MEASURING THE IMPLICATIONS OF REGIONAL DIVERSIFICATION – AN APPLICATION OF THE PORTFOLIO SELECTION FRAMEWORK TO QUEENSLAND DATA

Bernard Trendle
Office of Economic and Statistical Research, Queensland Treasury, P.O. Box 37, Albert Street, Brisbane, Qld. 4002, Australia.[1]

ABSTRACT It is widely believed that fluctuations in regional employment and economic growth can be reduced by increasing the diversity of a region's economic base. Several approaches have been developed to measure regional economic diversity. Most of these techniques while providing a measure of diversity do not link this measure to changes in the economic performance of the region. An exception to this is provided by the portfolio selection framework which explicitly links the concept of industrial diversity to a measure of regional efficiency. This framework can be used to study the implications of diversification policies. In this paper a portfolio selection model is applied to employment data for Queensland. The framework is used to provide an insight into how changes in the economic base of the State are subject to growth and instability trade-offs. Interestingly, the results suggest that greater stability may be achieved through greater regional specialisation.

1. INTRODUCTION

Regional employment or income instability is generally considered undesirable with an unstable economy experiencing fluctuations in aggregate regional income and employment. Early efforts to analyse stability used various measures of the degree of regional diversification such as coefficients of specialisation, the ogive index or national proportions. None of these methodologies attempts to provide an insight into the trade-off that may exist between regional diversification strategies and employment growth and stability. Instead it is generally accepted that diversification of a regional economic base is sufficient to increase regional economic stability.

Rather than attempting to measure the diversity of a regional economic base in isolation, the portfolio selection framework explicitly considers the link between regional diversity and the consequences for regional growth and stability. This is done by using the observed relationships between the various components of the regional economy. Portfolio selection models attempt to measure the portfolio of assets that yields the greatest return to the investor for a given level of risk. These

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models have their origin in the financial literature, particularly Markowitz (1952). Conroy (1974) introduced this methodology to regional economic analysis where it was applied to the problem of minimising employment instability. In a regional setting the portfolio becomes employment or income by industry sector, and the return to be maximised is the region's economic growth subject to some level of employment or income instability.

The portfolio selection framework permits the simultaneous consideration of the level of regional employment and the stability of the regional economy. In doing this the framework allows the calculation of a regional efficiency frontier, i.e. a frontier where regional instability is minimised for given rates of employment growth. These boundary solutions take into consideration the interactions between different parts of the regional economy so that while individual industries may be unstable, they are collectively stable. This is achieved by explicitly considering the variance of each industry's employment growth rate in addition to its covariance with other industries.

In the following section an outline of the model specification is provided. This is followed by an outline of the data requirements of the technique and the data used to implement the model in Queensland. The third section provides an outline of the data transformation and testing required before assembling the model while the final section outlines the model's solutions under different sets of constraints deriving efficiency frontiers for the Queensland economy. The implications of the model solutions are also briefly outlined.

2. MODEL SPECIFICATION

The portfolio selection model is derived from the variances and covariances of employment in the individual sectors of the Queensland economy. The variance of returns measures the risk involved in the stochastic process of the individual industries. It is assumed that investors and regions are adverse to risk. Following the definitions of risk and return relationships for portfolios of securities (see Markowitz 1952), the portfolio variance $\sigma^2{}_p$ for the industrial mix of a region is defined as:

$$\sigma_p^2 = \sum_i \sum_j \omega_i \omega_j \sigma_{ij} \tag{1}$$

where $\omega_i \omega_j$ are the proportions of regional employment associated with industries i and j, σ_{ij} is the covariance of industry employment series i and j, and σ_j^2 is the variance of employment in industry j. Equation (1) can be disaggregated into its variance and covariance components becoming:

$$\sigma^2{}_p = \sum_j \omega_j^2 \sigma_j^2 + \sum_{i \neq j} \sum_{j \neq i} \omega_i \omega_j \sigma_{ij} \tag{2}$$

From equation (2) it is clear how portfolio theory affects the choice of industries in developing a diversification strategy to reduce employment instability in a region. If regional policy makers have the choice of adding one of two industries, one of which has a large variance, and the other a low variance, the better policy choice might be the high variance industry because total portfolio variance depends not only on industry variance but on the weighted sum of all covariances with other industries in the portfolio. If employment in the industry with the greater variance was uncorrelated with employment in the other industries in the portfolio, or if it had large negative covariances with some or all of them, it might make a greater contribution to reducing total portfolio variance than the industry with the lower variance.

