Industrial diversification and regional employment stability - A framework for analysis

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Paper presented at the 1999 ANZRSAI annual conference
19 – 22 September 1999
Newcastle, New South Wales, Australia

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It is widely believed that fluctuations in regional employment and economic growth can be reduced by increasing the diversity of the economic base of the region. 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.

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. These techniques imply that regional policy should be directed towards trying to increase the measured diversification of regional economies. 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 yield the greatest return to the investor for a given level of risk. These 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 the data requirements of the technique and the data used to implement the model in Queensland are outlined. This is followed by an outline of the structure of the model. The final section outlines the model's solutions under different sets of constraints deriving efficiency frontiers for the Queensland economy. The implications of the solution are also outlined.

The Portfolio Selection Framework

The necessary data for the construction of a portfolio selection model are a time series of regional employment data disaggregated by industry sector. 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). 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 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.

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 s^2_p for the industrial mix of a region is defined as:

$$s^2_p = \sum_i \sum_j w_i w_j s_{ij} \qquad (1)$$

where $w_i w_j$ are the proportions of regional employment associated with industries *i* and *j and* s^2_p denotes the covariance of regional employment by industry. Equation (1) can be disaggregated into its variance and covariance components thus:

$$s^2_p = \sum_j w_j^2 s_j^2 + \sum_{i \neq j} \sum_{j \neq i} w_i w_j s_{ij} \qquad (2)$$

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.

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:

$$E_{jt} = b_0 + b_1 t + b_2 t^2 + e_{jt} \qquad (3)$$

where E_{jt} is the employment level in the jth industry at time t, the betas are parameters to be estimated, and e_{jt} is a stochastic error for the jth 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 a problem with this approach is that it ignores the implication that interdependence among regional industries has for the specification of the mean vector joint distribution. In this specification, the mean industry employment E_j for any given industry j is not explicitly a function of the means of the employments in the other industries. All means are specified as a function of time which implies that they are exogenously determined. This is inconsistent with the notion of interdependence of the industries in the local region.

An important consequence of this misspecification is that the estimated residuals are biased and inconsistent, implying that the variance-covariance matrix constructed from them is also biased and inconsistent. The econometric technique used will have a significant bearing on the outcome of the estimates and consequently the specification of the variance-covariance matrix. Hunt and Sheesley (1994) note that what is particularly important is 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 (3) 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:

$$E_{gjt} = b_{0j} + e_{jt} \qquad (4)$$

where

$$E_{gjt} = \frac{E_{jt} - E_{jt-1}}{E_{jt-1}} \qquad (5)$$

and β_{0j} is the mean industry employment of the jth industry over the sample period. The portfolio selection model is constructed using the e_{jt} of equation (4).

In addition to testing for stationarity of the series, the residuals or e_{jt} from the estimated relationship in equation (4) 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, 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.

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.

The next level of tests involved the application of 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 for up to three lags are presented. Because quarterly data are being used the 0 lag refers to the current quarter and the third lag to the fourth quarter. It appears reasonable to accept stationarity if the ADF statistic is above the critical value after four quarters.[3]

[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. Hunt and Sheesley (1994) note that it is important to remove any systematic components from the series to reduce the chance of bias in the estimates in the variance-covariance matrix.

[3]All of the tests have been conducted on the growth rate transformed employment by industry series after mean growth for each series has been removed from each observation.

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% level of significance. The degrees of freedom from these 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. Consequently, *df* is equal to 8 for all series which were shown to have no predictable components. Where there was evidence of systematic variation in the series, as given by the *Q* statistics, the degrees of freedom are given by *df*-(*m*-*q*) where *m* refers to the order of the autoregressive component of the ARMA model and *q* the order of the moving average component.

Model Specification

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:

$$G = \sum_{i=1}^{I} w_i g_i \qquad (6)$$

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

Therefore, given g_i , a change in the elements of w_i will produce a new value for *G*. This assumes that the values of the g_i are representative of long run growth for individual industries. Following Lande (1994), this procedure can be formalised by considering the equation for the portfolio variances as an objective function to be minimised.

Minimise
$$s_p^2 = \sum_j w_j^2 s_j^2 + \sum_{i \neq j} \sum_{i \neq j} w_i w_j s_{ij} \qquad (7)$$

subject to:
$$\sum_i w_i = 1 \qquad (8)$$

and
$$\sum_i w_i g_i = G \qquad (9)$$

The minimisation of the nonlinear objective function s_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. 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.

