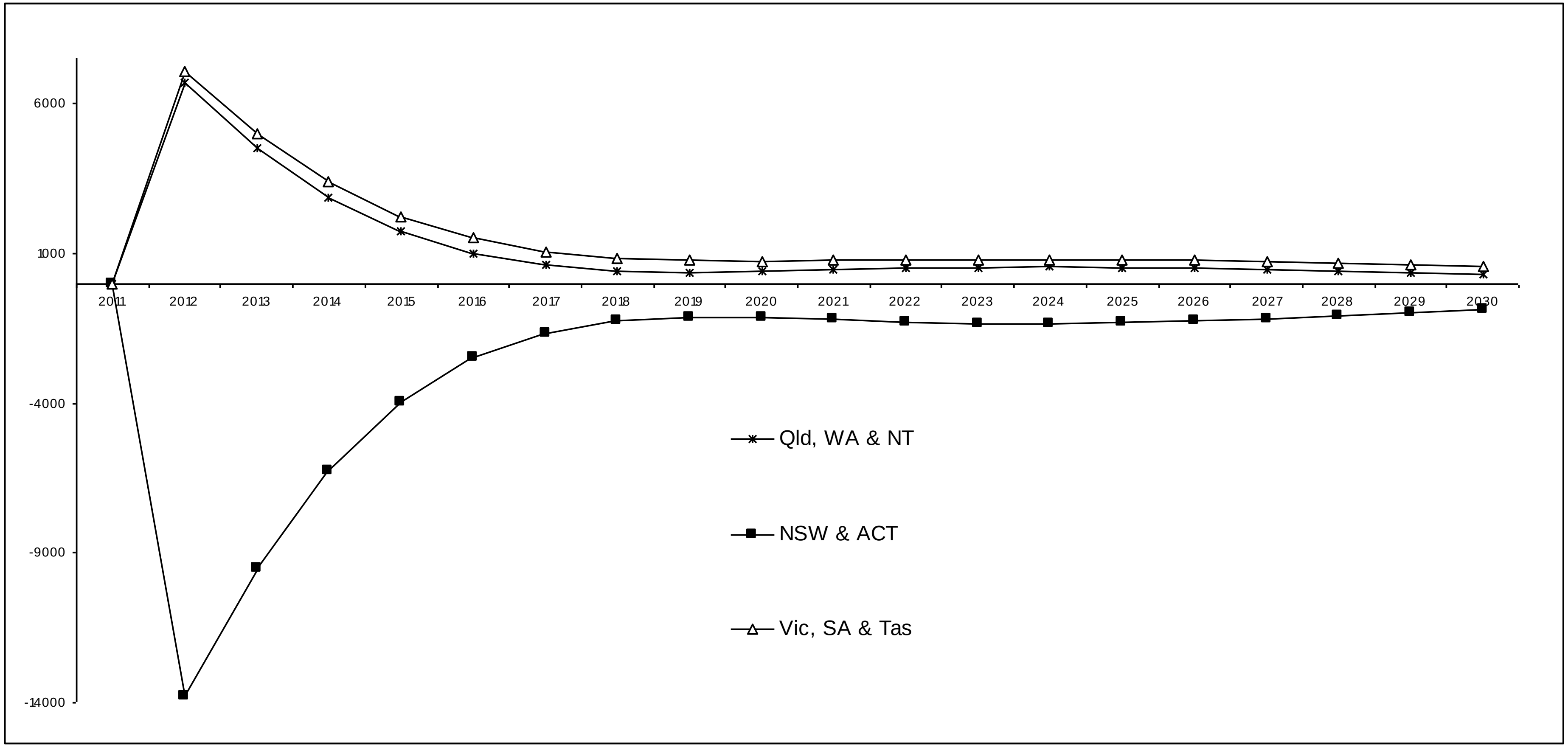

Chart 3: Simulating a fall in NSW& ACT amenity. Rates of return, investment and the capital stock for the NSW & ACT region (percentage deviation from basecase)