Computation of the portfolio variance makes possible an analysis of the effect of changes in the industrial structure on the stability of the regional economy. These effects can be derived by changing the weights of particular sectors. In this framework the rate of growth of employment is the weighted average of the actual employment growth rates in the various sectors of the regional economy. This is given by:

$$G = \sum_{i=1}^{I} \omega_i g_i \tag{3}$$

where g_i equals the growth rate of sector *I*, *I* = 1,...I.

Therefore, given g_i, a change in the elements of ω_i will produce a new value for *G*. Following Lande (1992), this procedure can be formalised by considering the equation for the portfolio variances as an objective function to be minimised.

Minimise:
$$\sigma_p^2 = \sum_j \omega_j^2 \sigma_j^2 + \sum_{i \neq j} \sum_{j \neq i} \omega_i \omega_j \sigma_{ij} \tag{4}$$

subject to:
$$\sum_i \omega_i = 1 \tag{5}$$

and
$$\sum_i \omega_i g_i = G \tag{6}$$

The minimisation of the nonlinear objective function σ_p^2 provides the optimal set of weights for the region under consideration. The constraints of this objective function ensure that the optimal solution will be within meaningful bounds. The first constraint requires that the sector weights sum to one, thereby preventing a solution which uses more or less than 100% of the regional employment. The second constraint makes possible the imposition of a growth constraint on the region. In the implementation chosen, *G*, the total employment growth rate is the choice variable. The value of total employment growth *G* can be varied so as to make possible the estimation of the relationship between employment growth and instability. This allows the generation of an efficiency frontier, i.e. the combination of points at which the variance of employment growth is minimised, for a given rate of growth in employment.

3. DATA REQUIREMENTS

The necessary data for the construction of a portfolio selection model are a time series of regional employment data disaggregated by industry sector. Ideally these data should relate to a discrete labour market. The available data for Queensland are one and two digit Australian and New Zealand Standard Industrial Classification (ANZSIC) quarterly data over the period 1984 (Q2) to 1998 (Q4). Alternatively one digit ANZSIC data for Queensland's labour force regions could be used. The one digit ANZSIC data have seventeen industry categories which is probably too aggregated to capture fully the interactions between various industries in a regional economy. This conclusion is supported by the work of Schoening and Sweeney (1991) who find that studies using aggregated industries produce results that are too generalised to provide much guidance to policy makers. An alternative approach is to use national or state based data to generate the variance-covariance matrix and regional industry employment derived from a detailed census to generate regional industry weights, an approach used by Conroy (1974 and 1975). However, several authors including Lande (1992) and Schoening and Sweeney (1991) find that this approach can lead to the optimisation of a portfolio that is significantly different from the local portfolio.

In this study the one digit ANZSIC data for Queensland are supplemented by two digit data for the manufacturing industries, so that the model encompasses a portfolio of twenty-five industries. The industry definitions are shown in Table A1 of the Appendix. A limitation of this methodology is that it implicitly treats Queensland as a single labour market. However, given the existence of more detailed data at the state level and the general observation that industrial policies are often formulated on a state basis it does not seem inappropriate to analyse regional diversification and stability at this geographic level.

4. DATA TRANSFORMATION AND TESTING

To estimate the industry variance-covariance matrix an estimate of the corresponding vector of mean industry employments is required. The approach taken by Conroy (1974 and 1975), Barth *et al* (1975), Board and Sutcliffe (1991) and Lande (1992) is to fit a quadratic time trend equation for each industry with ordinary least squares:

$$E_{jt} = \beta_0 + \beta_1 t + \beta_2 t^2 + \varepsilon_{jt} \tag{7}$$

where E_{jt} is the employment level in the *j*th industry at time *t*, the betas are parameters to be estimated, and ε_{jt} is a stochastic error for the *j*th industry with zero mean and constant variance.

