Forecasting Labour Force Participation Rates by age, gender and highest qualification levels

Julian Williams, Ram SriRamaratnam, Xintao Zhao
Labour Market and Business Performance Ministry of Business, Innovation and Employment[1]

Abstract

The labour force participation rate (LFPR) is an important indicator for forecasting and monitoring labour market activity. It is the percentage of the working age population (WAP) which is employed or actively seeking employment. In the short-term, where output is primarily determined by labour input, percentage changes in real GDP per WAP can be expressed as the sum of the percentage change in the LFPR and the percentage change in labour productivity.

The overall LFPR for the aggregate labour force is influenced by the LFPRs of its constituent and diverse groups. In previous work, we reported our monitoring and forecasting of LFPRs for groups disaggregated by age. In this paper we report the extension of this work to a more disaggregated level so that we include gender and highest qualification as additional dimensions.

We report annual forecasts to three years of 86 LFPRs. Eighty six forecasting equations arise from the product of 11 age cohorts, 2 genders, and 4 highest qualifications (degree, level 4+ tertiary, school, no qualifications), less 2 equations for degree holders in the 15 – 19 group for males and females, which are assigned to be non-existent. We propose a unique econometric model that we applied to the 86 time series spanning 1992 to 2012 to estimate the multivariate regressions.

We also report:

- an analysis of the historic and disaggregated time series of LFPRs. This includes measures of the differentials shown between LFPRs for various age-gender groups according to qualification over 20 years
- diagnostic criteria for model selections
- standard errors of regressions and tests of within-sample forecasts for the 2008 – 2012 period for some age cohorts.

The datasets of age by gender by highest qualification were constructed using the unit record data from Household Labour Force Survey (HLFS) annual data for the period 1992 to 2012.

---

[1] The views expressed and any omissions or errors are those of the authors and do not reflect the official view of the Ministry.

1.0 Introduction[2]

The labour force participation rate (LFPR) is an important indicator for forecasting and monitoring labour market activity. It is the percentage of the working age population (WAP) which is employed or actively seeking employment. In the short-term, where output is primarily determined by labour input, the percentage change in real GDP per WAP can be expressed as the sum of the percentage change in the LFPR and the percentage change in labour productivity.

MBIE's labour market analysts are concerned with forecasting and monitoring the behaviour of the labour market in a macroeconomic context. Part of this work involves monitoring and forecasting of LFPR for the aggregate labour force as well as its component groups.

In general, historic series of LFPRs and projections of LFPRs for the aggregate labour force are well reported. Labour Force projections are regularly updated by Statistics New Zealand classified by age and gender (2012a Statistics New Zealand). MBIE has reported studies of general trends and features of specific age groups in previous studies (2012b SriRamaratnam et al, 2012c SriRamaratnam et al) and in regular monitoring reports (2013 Ministry of Business, Innovation and Employment).

The qualifications possessed by the labour force are important determinants of its productivity and therefore of future economic growth. From a labour market perspective, qualifications of workers shape both their readiness to participate in the workforce as well as their capacity to meet demand for specific skills.

LFPRs corresponding to different qualifications for each age-gender combination show large variations between themselves. Importantly this behaviour is not revealed by the aggregate LFPR for the age-gender combination. This is shown in Fig 1 to Fig 3 below (discussed more fully later) where the LFPRs for both genders of the 40-44 age group in Fig 1 can be compared to the LFPRs for their qualification-specific components in Fig 2 and Fig 3. Hence investigating and forecasting LFPRs for age-gender-qualification combinations will improve our forecasting of LFPRs and our monitoring of them.

Models which project LFPRs several years and decades ahead based mainly or solely on demographic drivers (fertility, mortality and net migration) have a useful purpose to serve with respect to assessing LFPR constraints and supply and demand imbalances that may arise in 20-30 years or even 60 years ahead.

At the same time, these models do not take into account economic and business cycle effects that determine LFPR. The responses of different groups characterised by age gender and highest qualification attainment levels are expected to show different short-term responses to these effects.

[2] *Access to the data used in this study was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The results presented in this study are the work of the author, not Statistics New Zealand.*

In this study, we apply a conceptual modeling framework that seeks to capture these economic effects by incorporating the employment rates (age group and/or gender and age group specific) as proxy variables representing the business cycle effects.