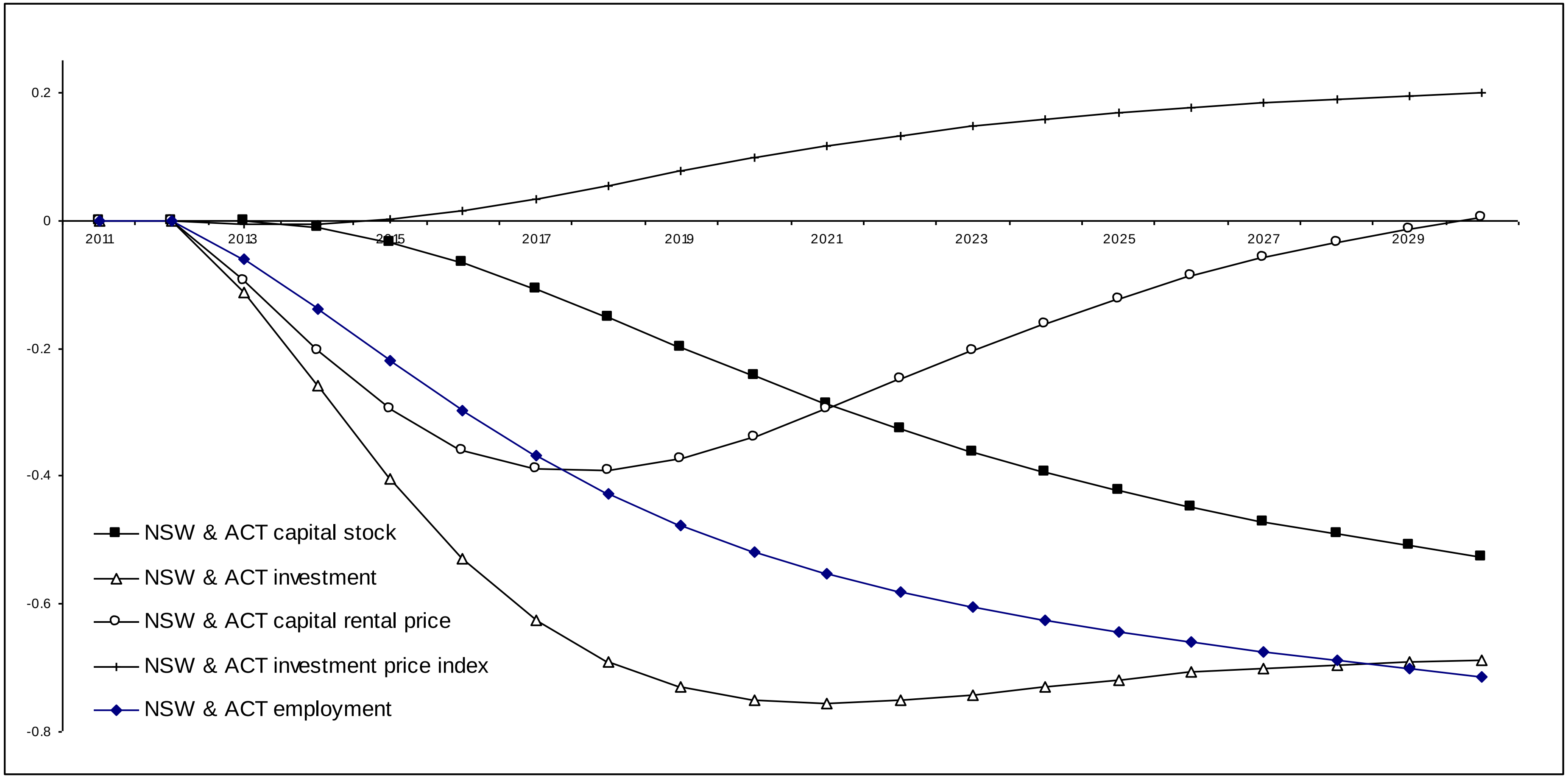

Chart 4: Simulating a fall in NSW & ACT amenity. Population, employment and the real wage in QLD, WA & NT (percentage deviation from basecase)