An estimate of the variance-covariance matrix used in portfolio analysis is constructed from the estimated residuals. Hunt and Sheesley (1994) note that the econometric technique used will have a significant bearing on the outcome of the estimates and consequently the specification of the variance-covariance matrix. It is particularly important to use a technique that incorporates stationarity and estimates the purely non-systematic component of variation to the extent possible. Estimating equations such as equation (7) runs the risk of spurious results due to the non-stationarity of the data.

St Louis (1980) and Brown and Pheasant (1985) estimate industry employment equations that are specified in growth rate form. This growth rate transformation has been found to result in stationarity in many economic series. However, neither paper provides the results of any formal tests of stationarity.

The particular specification used in estimating the equations for Queensland follows that of St Louis (1980). This specification is:

$$E_{gjt} = \beta_{0j} + \varepsilon_{jt} \tag{8}$$

where

$$E_{gjt} = \frac{E_{jt} - E_{jt-1}}{E_{jt-1}} \tag{9}$$

and β_{0j} is the mean industry employment of the jth industry over the sample period, where the mean refers to the arithmetic average of industry employment growth. The portfolio selection model is constructed using the ε_{jt} of equation (8).

Stationarity is an important requirement of time series modelling, for this reason two levels of testing were carried out. The first involved a test for seasonality. This was done by regressing each transformed employment series on four seasonal dummy variables. Evidence of seasonal patterns were found in three series, these being ANZSIC one digit *Wholesale trade*, *Retail trade* and *Government administration and defence*. Rather than incorporating higher level seasonal differencing on these series each of the variables was regressed on quarterly seasonal dummies to remove the seasonal pattern. The resulting residuals from this process were used in the construction of the variance-covariance matrix.[2] Tests of the residuals from the ensuing series confirmed that these potential problems had been overcome.

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[2]The reason for this choice was that firstly, higher levels of differencing, say first differences of four period differences, would in creating a stationary series increase the variance of the variables. These variances form a crucial part of the portfolio selection model. Increasing them would bias the choice of the optimum portfolio using this framework. Secondly, the framework requires that all series are transformed in the same manner so that the variance-covariance matrix is measuring the same transformation of different employment series. Finally, the regression appears to have induced stationarity in the series and removed a systematic component present in the error term of the three series.

The next level of tests involved the application of Dickey-Fuller and Augmented Dickey-Fuller (ADF) tests on the growth rate transformed series, including the seasonally adjusted series. In all cases the results indicate that the transformation had induced stationarity as can be seen in Table A2 of the Appendix where ADF statistics including up to four lagged first differences are presented. The results in Table A2 indicate that, irrespective of the order of augmentation chosen for the ADF test, the absolute values of the test statistics are well above the 95% critical value given at the foot of the table. Because quarterly data are being used it seems unnecessary to include more than four lagged terms. Consequently the employment by industry growth rates can safely be assumed to be stationary.

In addition to testing for stationarity of the series, the residuals or ε_{jt} from the estimated relationship in equation (8) are tested to see if they can be described as a white noise process. The importance of white noise residuals stems from the role that they play in the construction of the portfolio selection model. The residuals are the data from which the variance-covariance matrix is constructed. This matrix provides the information used to construct the estimate of portfolio risk. Hunt and Sheesley (1994) note that the concept of risk relates to unsystematic variation, with residuals that are not white noise contain predictable components. For this reason some E_{gjt} were modelled using ARMA models and the residuals from these models were used to construct the variance-covariance matrix.

Table A3 of the Appendix provides test results of the residuals using the Box-Pierce and Ljung-Box Q statistic. In all cases the test statistics indicate that the null hypothesis that the series are a white noise process cannot be rejected at the 5% and 10% levels of significance. The degrees of freedom from this test are derived following the rule of thumb outlined in Mills (1990), which specifies the degrees of freedom from such tests as being given by $df=N^{1/2}$ where N is equal to the number of observations in the series. Where the series were transformed using an ARMA model the degrees of freedom is given by $N^{1/2}-p-q$ where p refers to the order of the autoregressive component of the ARMA model and q the order of the moving average component used to estimate the systematic component of employment growth.