Model Solution

The model, once assembled, is solved for different levels of G. 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.

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.

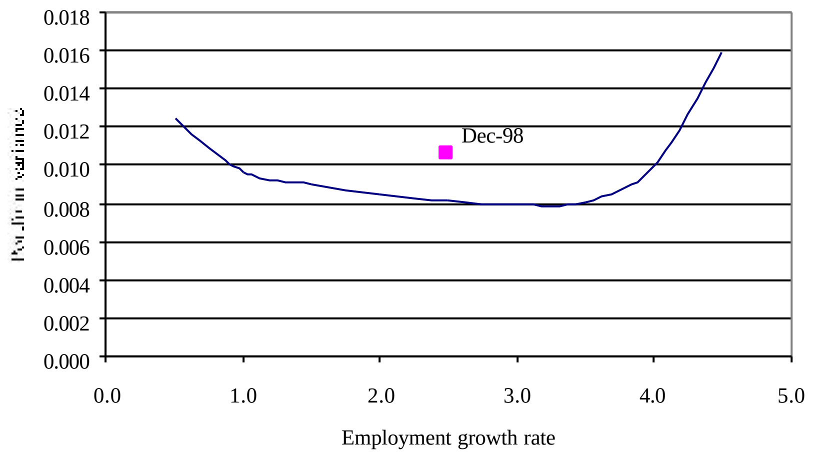
The model set out in equations (6) through (9) was solved under three different scenarios. The difference in the scenarios centred on the amount the w_i's (industry shares of total employment) were allowed to vary. In the first scenario, regional industry employment shares were allowed to vary by up 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, in particular the public sector industries of *Electricity, gas and water*, *Government administration and defence*, *Educatio*n and *Health and community services*, 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 effects the position of the efficiency frontier in the model solution, while the final scenario shows how industries can be removed from the constraint set.

In the model solution the g_i (employment by industry growth) was set equal to the average growth rate of the four quarters of 1998. Some authors (for example see Hunt and Sheesley 1994) have used time series techniques to generate forecast growth rates; however, this seems unnecessary for the purpose of the present study.

Scenario 1: 50% constraint

Figure 1 shows the regional efficiency frontier for Queensland when industry employment shares are allowed to move by as much as 50% from their December quarter 1998 position. This figure shows that quarterly employment growth rates of less than 1% and more than 4% result in larger variations in the portfolio variance of regional employment. The figure also shows the position during the December quarter 1998 in relation to the regional efficiency frontier.

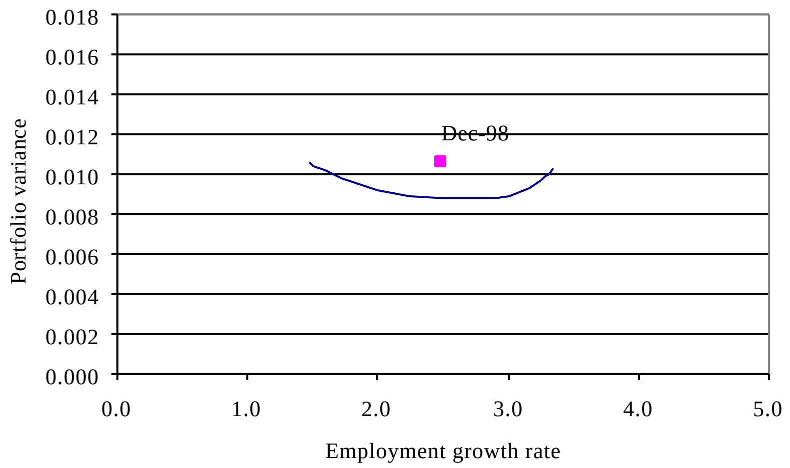
Figure 1: Instability Growth Frontier (50% constraint)



Scenario 2: 25% constraint

Figure 2 shows the regional efficiency frontier for Queensland when 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. Once again the figure also shows the position during the December quarter 1998 in relation to the regional efficiency frontier.

Figure 2: Instability Growth Frontier (25% constraint)



Scenario 3: 50% constraint plus fixed public sector

Figure 3 shows the regional efficiency frontier for Queensland when 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.