Figure 1: LFPR for Females and Males 40-44 years old

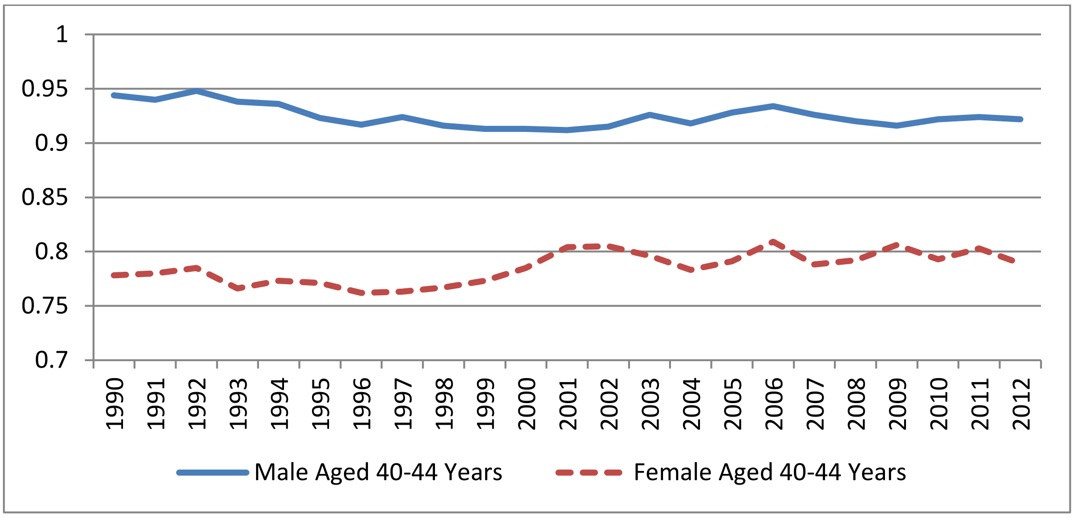


Figure 2: LFPR for males 40-44

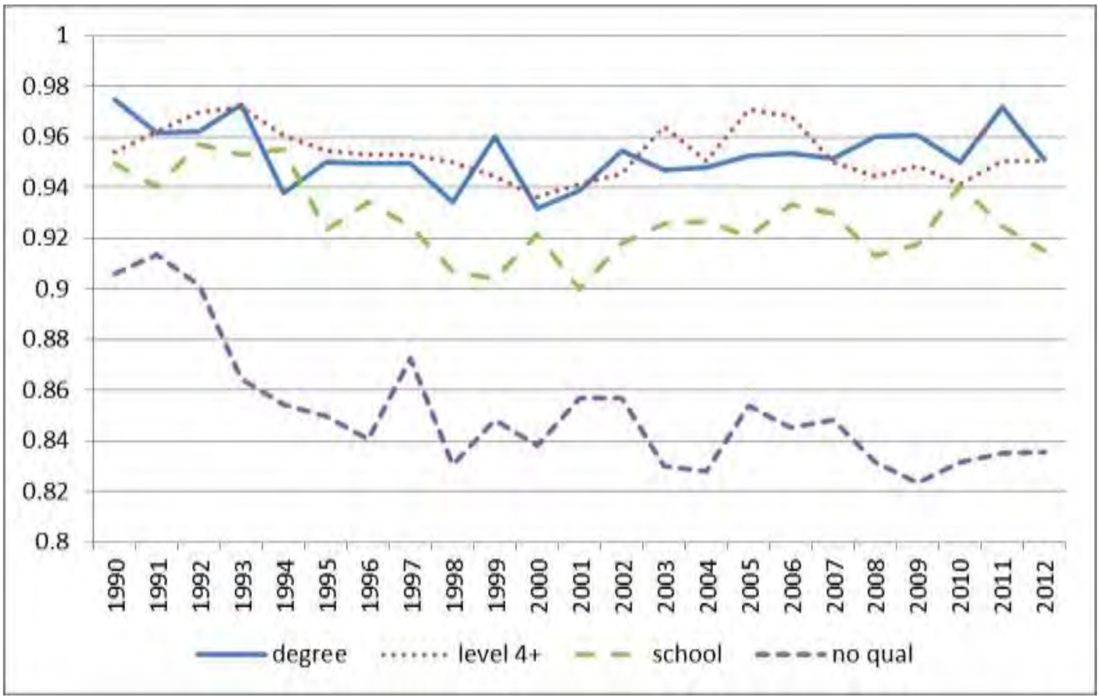
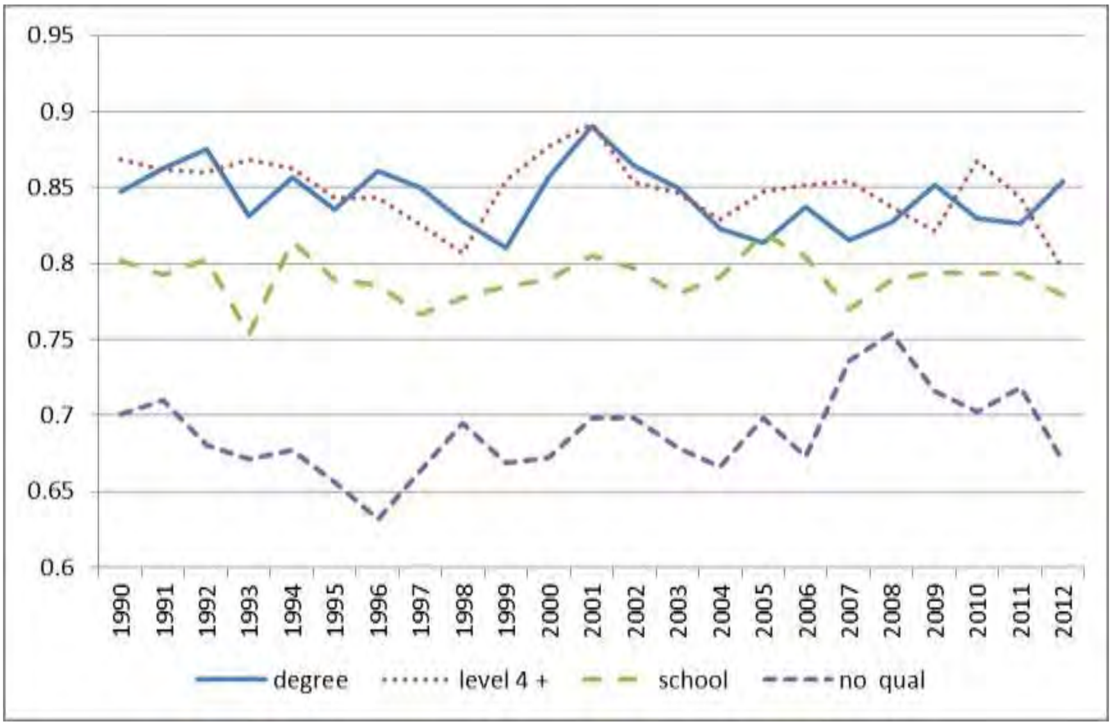


Figure 3: LFPR for females 40-44 years



In summary, the objectives of this study are to:

- forecast 86 series of LFPRs to a three year horizon for HLFS-based data disaggregated by age, gender and qualification
- incorporate the influence on the forecasts of business cycles as important short term economic factors
- develop a simple and easily manageable process for producing and updating forecasts
- compare the annual changes in the forecasts with those in Statistics NZ projections, at an aggregated level
- draw insights from analysis of disaggregated historic data series

The outcome of this study will be a better understanding of the unique behaviour of each subgroup. This will improve our capacity to interpret changes and predict future trends in aggregate LF. We expect this understanding to also improve the robustness of the forecasting process over time.