5. MODEL SOLUTION

Early formulations of this procedure (see Brown and Pheasant, 1985 or St Louis, 1980) used a simplified form of portfolio theory developed by finance theorists. Board and Sutcliffe (1991) note that this method imposes restrictions on the variance-covariance matrix which are not desirable in a regional application such as the present study. Additionally, the computational reasons for developing these techniques no longer exist. In this study the generalised reduced gradient nonlinear optimisation procedure was used, an outline of which is provided in Hillier (1997). This procedure is available within the Solver facility of Microsoft EXCEL.

The model set out in equations (4) through (6) was solved under three different scenarios. The difference in the scenarios centred on the amount the ω_i's (industry shares of total employment) were allowed to vary. In the first scenario, regional industry employment shares were allowed to vary by up to 50% from the value in the last quarter (December 1998) for which data existed. In the second scenario the upper and lower bounds were restricted to 25% of the December quarter 1998 industry employment shares. These bounds were increased to 50% again in the third scenario; however, for selected industries a constraint of 0% change, i.e. effectively fixed to their share of the December quarter 1998 employment, was specified. The first two scenarios were chosen to show how restricting the amount of adjustment affects the position of the efficiency frontier in the model solution, while the final scenario shows how industries can be removed from regional diversification strategies.

A limitation of the adopted methodology is the *ad hoc* way in which these constraints have been specified. A more appropriate methodology may be to follow Board and Sutcliffe (1991) or Wundt and Martin (1993) and incorporate input-output restrictions into the framework. This approach has two advantages. Firstly it allows for greater recognition of the interindustry interactions in adjustments to the regional portfolio. Secondly, it can be formulated to allow the introduction of government expenditure constraints in adjustments to the regional portfolio. However, due to the incompatibility of the aggregation scheme in the 1992-93 Queensland input-output table this approach was not considered.

In deriving the regional efficiency frontier alternate growth rates have been incorporated in the model solution. Hunt and Sheesley (1994) employ time series techniques to generate forecasts of the g_i implying an interest in the optimal regional portfolio over the forecast period. Other authors e.g. Lande (1992) use the average g_i over the estimation period implying an interest in the regional portfolio given the observed long-run growth of industry employment.

In this exercise two specifications of regional growth rates have been employed. The first involves the use of average growth rates for the four quarters of 1998. This implies an interest in the optimal regional employment portfolio given the growth rates observed during the 1998 calendar year which is the most recent year for which data exists. The second model solution involves the use of the average g_i over the entire sample period implying an interest in the optimal regional portfolio given observed long-term growth rates. These two specifications have been used to provide a means of gauging the sensitivity of the model solution to different growth rate specifications.

Figure 1 provides regional efficiency frontiers generated by solving the model for three scenarios using the average growth rates for the four quarters of 1998. This figure also shows the position during the December quarter 1998 in relation to the regional efficiency frontiers. Under scenario 1 industry employment shares are allowed to move by as much as 50% from their December quarter 1998 position. Under the second scenario industry employment shares are restricted to a

25% adjustment from their share of total employment in the December quarter 1998.

This figure shows that quarterly employment growth rates of less than 1.5% and more than 3% result in larger variations in the portfolio variance of regional employment. In fact, the model was unable to solve for values less than 1.47% or greater than 3.5%. Consequently, the tightening of the constraints results in a reduction in the bounded area of the portfolio problem.

In the final scenario industry employment shares are allowed to move by 50% from their December quarter 1998 position with the exception of the public sector industries of *Electricity, gas and water*, *Public administration and defence* and the part government run industries of *Education* and *Health and community services*. These industries have been removed from the portfolio solution by adjusting the constraint setting and effectively fixing them to the December quarter 1998 shares of total regional employment. This has been done to add realism to the solution set. Industry diversification strategy is frequently concerned with government policies which are aimed at encouraging non-government industries from establishing or increasing output and employment in the regional economy. Consequently public enterprises are effectively removed from the portfolio choice as in this scenario. In scenario 3 quarterly employment growth rates of less than about 1.5% and more than about 3% result in larger variations in the portfolio variance of regional employment.