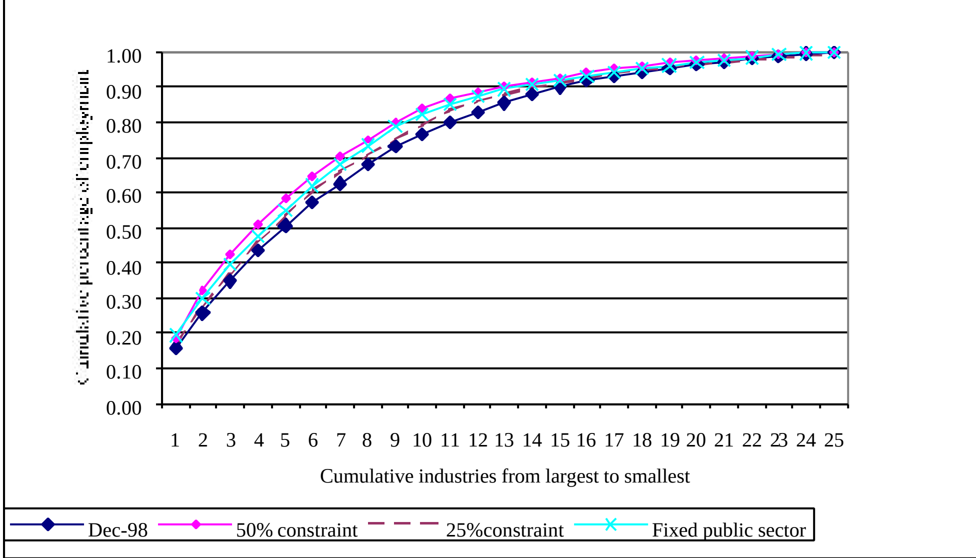
This figure shows that quarterly employment growth rates of less than about 1.5% and more than about 3% result in larger variations in the portfolio variance of regional employment.

Figure 3: Instability Growth Frontier (50% constraint plus fixed public sectors)

An interesting issue is the extent to which the economy must diversify to reach the efficiency frontier. Figure 4 provides concentration curves for the December quarter 1998 portfolio and the regional industry portfolios for each of the three scenarios at the 3% growth rate.

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. They are calculated as the cumulative shares of output of the largest firms. In this section they are used to provide some insight into the implications that the portfolio boundary solutions at the 3% 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 employment by industry of the largest employing industries. These shares are added to the total of the preceding industries until all employment is accounted for.

Figure 4: Concentration curves



An interesting feature evident from Figure 4 is that in all cases the concentration curves for the portfolio model solutions lie above the concentration curve for December 1998. There are two implications of this finding. Firstly, the relative position of the efficiency frontiers in Figures 1 to 3 suggest 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% 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 index[4] for each of the three scenarios and the December quarter 1998 position. The indexes are shown in Table 1.

Table 1: Herfindahl indexes of employment concentration

Scenario	**Herfindahl index**	**Rank**
December 1998	0.0414	4
50% constraint	0.0422	1
25% constraint	0.0417	3
Fixed public sector	0.0420	2

The Herfindahl index (*H*) is calculated as;

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

where n refers to the number of firms and s^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 economy. The higher the value that the index takes the more specialised is the regional economies economic base. Table 1 indicates that in all cases the

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

efficiency frontier positions at 3% growth exhibit a higher level of employment concentration than does the position of 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 point to a need for greater understanding of regional structure and behaviour before the formulation of regional diversification strategies.

Due to the implications these findings may have for industrial diversification policies and the effects of such policies on employment growth the model was subject to another series of tests. These tests consisted of three simple linear regressions, the results of which are presented in Table 2. Simple regressions were chosen because the author is unaware of any correlation test similar to Spearman's rank correlation test which is appropriate for a non-continuous variable such as the implied change in the portfolio which is constrained to $\pm$50% and so has an upper and lower bound.

Table 2: The link between variances and implied changes in industry shares

Equation 1	Variance =	0.02	+	-0.00009	(industry size)	+	e_i
		(-8.2)		(-4.3)	F (1,23) = 18.74		
Equation 2	Variance =	0.01	+	-0.002	(employment growth rate)	+	e_i
		(-3.9)		(-0.6)	F (1,23) = 0.35		
Equation 3	Variance =	0.009	+	-0.00	(implied change in portfolio)	+	e_i
		(5.2)		(-0.3)	F (1,23) = 0.09		

The first regression performed was a regression of industry size on its variance. In the second regression the growth rate over the period was regressed on the variance. Finally, the implied changes derived from scenario 1 when solved for 3% growth, were regressed on the industry variance.