2.0 Analysis of historic labour force participation rate data series

Analysis of historic data can provide insights into behaviour of sub-components of LF and of their contribution to aggregate labour supply changes.

2.1 LFPR data series differ by age, gender and qualification

The charts above ~~below~~ (Fig 2~~4~~ and Fig 3~~5~~) ~~are provided as examples to~~ aid the following discussion. They show eight (four in each Figure) of the 86 historic LFPR time series. Fig 2~~4~~ shows time series of LFPRs for the ~~fe~~males in the 40-44 years age group. The four time series are for highest qualification categories of degree, level 4+, school, and no qualification. Fig 3~~5~~ shows the corresponding time series for females.

Visual inspection of these time series shows a number of interesting differences that have been quantified in simple ways. We present and discuss two of these:

- "gender effect" on LFPR
- "qualification effect" on LFPR

2.2 Gender effect on labour force participation rate (LFPR)

A "gender effect" is calculated as the average annual difference (over the 21 years from 1992 to 2012) between LFPRs for males and females for each age-qualification combination. In Fig 2~~4~~ and Fig 3~~5~~ this amounts to calculating the average of the annual difference between lines of the same colour (same qualification). We obtain four averages for the age group 40-44 years. When this is repeated for all 11 age groups we obtain 43 average annual differences. These are plotted in Fig 4~~6~~ with colour coding to aid the discussion of them.

In algebraic terms, we can express this average annual difference in LFPR for males (LFPR_M) and that for females (LFPR_F) in the years from i=1992 to i=2012, for each age-qualification combination as:

$$AVG\_GEN\_DIFF = \left(\frac{1}{21}\right)\sum_{i=1992}^{i=2012}\left(LFPR_{M_i} - LFPR_{F_i}\right)$$

In the main, Fig 4~~6~~ shows that avg-gen-diff (average difference due to gender) is:

- generally positive in favour of males, indicating that on average, males showed higher LFPRs for all age groups and qualifications compared to females over the 1992 to 2012 period

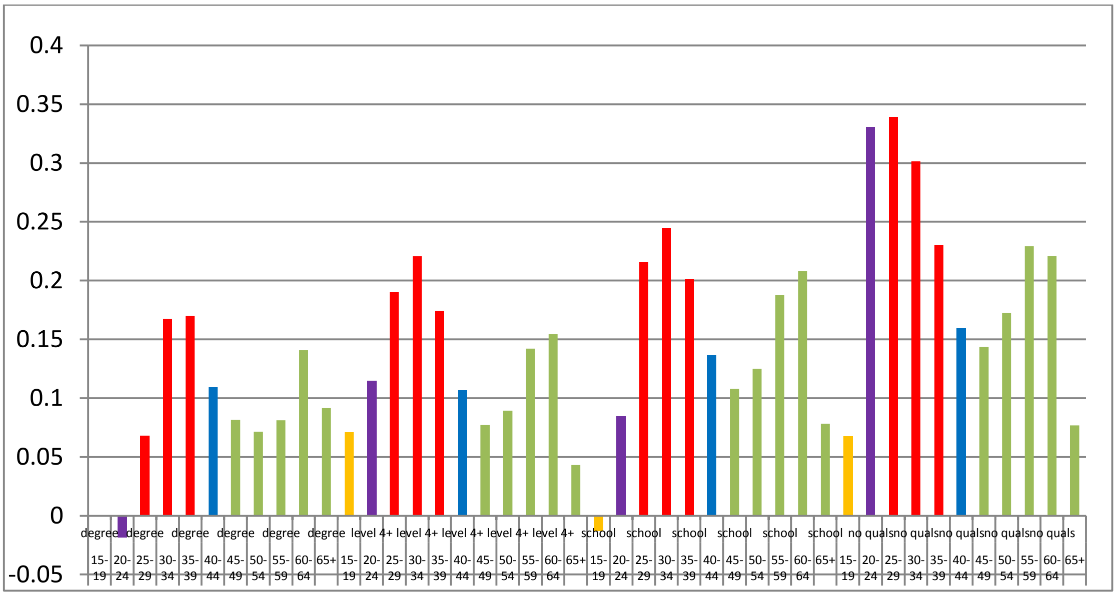
- generally this difference in favour of males is highest for "no quals" followed by "school", "level 4+" and "degree", indicating that, in general, possessing a "level 4+" or "degree" qualification reduces the gender disparity in LFPR by approximately similar amounts

- generally this difference in LFPR between males and females is also higher for the 3 age groups in the 25-39 age range (covering those of child bearing age) than for other age groups

- for the older age groups covering 45-65+ the difference between males and females tend to show a similar pattern of differences for all qualifications, rising with age up to 60-64 then falling for the 65+ age group

- for the younger age groups covering those in 15-19 and 20-24 categories, the male female differences show different behaviour across the different qualifications, including higher participation by females 15-19 years with school and 20-24 years with degree qualifications

Figure 4: Gender effect on LFPR



2.3 Qualification effect on labour force participation rate (LFPR)

A "qualification effect" (qual_eff) is calculated as the average annual difference (over the 21 years from 1992 to 2012) between LFPRs for persons by age and gender with a qualification (such as school, level 4+ and degree) and the corresponding LFPR for the case of no qualification.

In Fig 24 and Fig 35 above this amounts to calculating the difference for each year between the violet line (no qual) and each of the red, blue and green lines (representing higher qualifications). The average of the differences over 21 years is calculated. The results for each age-gender combination are shown in Table 1 below.