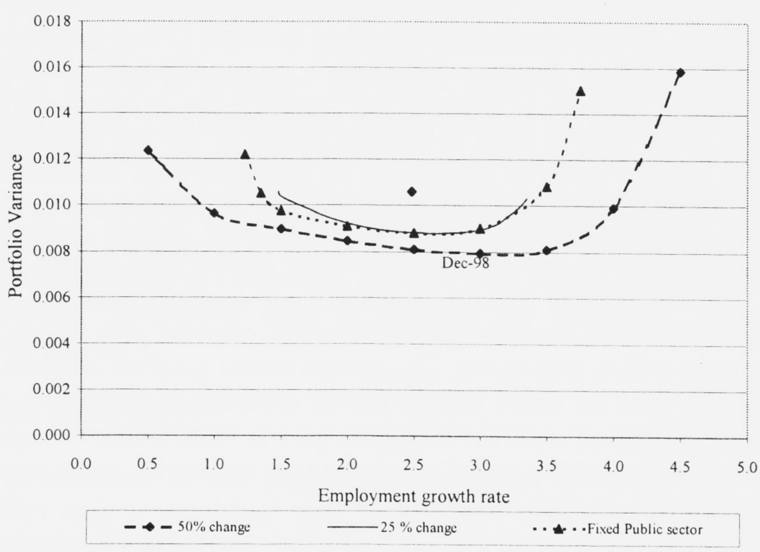

Figure 1. Regional Efficiency Frontiers, Average Growth Rates of 1998

Figure 2 provides efficiency frontiers for the model when it is solved using the long-run employment growth rates. An important point to note in interpreting this diagram or in comparing it to the previous figure is that employment growth is calculated using equation (3). Consequently, the substitution of the 1998 average growth rates for the observed average growth rates over the estimation period has resulted in a different estimate of growth for the December quarter 1998. As in the previous model solution, it appears that increasing the constraints by reducing the amount that employment is allowed to vary from the initial position leads to a reduction in the range of values available in the boundary solutions.

An interesting issue is the extent to which the economy must diversify to reach the efficiency frontier. Figure 3 provides concentration curves for the December quarter 1998 portfolio and the regional industry portfolios for each of the three scenarios at the 3.5% growth rate when the model is solved using the average employment growth rates of 1998. A similar figure, showing the concentration curves for the model when solved using the long-run growth rates is not provided because the similarity of the results means it is almost indistinguishable from Figure 3.

The concept of concentration ratios has been borrowed from industry economics where they are used to measure the degree of concentration in a particular industry. In this section they are used to provide some insight into the implications that the portfolio boundary solutions at the 3.5% growth rate have for the level of specialisation in the Queensland economy. For the purpose of this exercise the concentration ratios are calculated as the cumulative shares of employment by industry after the industries employment shares have been ordered from largest to smallest. These shares are added to the total of the preceding industries until all employment is accounted for.