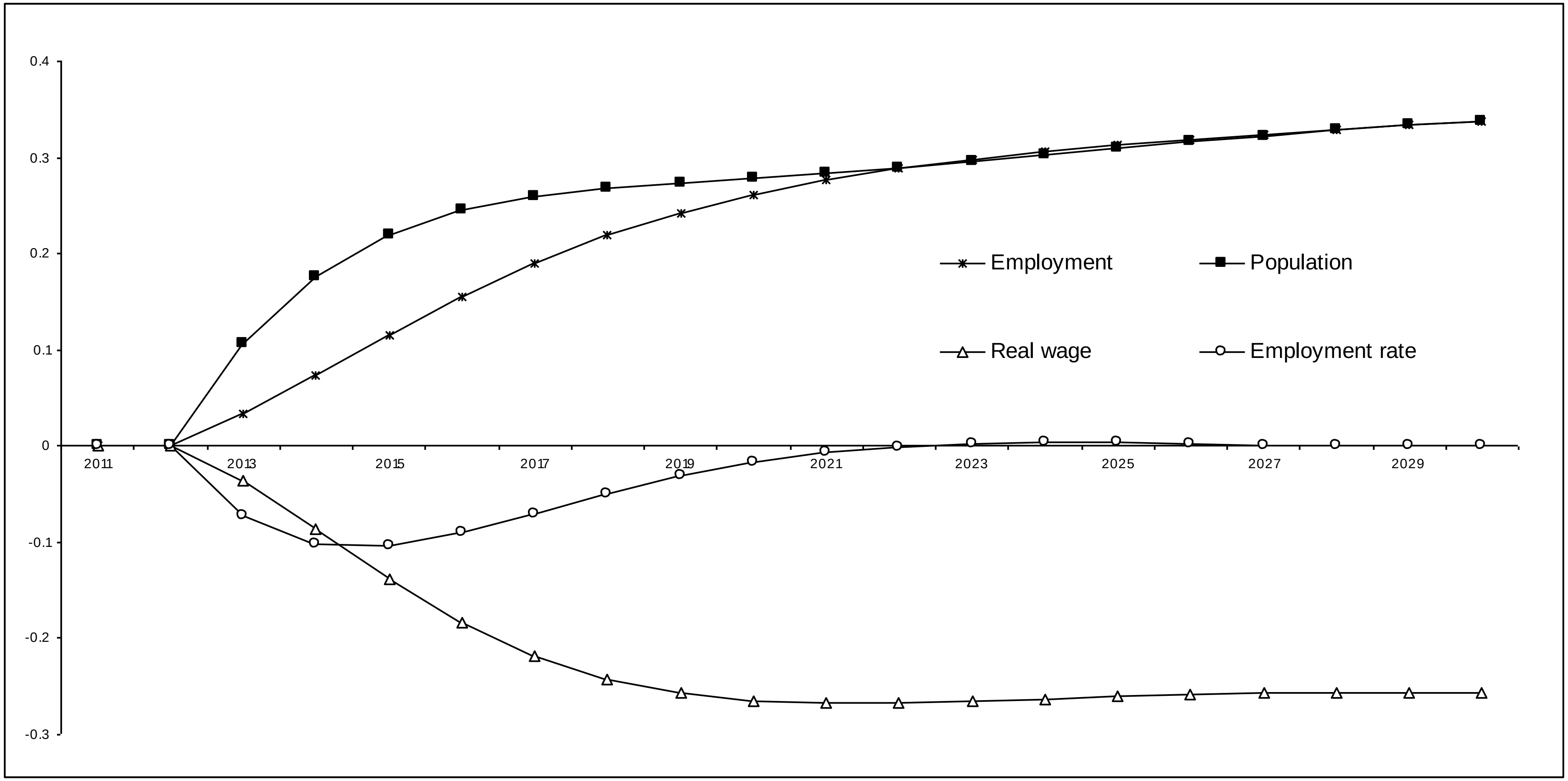

Chart 5: Simulating a fall in NSW& ACT amenity. Nominal wages, by region (percentage deviation from basecase)