In algebraic terms, we can express this average annual difference in LFPR for persons with a qualification of degree, level 4+, school (LFPR_Q) and corresponding persons with no qualification (LFPR_N) in the years from i=1992 to i=2012, for each age-qualification combination as:

$$QUAL\_EFF = \left(\frac{1}{21}\right) \sum_{i=1992}^{i=2012} (LFPR\_Q_i - LFPR\_N_i)$$

Table 1: Qualification effect on LFPR

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
male -degree	n/a	0.02	0.10	0.11	0.11	0.11	0.10	0.12	0.13	0.20	0.17
male - level 4+	0.43	0.11	0.11	0.12	0.11	0.11	0.10	0.11	0.13	0.14	0.04
male - school	0.14	-0.04	0.07	0.08	0.08	0.08	0.08	0.09	0.10	0.10	0.02
female -degree	n/a	0.37	0.37	0.25	0.17	0.16	0.17	0.22	0.28	0.28	0.16
female - level 4+	0.42	0.32	0.26	0.20	0.17	0.16	0.17	0.20	0.21	0.21	0.07
female - school	0.22	0.20	0.19	0.14	0.11	0.10	0.12	0.13	0.14	0.11	0.02

Males

1. We can conclude that degree and "level 4+" qualifications provide similar premiums (ranging from 10% to 13%) for males for the 25-59 age groups. This is larger than the premiums of LFPR for "school" qualification (ranging from 7% to 10%).

   In general, this suggests that:
   - a qualification of some kind provides a similar LFPR premium over no qualification for males covering large portion of the working age groups
   - premiums for "degree" and "level 4+" are similar but larger than that for "school".

2. All qualifications provide a premium in terms of LFPR for the 60-64 and 65+ age groups with “degrees” providing the highest, followed by “level 4+” and then “school” .

3. By comparison “level 4+” (43%) and “school” (14%) qualifications provide premiums in terms of LFPR for the 15-19 age group.

4. The 20-24 age group benefits little from degree (2%) qualification and a school qualification is a detriment (-4%) to LFPR compared with no qualification.

Females

1. We can conclude that degree and “level 4+” qualifications provide similar premiums (ranging from 16% to 37%) for females for the same 20-59 age groups. This is larger than the premium for “school” qualification (ranging from 10% to 20%).

   In general, similar to the result for males, this suggests that:

   - a qualification of some kind provides a similar LFPR premium over no qualification for females covering large proportion of the working age groups

   - the premiums for “degree” and “level 4+” are similar but larger than that for “school”.

2. Compared with the results for males, the premiums for females from having a qualification are generally higher and show greater variation across the age groups, possibly reflecting the influence of other factors including being primary child carers.

3. All qualifications provide a premium in terms of LFPR for the 60-64 and 65+ age groups with “degrees” providing the highest, followed by “level 4+” and then “school” . These premiums are similar to those for the corresponding male age groups.

4. By comparison “level 4+” (42%) and “school” (22%) qualifications provide premiums in terms of LFPR for the 15-19 age group that are comparable to the corresponding male premiums (43% and 14%).

5. Interestingly, the premium in terms of LFPR for the 20-24 age group with a degree (37%) qualification and with a school qualification (20%), are very different to those observed for males (2% and -4%).

3.0 Conceptual Framework

This section describes the simple conceptual models used to derive forecasts for 86 age-gender-qualification combinations for labour force participation rate. In this study the time series of the levels of LFPRs are non-stationary and we prefer to work with stationary time series of the annual percentage changes (apc(LFPR)) for estimating econometric equations.

In order to forecast 86 LFPRs, we first forecast the corresponding apc(LFPRs and apply the forecasts to current period LFPRs.

We hypothesise that a simple generic structural model applies to all LFPRs that explains their historic behaviour and enables their forecast.

The corresponding econometric model with no restriction on the number of variables for each age-gender-qualification sub group for age class i, gender class j and qualification class k is:

$$\boldsymbol{apc}(\boldsymbol{LFPR_{ijkt}}) = \sum_p \boldsymbol{\alpha_{ijk,t-p}}\, \boldsymbol{apc}(\boldsymbol{LFPR_{ijk,t-p}}) + \sum_q \boldsymbol{\beta_{ijk,t-q}} \boldsymbol{apc}(\boldsymbol{ER_{ijk,t-q}}) + \boldsymbol{\gamma_{ijk,r}} \boldsymbol{MA_{ijk,r}} + \boldsymbol{\epsilon_{ijkt}} \quad (1)$$

This specification expresses the apc of the participation rate $\boldsymbol{LFPR_{ijk,t-p}}$ for subgroup i,j,k at any time t as a (i) linear combination of past apc's, (ii) a linear combination of past apcs of the employment rate $\boldsymbol{ER_{ijk,t-q}}$ used as a proxy for the influence of the state of the business cycle; and (iii) a moving average term $\boldsymbol{MA_{ijk,r}}$. In some cases the employment rate used is both age and gender specific.

Estimating this equation for each subgroup provides estimates of coefficients $\boldsymbol{\alpha_{ijk,t-p}}$ and $\boldsymbol{\beta_{ijk,t-q}}$ and $\boldsymbol{\gamma_{ijk,r}}$.