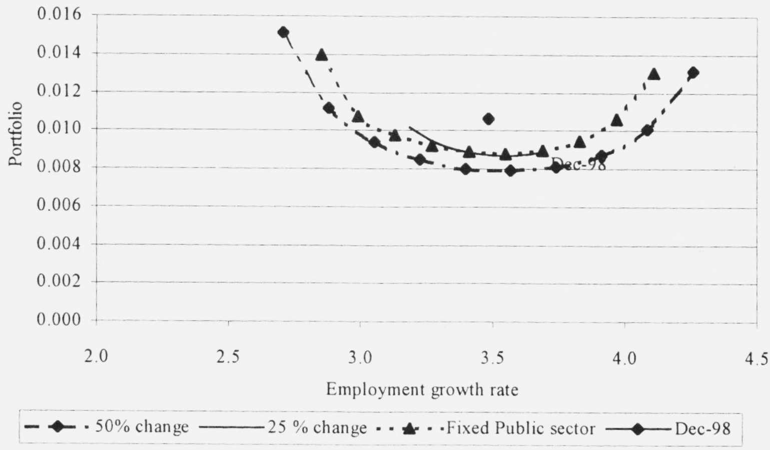

Figure 2: Regional Efficiency Frontiers, Long Run Growth

An interesting feature evident from Figure 3 is that in all cases the concentration curves for the portfolio model solutions lie above the concentration curve for December quarter 1998. This finding, together with the position of the efficiency frontiers in the model solutions in Figures 1 and 2 relative to the position in December quarter 1998 has two implications. Firstly, the relative position of the efficiency frontiers suggests that changing the regional industrial structure could result in both a higher rate of employment growth and greater stability in the labour market. Secondly, the relative positions of the concentration curves derived from the implied industry shares of the three scenarios when solved for the 3.5% growth rate suggest that the industry structure at the efficiency frontier is more concentrated than the industry structure of the December quarter 1998.

The same conclusion is provided by the Herfindahl index3 for each of the three scenarios and the December quarter 1998 position. The Herfindahl index (H) is calculated as:

$$H = n\sigma^2 + \frac{1}{n} \qquad (10)$$

where n refers to the number of firms and σ^2 is the variance of industry employment shares. This index is again borrowed from industrial economics where it has been developed to provide a measure of the level of concentration in a particular market. By calculating the index using employment shares by industry rather than shares of output the index provides an indication of the diversity of the

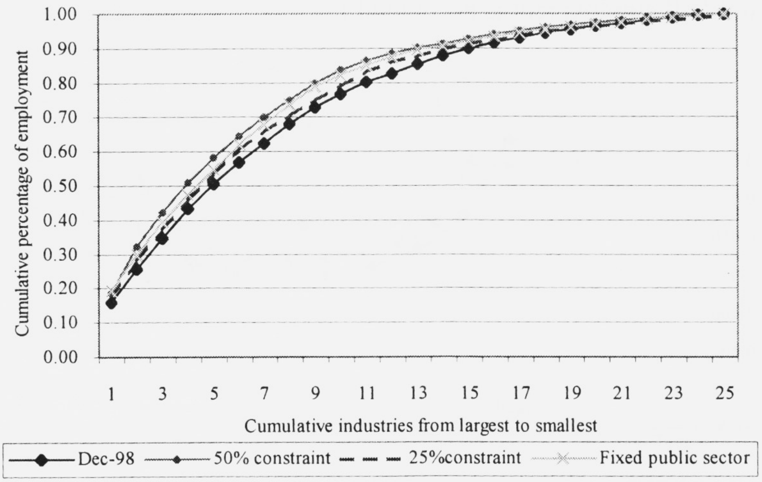

Figure 3: Concentration Curves

[3] For a full discussion on measures of concentration see Hay and Morris (1987)

Table 1. Herfindahl Indexes of Employment Concentration, Model Solution Using Average Growth Rates of 1998

Scenario	Herfindahl Index	Rank
December 1998	0.0414	4
50% constraint	0.0421	1
25% constraint	0.0416	3
Fixed public sector	0.0419	2

Table 2. Herfindahl Indexes of Employment Concentration, Model Solution Using Average Growth Rates of Sample Period

Scenario	Herfindahl Index	Rank
December 1998	0.0414	4
50% constraint	0.0419	1
25% constraint	0.0414	3
Fixed public sector	0.0419	2

economy. The higher the value that the index takes the more specialised is the regional economic base.

The indexes derived from the model solution using the average employment growth rates of 1998 are shown in Table 1. This table indicates that in all cases the efficiency frontier positions at 3.5% growth exhibit a higher level of employment concentration than does the position of the December quarter 1998.

The same conclusion is provided in Table 2 which presents Herfindahl indexes derived from the model solution when the model is solved using growth rates calculated using data spanning 1984 (Q2) to 1998 (Q4). The only significant difference in Table 2 is the size of the calculated Herfindahl indexes, although the difference between these results and those of Table 1 appear minimal. Interestingly, the ranking of the three scenarios under both model specifications imply a higher level of concentration than that observed during the December quarter 1998.