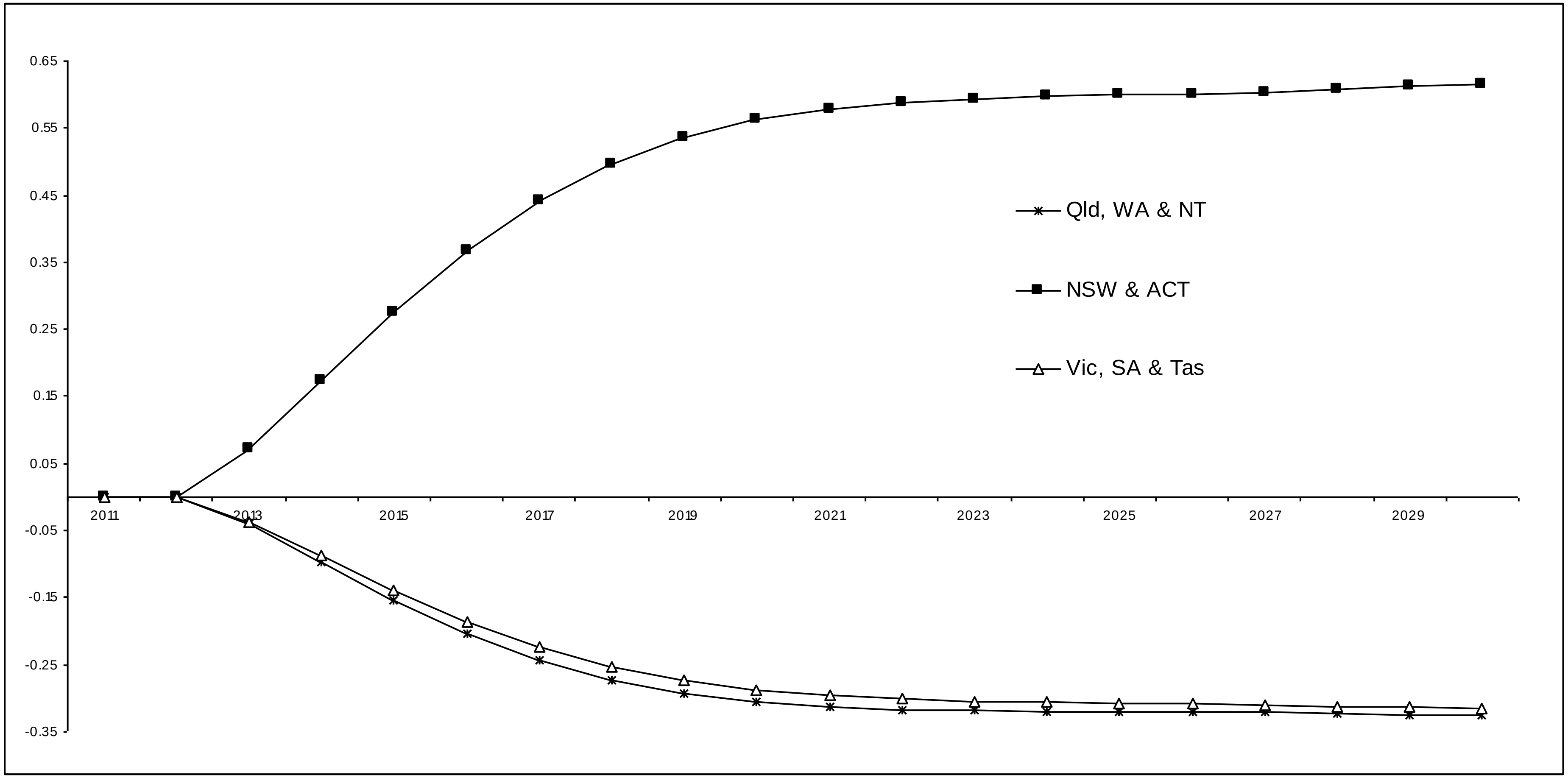

Chart 6: Simulating a fall in NSW & ACT amenity. Regional real GDP and GDP deflators, by region (percentage deviation from basecase)