This specification is selected to reflect the following assumptions that $\boldsymbol{apc}(\boldsymbol{LFPR_{ijkt}})$:

- has an autoregressive behavior since in the absence of any change influences, it will follow recent past patterns that we observe but cannot specify. This behavior can be explained by the cumulative effect of past participation decisions of individuals to participate in the labour force at time t
- is determined by the decisions of individuals who are influenced by their perceptions or experiences of the state of the business cycle that is proxied by the employment rate
- is influenced by past trends, specified by moving average terms of the residuals

In order to achieve simplicity and transparency of forecasting, we restrict this general model for each specific disaggregated series so that we estimate equations for each of the 86 series in terms of 3 (sometimes 4) terms:

- an autoregressive term
- a moving average term

- a selected explanatory variable that is a proxy for the state of the business

4.0 Previous work and literature review

The Labour Market and Business Performance unit of MBIE formerly commissioned work leading to the development of a model forecasting labour supply (DLSSM - the disaggregated labour status scenario model) and a variation of it. Both recognise that labour supply forecasts should account for age, gender and qualification of the working age population. However, neither model includes any economic variables to capture the short-term variations in LF due to business cycles. Further neither explicitly accounts for the qualification characteristic. These shortcomings are addressed in the present work.

The Cdefop report (2009 Cdefop) provides a helpful overview of macroeconomic modelling of labour market variables.

Cdefop (p100) models the qualification structure of the population separately and independently from the qualification structure in the labour force using changing patterns over time within each sub-group. Labour force participation rates are then obtained by dividing the estimated labour force for each qualification group by the corresponding population estimate.

This can lead to implausible outcomes in some cases. To avoid this problem, cdefop suggests that a useful development would be to model labour force participation rates for age, gender and qualification categories separately and directly.

This present study uses data disaggregated by age, gender and highest qualification as suggested by cdefop. This removes the need to make separate assumptions about, or to estimate separately, the distribution of qualifications over the age and gender groups, for the population and the labour force.

Cdefop notes that from a macroeconomic modelling context (p26) the main drivers of labour supply are demographic factors; real wage output levels; unemployment rates; social benefits; and the structure of the economy (manufacturing versus services). These are reflected in the labour supply components of cdefop's E3ME macroeconomic model[3].

The work of Pollitt and Chewpreecha (2008), cited by cdefop at p27 acknowledges that a number of factors are important in explaining changing patterns of labour-market participation, including hours worked, the qualification mix and unemployment.

The cdefop report notes that best practice (p30) for developing projections of labour supply by qualification, involves a full stock-flow analysis. This is where stocks in

---

3 http://www.camecon.com/AnalysisTraining/suite_economic_models/E3ME/purpose_and_design.aspx

one period are related to stocks in an earlier period, plus inflows less any outflows. The flows can be linked to demographic developments, migration and to a range of behavioural drivers, including economic and social factors.

One main issue with estimating flows is that there is limited information available on flows for lower-level qualifications. Various methods are used to overcome this barrier, including developing projections using trends in historic time series. However, limited data and the lack of consistency between databases make it difficult to produce robust forecasts (p38). For this reason, cdefop focuses on stock-based models.

5.0 Data

The LFPR series are obtained from HLFS unit record data disaggregated by age, gender and qualification

A database of apcs was obtained for 86 time series from 1992 to 2012.

The 86 time series are comprised of:

- 11 age cohorts (15-19; 20-24; 25-29; 30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; and 65+
- 4 highest qualification levels (degree; level 4+; school; no qualification)
- 2 genders
- less two combinations, considered as non-existent, for males and females of 15 to 19 years with degrees.

The LFPR is the number of persons employed or unemployed divided by the corresponding working age population for the 86 combinations. This represents or relate to the most common concept of actual labour supply rather than a potential labour supply.

The 86 time series were sourced from the HLFS unit record data of Statistics New Zealand using a SAS program. Unit record counts were aggregated for each combination and the LFPR and WAP calculated accordingly. The data for each age-gender-qualification combination were annual data from 1992 to 2012, being averages of four quarters of data for the year ended in the June quarter. The data used to estimate the econometric models were annual percentage changes as noted above.

6.0 Model Estimation

6.1 Econometric Estimation

The model specification is shown in equation 1 above. Equations for 86 different age-gender-qualification combinations were estimated using least squares estimation methods. Results for estimated equations are shown in Appendix A. Table A1a (males) and Table A1b (females) show the estimated coefficients and the levels of significance together with diagnostic criteria for each combination. The modelling technique constructs each equation with a selection of three parameters. As before, the "A_" prefix denotes annual percentage change. There is:

- usually one (at most two) autoregressive terms, A_LFPR_{t-i}
- one age specific or age and gender specific employment rate term, A_EMP_{t-j}
- one moving average term (MA (l)) of residuals.

Dickey-Fuller unit root tests were performed to check all apc variables for stationarity.

In general the equations use the apc of the employment rate for both sexes (A_EMP). As noted in section 2 above, in some cases the apc of the gender specific employment rates (eg A_EMP_M for males and A_EMP_F for females) were used in order to improve the fit of the equations estimated.

The length of the lags in parameters and the period of the moving average term are selected in order to produce the best test statistics as follows:

- t-tests for the significance of the parameters
- F-tests for the significance of the equation as a whole

Residuals tests are then applied to test for the presence of autocorrelation (Q-statistic test) and heteroscedasticity (ARCH and White tests). Heteroscedasticity and autocorrelation consistent corrections (Newey-West HAC corrections) are then applied to arrive at the best possible equation.

All coefficients are significant at least at the 10 per cent level and many at the 1 per cent level. The specification of the equations is evaluated by F-statistics significant at least at the 10 per cent level. The overall goodness of fit measured by the R-squared and adjusted R-squared and the standard errors of the regressions are reported for equations estimated.

6.2 In-sample forecast tests

In order to assess the typical forecasting accuracy of the equations, tests of within-sample forecasts were made for LFPRs for 30-34 and 35-39 age cohorts by qualification and gender. For the 16 equations, mean absolute percentage errors (MAPEs) were calculated by comparing the corresponding forecast and actual values for the two in-sample June years ending 2011 and 2012. All MAPEs are below 5%.