This is an unusual finding and one which has significant implications for regional industrial and employment diversification strategies. Generally it is thought that increases in regional economic diversification are sufficient to increase regional stability. For this reason industrial diversification strategies often aim at establishing new industries in regional economies in an attempt to reduce the magnitude of fluctuations. The results of the analysis suggest that this generally held belief may not be applicable in all situations and points to a need for greater understanding of regional structure and behaviour before the formulation of regional diversification strategies.

6. CONCLUSIONS

The portfolio selection model provides a framework for the evaluation of one aspect of regional economic development strategy, i.e. the trade-off that exists between industrial diversification and regional economic growth and stability. By capturing the impacts of individual industry and interindustry behaviour on regional growth and stability, this framework yields results of practical value to policy makers. Changes in the industrial structure of a region can be evaluated to determine the consequences for the regional economy assuming that the past relationships hold into the future. Consequently this methodology provides the policy maker with a framework for identifying diversification strategies which can serve the dual role of stimulating economic growth while stabilising the regional economy. This is achieved because the portfolio selection model allows for a distinction between an industry which is stable and one which is stabilising to the regional economy.

The modelling undertaken for Queensland in this paper has shown the efficiency frontier under three different assumptions concerning the amount of industry adjustment that is allowed to occur in reaching an optimal portfolio. In all cases the efficiency frontier was below the position the Queensland economy was in during the December quarter 1998. A limitation of the methodology in its current form is the *ad hoc* way in which the constraints have been specified. In spite of this limitation the same conclusion from all three scenarios under both specifications of the g_i (employment growth rates) used in the model solution suggests the results that have been obtained from this analysis are fairly robust. Further, the discussion in Board and Sutcliffe (1991) suggests that the incorporation of further constraints will not alter the general conclusions but merely reduce the range of feasible solutions obtained from the model.

The practical value of the current form of this model is that its solution implies that policy makers have the opportunity to pursue diversification strategies which have the dual goal of increasing the rate of employment growth while increasing the stability of the labour market. The model solution also provides evidence that the pursuit of regional diversification strategies, or indeed the stimulation of economic activity in a particular industry in the Queensland economy, is subject to growth and instability trade-offs. In particular, the model solution has identified industries that have contributed to instability in employment growth.

The results of the analysis conducted in this study also suggest that a reduction in industrial diversification will reduce the magnitude of fluctuations in employment growth and thus reduce instability in the labour market. This occurs as stable and stabilising industries displace unstable industries in the regional portfolio. This finding may have significant implications for regional diversification strategies, and highlights the need for a greater understanding of regional industry structure and interrelationships.

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Table A1. ANZSIC Industry Aggregation

ANZSIC Industry	Description
ANZSIC A	Agriculture, forestry and fishing
ANZSIC B	Mining
ANZSIC 21	Food, beverage and tobacco manufacturing
ANZSIC 22	Textile, clothing, footwear and leather manufacturing
ANZSIC 23	Wood and paper product manufacturing
ANZSIC 24	Printing, publishing and recorded material
ANZSIC 25	Petroleum, coal, chemical and associated product manufacturing
ANZSIC 26	Non-metallic mineral product manufacturing
ANZSIC 27	Metal product manufacturing
ANZSIC 28	Machinery and equipment manufacturing
ANZSIC 29	Other manufacturing
ANZSIC D	Electricity, gas and water supply
ANZSIC E	Construction
ANZSIC F	Wholesale trade
ANZSIC G	Retail trade
ANZSIC H	Accommodation, cafes and restaurants
ANZSIC I	Transport and storage
ANZSIC J	Communication services
ANZSIC K	Finance and insurance
ANZSIC L	Property and business services
ANZSIC M	Government administration and defence
ANZSIC N	Education
ANZSIC O	Health and community services
ANZSIC P	Cultural and recreational services
ANZSIC Q	Personal and other services