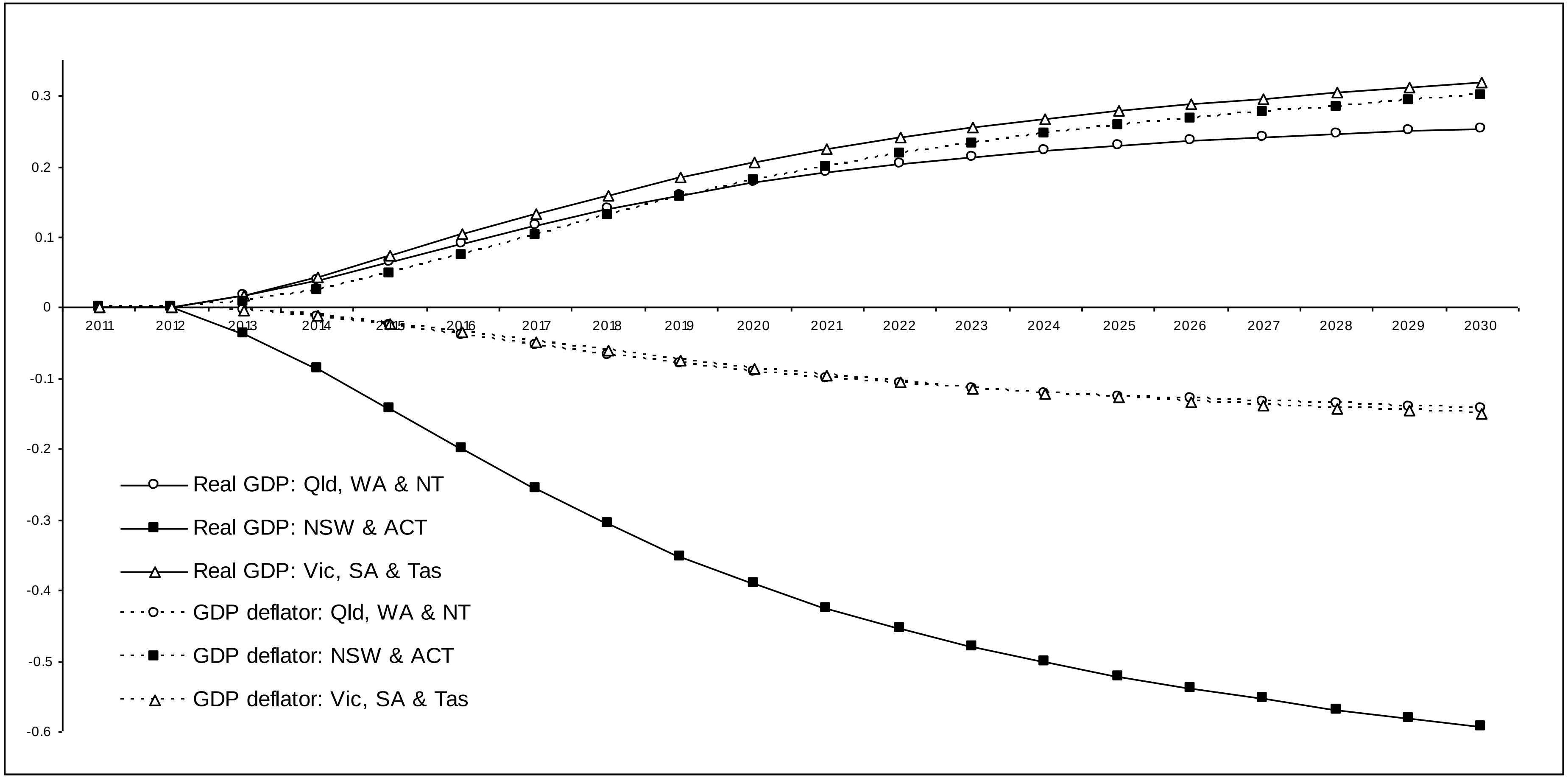

Chart 7: Simulating a fall in NSW& ACT amenity. Capital rental rates and investment price deflators, by region (percentage deviation from basecase)