6.3 Error estimates for the estimated equations

The standard errors of the apc of the regression equations are shown in the Tables in Appendix A. These form the basis of the errors that we can associate with the forecasts of WAP and LFPR and therefore of LF.

In general the standard errors[4] of regressions for LFPR are of the order of about 2.1% for males and 3.0% for females.

The standard errors are expressed in the same units as the apc of the dependent variables.

In order to generate a forecast of LFPR in the next period, the forecast apc of LFPR is applied to the current period LFPR. The associated forecast error in the forecast LFPR is the same as the forecast error in the apc.

This result is useful because the error term is small compared with the LFPR. Hence comparison of actual out-turns of LFPRs can be compared with reference to this error margin to provide a measure of significance of an out-turn.

This result is also useful because inspection of the LFPR data shows that differences between forecast LFPRs, of different age-gender-qualification groups, is often smaller than the sum of the associated error margins. This is especially true in many cases of interest (such as in comparing groups of no qualifications with qualifications or in investigating gender differences). Hence comparison of differences in forecast LFPRs for different age-gender-qualification groups can be made with some measure of the margin of error.

In general, the above error analysis supports the application of the forecast LFPRs in producing LF and other forecasts by age-gender-qualification with an estimated error of about +/- 2.5%.

7.0 Forecasts

7.1 Forecast Results

Historic data (1993 to 2012) and forecasts (2013 to 2015) are shown as charts in Appendix B. They show that 3 year forecasts appear to reflect both recent trends and fluctuations in the historic data series.

Our estimates of annual LFPR are derived from econometrically estimated structural models. Statistics NZ LFPRs are derived using specific assumptions about future LFPRs of specific groups in the LF. They are also projections at the end of each June year similar to the estimates. They are also reported only at the age-gender level and not at the age-gender-qualification level attempted in this project to assess the impact of qualification on LFPR.

In order to compare the MBIE forecasts with Statistics NZ projections, MBIE forecasts of labour supply and working age population (not reported here) are aggregated up to an age-gender level and a corresponding LFPR is calculated from them. The two series are quite similar. However, numerical differences between the two series are evident and reflect the different points in times at which the LFPRs are assessed.

[4] Estimated by excluding a few standard errors of 10% or more.

7.2 Process for updating forecast with new data

All forecasts developed in the project are easily updated by including latest actual data and applying the forecast equations. This will produce a new set of 3 year ahead forecasts. When the disaggregated LFPR data for the 2013 year ended June is available after the release of the June 2013 quarter data in August 2013 they could be compared with the forecasts.

After two years it would be helpful to re-estimate the forecast equations incorporating two years of additional data and any improvements considered necessary with model specification as well as estimation and then develop new forecasts based on these models.

When data from the 2013 Census are available, the database can be adjusted and new forecasts produced.

8.0 Summary and Implications for Labour Supply

The charts in Appendix B clearly show the differences in LFPRs exhibited by different age-gender-qualification groups. We conclude that forecasting these series separately will:

- refine our forecasts of these and their aggregates and
- improve our understanding of LFPR results from year to year.

The magnitudes of the differences due to gender and qualification provide important insights into their impact relative to each other and to other more general impacts affecting LFPRs. This informs forecasting in the context of changing labour market condition, demographics and economic conditions.

In general, our simple conceptual framework appears to be effective in providing robust equations and reasonable standard errors of regression. These provide a helpful basis from which reasonable 3 year ahead forecasts can be made at such a disaggregated level.

While mixed interpretations may arise for the lags and relevance of some of the fitted parameters, we emphasise that our main priority is to develop technically robust equations, with reasonable explanatory parameters. In this context, the fitted equations provide an important base for further econometric investigation, as necessary.

Indeed the raft of 86 individual equations in Appendix A developed with a small number of explanatory variables, together suggest an underlying economic model that can be further explored with additional explanatory parameters on a case by case basis, subject to data availability.

This type of analysis is particularly useful in helping to understand the labour supply behavior of specific groups such as younger workers and older workers and the impacts on LFPR of higher qualifications by gender. It is from these groups that large gains in LFPR are possible and with which overall LFPR and overall labour supply can be increased resulting in higher future economic growth.

References

2013: Ministry of Business, Innovation and Employment, "Quarterly Labour Market Report", May 2013, Wellington.

2012a: Statistics New Zealand, "National Labour Force Projections".

2012b: SriRamaratnam, R.; Zhao, X. and W. Bell, "Employment Growth and Unemployment Rate Reduction: Historical Experiences and Future Labour Market Outcomes", prepared for 2012 New Zealand Association of Economists' Conference, Department of Labour, Wellington.

2012c: SriRamaratnam, R.; Zhao, X. "Impacts of Employment Rates (Demand) and Participation Rates (Supply) on Unemployment Rates: a Disaggregated Analysis", prepared for 2012 Labour, Employment and Work in New Zealand Conference, Department of Labour, Wellington.

2010: Paterson, D. and S. Brown, "Labour Force participation in New Zealand: recent Trends, Future Scenarios and the Impact on Economic Growth", for 2010 Labour, Employment and Work in New Zealand Conference, Department of Labour, Wellington.

2009: European Centre for the Development of Vocational Training, "Future Skill Supply in Europe".

2008: Infometrics Ltd, "Disaggregated Labour Status Scenario Model 2008 Update", prepared for Department of Labour, Wellington.