Table A2. Dickey-Fuller and Augmented Dickey-Fuller Test Statistics

Industry	DF	ADF(1)	ADF(2)	ADF(3)	ADF(4)
Agriculture, forestry and fishing	-8.32	-6.69	-7.07	-5.56	-4.05
Mining	-8.80	-6.05	-5.66	-5.20	-3.69
Food, beverage and tobacco manufacturing	-6.99	-6.12	-5.99	-4.67	-4.69
Textile, clothing, footwear and leather manufacturing	-10.10	-6.02	-6.45	-5.56	-5.00
Wood and paper product manufacturing	-8.38	-6.67	-5.67	-4.89	-3.50
Printing, publishing and recorded material	-9.05	-6.38	-6.73	-4.37	-3.97
Petroleum, coal, chemical and associated product manufacturing	-10.44	-7.62	-6.02	-4.21	-3.56
Non-metallic mineral product manufacturing	-8.16	-6.89	-5.21	-4.84	-4.88
Metal product manufacturing	-8.64	-6.77	-5.01	-4.68	-3.45
Machinery and equipment manufacturing	-7.87	-4.98	-4.89	-4.63	-3.86
Other manufacturing	-10.57	-6.96	-6.23	-5.65	-3.81
Electricity, gas and water supply	-8.21	-7.91	-6.10	-5.68	-4.36
Construction	-7.01	-5.86	-4.04	-3.33	-2.78
Wholesale trade	-8.36	-5.55	-6.17	-5.04	-4.92
Retail trade	-9.59	-5.87	-7.79	-4.81	-4.04
Accommodation, cafes and restaurants	-9.72	-7.31	-6.77	-6.66	-4.52
Transport and storage	-8.64	-6.54	-5.75	-4.79	-4.46
Communication services	-8.67	-7.15	-5.56	-4.60	-3.38
Finance and insurance	-7.56	-9.44	-7.70	-5.81	-5.50
Property and business services	-6.59	-5.81	-4.26	-3.56	-3.02
Government administration and defence	-7.38	-5.82	-4.63	-4.85	-4.10
Education	-7.46	-6.12	-5.73	-4.40	-4.35
Health and community services	-9.33	-8.86	-5.82	-3.72	-3.75
Cultural and recreational services	-7.12	-6.30	-5.42	-5.02	-4.98
Personal and other services	-7.84	-7.31	-6.10	-5.41	-5.33
Critical value = -2.92					

Table A3. Box-Pierce and Ljung-Box Test Statistics

Industry	Box-Pierce	Ljun-Box	Degrees of Freedom	Critical Value (5%)	Critical Value (10%)
Agriculture, forestry and fishing	9.28	10.18	8	15.51	13.36
Mining	11.21	12.63	8	15.51	13.36
Food, beverage and tobacco manufacturing	7.77	8.56	8	15.51	13.36
Textile, clothing, footwear and leather manufacturing	3.42	3.8	6	12.59	10.64
Wood and paper product manufacturing	9.91	11.12	8	15.51	13.36
Printing, publishing and recorded material	0.06	0.07	2	5.99	4.61
Petroleum, coal, chemical and associated product manufacturing	9.73	11.14	7	14.07	12.02
Non-metallic mineral product manufacturing	7.12	7.99	8	15.51	13.36
Metal product manufacturing	6.64	7.42	8	15.51	13.36
Machinery and equipment manufacturing	8.56	9.49	8	15.51	13.36
Other manufacturing	4.25	4.83	7	14.07	12.02
Electricity, gas and water supply	8.34	8.97	8	15.51	13.36
Construction	3.23	3.61	8	15.51	13.36
Wholesale trade	6.89	7.63	7	14.07	12.02
Retail trade	1.34	1.48	5	11.07	9.24
Accommodation, cafes and restaurants	6.18	6.64	8	15.51	13.36
Transport and storage	4.93	5.51	8	15.51	13.36
Communication services	10.58	11.83	8	15.51	13.36
Finance and insurance	0.65	0.72	5	11.07	9.24
Property and business services	5.31	6.01	8	15.51	13.36
Government administration and defence	3.90	4.39	8	15.51	13.36
Education	7.45	8.31	8	15.51	13.36
Health and community services	9.85	11.16	6	12.59	10.64
Cultural and recreational services	4.28	4.69	8	15.51	13.36
Personal and other services	1.98	2.13	6	12.59	10.64