The results of the first regression, in particular the t-statistic (in brackets) on the coefficient of industry size, and the coefficient itself suggest that there is a negative relationship between industry size and variance. This result implies that small industries in terms of total employment have larger variances in employment than large employing industries. This may be due to a number of factors, with the main concern being the standard errors due to the sampling methodology used which results in smaller industries having larger standard errors due to fewer observations being collected. One consequence of this is larger variances for these industries. Taken by itself this result may suggest that the portfolio selection framework may tend to choose for expansion those industries with smaller variances, in our case relatively large industries. This would suggest that data quality is driving the conclusions of the model.

The case for accepting the conclusions of the model would be further weakened if there was a strong relationship between industry growth and industry variance. Such a result, coupled with the findings of the first regression, might suggest that the framework is selecting industries that have been relatively stable over the sample period. However, the insignificant t-statistic on the coefficient of growth rate when regressed on variance (shown in equation 2 in Table 2) suggests that there is no correlation between high growth industries and industry variance.

Additional support for the conclusions of the model can be drawn from the results of the third regression. In this regression the t-statistic of the coefficient for the variance suggests that it is insignificantly different from zero. This indicates that industry variance by itself is not significant in the model's choice of which industries' shares of total employment are increased or decreased.

These results can be understood when looking at the variance-covariance matrix. This matrix has N * N elements (in our case N = 25). The N diagonal elements are the industry variances while the remaining (N-1)*(N-1) are industry covariances or measures of the strength of how industries move together over time.

The portfolio selection framework attempts to minimise instability by looking not only at industry variance, but also at the size of the industry's covariances. Industries that have relatively large positive covariances with other industries in the regional employment portfolio tend to move in the same pattern as the industries with which they share this positive covariance. Expansion of such industries tends to result in an increase in employment stability. Thus, an industry with a relatively large variance may be expanded if it shares negative covariances with several other industries in the regional portfolio.

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.

The practical value of this model to Queensland 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 model solution also suggests 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

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Table A2: ADF values for 1 through 4 lags

Industry	Lag(0)	Lag(-1)	Lag(-2)	Lag(-3)
Agriculture, forestry and fishing	-8.32	-6.69	-7.07	-5.56
Mining	-8.80	-6.05	-5.66	-5.20
Food, beverage and tobacco manufacturing	-6.36	4.51	-4.51	-3.09
Textile, clothing, footwear and leather manufacturing	-10.1	-6.02	-6.45	-5.56
Wood and paper product manufacturing	-8.38	-6.67	-5.67	-4.89
Printing, publishing and recorded material	-7.01	-4.65	-3.78	-3.28
Petroleum, coal, chemical and associated product manufacturing	-7.36	-5.91	-4.46	-3.25
Non-metallic mineral product manufacturing	-8.16	-6.89	-5.21	-4.84
Metal product manufacturing	-8.64	-6.77	-5.01	-4.68
Machinery and equipment manufacturing	-7.87	-4.98	-4.89	-4.63
Other manufacturing	-6.67	-4.80	-4.47	-3.60
Electricity, gas and water supply	-8.21	-7.91	-6.10	-5.68
Construction	-7.01	-5.86	-4.04	-3.33
Wholesale trade	-6.16	-4.13	-5.00	-3.78
Retail trade	-7.53	-5.21	-4.21	-3.19
Accommodation, cafes and restaurants	-9.72	-7.31	-6.77	-6.66
Transport and storage	-8.64	-6.54	-5.75	-4.79
Communication services	-8.67	-7.15	-5.56	-4.6
Finance and insurance	-7.09	-5.14	-4.44	-3.48
Property and business services	-6.59	-5.81	-4.26	-3.56
Government administration and defence	-7.38	-5.82	-4.63	-4.85
Education	-7.46	-6.12	-5.73	-4.40
Health and community services	-7.11	-5.93	-3.77	-3.06
Cultural and recreational services	-7.12	-6.30	-5.42	-5.02
Personal and other services	-6.21	-5.65	-4.35	-3.88
Critical value = -2.92				

Table A3: Box-Pierce and Ljung-Box test statistics

Industry	Box-Pierce	Ljung-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

Bibliography