Appendix A: Table A1

Labour Force Participation Rate (Male)

Model Type : A_LFPR = A_LFPR (Gen, Age, Qual)

Model Specification : $A\_LFPR_t = \alpha_{t-i} * A\_LFPR_{t-i} + \beta_{t-j} * A\_EMP_{t-j} + \gamma_{t-k} * A\_EMP\_M_{t-k} + \delta_l * MA(l) + \varepsilon_t$

Significance : * 10% ; ** 5%; *** 1%

	Model Type			Estimated Coefficients				Diagnostic Criteria			
	Gen	Age	Qual	α(i)	β(j)	γ(k)	δ(l)	RSQ	Adj RSQ	F	S.E. of Reg
1	M	15_19	4+	0.775 (7)**	0.315 (1)**		-1.000 (1)***	0.718	0.641	9.320	3.7%
2	M	15_19	sch	-0.861 (4)*	0.633 (4)*		0.897 (7)***	0.414	0.289	3.298	3.1%
3	M	15_19	no q	0.271 (3)*		0.915(0)*	0.731 (7)***	0.823	0.788	23.291	2.8%
4	M	20_24	deg	0.772 (7)**	1.024 (4)**		-0.918(7)***	0.779	0.720	12.973	2.4%
5	M	20_24	4+	0.773 (3)***	0.482 (5)*		0.681(7)*	0.696	0.626	9.910	1.9%
6	M	20_24	sch	-0.668 (1)***		-0.479 (4)**	0.054(2)***	0.657	0.583	8.928	2.5%
7	M	20_24	no q	-0.598 (7)***		-0.738 (3)***	-0.843(5)***	0.723	0.647	9.553	2.3%
8	M	25_29	deg	-0.429 (1)**		0.917 (7)**	-0.893(4)***	0.516	0.384	3.912	1.9%
9	M	25_29	4+	-0.301 (2)**		0.573 (0)***	0.999 (3)***	0.386	0.270	3.347	1.1%
10	M	25_29	sch	0.495 (5)**		-0.452 (3)**	0.894 (3)***	0.506	0.392	4.441	1.3%
11	M	25_29	no q	0.509 (3)**	0.631 (2)*		0.084 (4)***	0.369	0.242	2.920	3.0%
12	M	30_34	deg	-0.802 (1)***		-0.426 (3)**	0.939 (1)***	0.398	0.278	3.306	1.3%
13	M	30_34	4+	-0.462 (1)***	0.438 (5)***		-0.876 (7)***	0.660	0.582	8.413	0.7%
14	M	30_34	sch	-0.550 (1)***		0.181 (5)*	0.969 (1)***	0.467	0.344	3.793	1.1%
15	M	30_34	no q	0.807 (4)***	-2.676 (1)***		-0.880 (6)***	0.766	0.716	15.294	2.4%
16	M	35_39	deg	-0.664 (1)***	1.057 (6)***		-0.900 (3)***	0.528	0.410	4.470	1.4%
17	M	35_39	4+	0.500 (4)***	-0.424 (3)***		-0.998 (4)***	0.620	0.539	7.613	0.5%
18	M	35_39	sch	-0.422 (1)**	0.340 (1)**			0.320	0.245	4.241	1.0%
19	M	35_39	no q	-0.656 (2)***	-0.460 (4)**		-0.867 (3)***	0.562	0.468	5.987	1.6%
20	M	40_44	deg	-0.749 (1)***	0.406 (3)*		0.523 (3)**	0.705	0.646	11.973	1.0%
21	M	40_44	4+	-0.892 (1)***	-0.359 (7)**		1.000 (1)***	0.469	0.309	2.942	1.0%
22	M	40_44	sch	-0.916 (5)***	-0.650 (7)***		-0.924 (4)***	0.724	0.649	9.629	0.9%
23	M	40_44	no q	-0.507 (1)**	-0.855 (4)**		0.382 (4)***	0.503	0.397	4.729	1.6%
24	M	45_49	deg	0.488 (5)***	0.654 (2)*		0.812 (5)***	0.706	0.638	10.402	0.8%
25	M	45_49	4+	-0.526 (1)***	-0.424 (3)**		-0.909 (3)***	0.618	0.541	8.072	0.6%
26	M	45_49	sch	-0.567 (1)***	1.195 (5)***		-0.995 (5)***	0.667	0.590	8.667	1.0%
27	M	45_49	no q	-0.547 (2)*	-1.027 (2)*		-0.837 (6)***	0.396	0.283	3.504	1.5%
28	M	50_54	deg	0.228 (7)**		-0.743 (7)***	-0.574 (1)*	0.737	0.665	10.251	0.8%
29	M	50_54	4+	-0.770 (1)**		-0.250 (2)***	-0.894 (3)***	0.702	0.646	12.547	0.6%
30	M	50_54	sch	-0.637 (1)***		-0.424 (4)**	0.659 (1)**	0.411	0.285	3.254	1.4%
31	M	50_54	no q	0.497 (3)***		0.559 (3)*	0.823 (4)***	0.557	0.468	6.283	1.4%
32	M	55_59	deg	-0.613 (1)***		0.659 (4)**	0.240 (7)***	0.532	0.432	5.302	1.8%
33	M	55_59	4+	-0.590 (3)***	-0.606 (4)*		-0.510 (4)***	0.515	0.411	4.947	1.5%
34	M	55_59	sch	-0.494 (7)*		1.207 (7)**	0.888 (3)***	0.652	0.557	6.869	1.8%
35	M	55_59	no q	-0.565 (4)**	0.557 (1)**		-0.913 (1)***	0.658	0.585	8.997	2.0%
36	M	60_64	deg	-0.358 (6)**		0.658 (5)***	0.283 (4) ***	0.431	0.289	3.305	4.0%
37	M	60_64	4+	-0.408 (2)*	0.814 (1)***		-0.847 (7)***	0.745	0.697	15.593	4.0%
38	M	60_64	sch	0.807 (6)***		-0.735 (6)**	0.732 (3)*	0.518	0.398	4.299	5.4%
39	M	60_64	no q	0.299 (5)*		0.460 (3)**		0.365	0.274	4.018	4.1%
40	M	65+	deg	-0.471 (1)**		1.049 (7)**	-0.797 (4)***	0.592	0.480	5.315	11.4%
41	M	65+	4+	0.491 (4)**		0.606 (6)**		0.448	0.363	5.282	8.0%
42	M	65+	sch	0.239 (6)**	-1.119 (6)***		-0.951 (3)***	0.793	0.741	15.312	6.3%
43	M	65+	no q	-0.361 (4)*		0.730 (5)**	0.815 (3)***	0.602	0.510	6.542	10.4%

Appendix A: Table A2

Labour Force Participation Rate (Female)

Model Type : A_LFPR = A_LFPR (Gen, Age, Qual)

Model Specification : $A\_LFPR_t = \alpha_{t-i} * A\_LFPR_{t-i} + \beta_{t-j} * A\_EMP_{t-j} + \gamma_{t-k} * A\_EMP\_F_{t-k} + \delta_l * MA(l) + \varepsilon_t$

Significance : * 10% ; ** 5%; *** 1%

	Model Type			Estimated Coefficients				Diagnostic Criteria			
	Gen	Age	Qual	α(i)	β(j)	γ(k)	δ(l)	RSQ	Adj RSQ	F	S.E. of Reg
1	F	15_19	4+	0.590 (3)**	0.270 (3)*		0.421 (5)**	0.389	0.267	3.188	5.4%
2	F	15_19	sch	0.559 (4)*	0.011 (1)**		-0.911 (4)***	0.376	0.243	2.816	3.1%
3	F	15_19	no q	-0.876 (8)**	1.023 (7)*		-0.894 (5)***	0.713	0.627	8.282	4.7%
4	F	20_24	deg	0.524 (3)*	0.733 (4)***		-0.979 (4)***	0.622	0.541	7.686	2.7%
5	F	20_24	4+	0.581 (3)*		-0.932 (3)**		0.354	0.274	4.393	3.4%
6	F	20_24	sch	-0.756 (1)***	-0.419 (3)*		0.887 (3)***	0.487	0.385	4.751	3.1%
7	F	20_24	no q	-0.554 (2)**		-1.302 (4)*	-0.316 (2)***	0.571	0.479	6.212	6.2%
8	F	25_29	deg	-0.905 (4)*	1.078 (1)**		-0.891 (7)**	0.490	0.381	4.488	2.2%
9	F	25_29	4+	-0.487 (1)***		0.455 (0)***	-0.932 (2)***	0.711	0.659	13.907	1.9%
10	F	25_29	sch	-0.611 (7)*	-1.071 (3)***		0.704 (4)***	0.533	0.405	4.178	2.7%
11	F	25_29	no q	-0.574 (4)*		-1.006(7)*	0.696 (5)**	0.564	0.446	4.751	5.1%
12	F	30_34	deg	-0.462 (1)*	0.810 (6)*		-0.823 (4)	0.633	0.541	6.890	1.6%
13	F	30_34	4+	-0.434 (1)*	-0.902 (2)*		-0.815 (6)***	0.606	0.515	6.658	1.9%
14	F	30_34	sch	-0.995 (1)*	1.396 (1)***		-0.429 (4)*	0.744	0.699	16.478	2.1%
15	F	30_34	no q	-0.509 (4)**		0.916 (5)*	-0.953 (3)***	0.530	0.422	4.896	3.4%
16	F	35_39	deg	-0.461 (1)**	1.594 (3)**		-0.845 (3)***	0.463	0.356	4.311	3.4%
17	F	35_39	4+	-0.946 (4)***	0.913 (1)**		-1.000 (3)***	0.575	0.484	6.313	1.9%
18	F	35_39	sch	0.548 (3)*	-0.681 (2)***		-1.000 (2)***	0.706	0.647	12.021	1.6%
19	F	35_39	no q	-0.382 (6)*		-0.688 (6)*	-0.921 (3)***	0.529	0.411	4.491	4.0%
20	F	40_44	deg	-0.819 (2)***		-0.334 (5)*	-0.992 (4)***	0.720	0.655	11.143	1.7%
21	F	40_44	4+	-0.537 (2)***		0.750 (5)*	-0.840 (6)***	0.729	0.666	11.652	1.8%
22	F	40_44	sch	-0.313 (2)*	0.670 (4)**		0.884 (3)***	0.514	0.410	4.945	1.6%
23	F	40_44	no q	-1.113 (5)***	2.107 (2)**		1.000 (5)***	0.750	0.692	12.979	2.4%
24	F	45_49	deg	-0.608 (2)***		-0.934 (5)*	0.353 (2)***	0.644	0.562	7.838	2.5%
25	F	45_49	4+	-0.367 (4)**		-0.430(4)**	-1.000 (1)***	0.601	0.516	7.038	1.3%
26	F	45_49	sch	-0.563 (1)**	-1.088 (5)**		-0.669 (3)***	0.719	0.654	11.063	1.3%
27	F	45_49	no q	0.443 (4)**	-1.391 (2)**		0.895 (7)***	0.735	0.678	12.942	1.3%
28	F	50_54	deg	-0.438 (4)***		-0.453 (4)**	-1.000 (1)***	0.844	0.810	25.178	1.8%
29	F	50_54	4+	-0.507 (1)***		-0.382 (4)**	-0.859 (5)***	0.623	0.542	7.715	1.4%
30	F	50_54	sch	-0.888 (6)***		0.555 (6)*	-0.955 (1)***	0.643	0.553	7.194	1.6%
31	F	50_54	no q	-0.482 (1)**	1.161 (1)**		0.402 (4)***	0.440	0.342	4.459	2.5%
32	F	55_59	deg	0.250 (7)**	-1.153 (1)*		-0.956 (3)***	0.913	0.890	38.610	3.5%
33	F	55_59	4+	-0.360 (1)*		0.467 (5)*	-0.908 (4)***	0.553	0.450	5.371	2.9%
34	F	55_59	sch	-0.427 (3)*		-0.850 (5)**	0.663 (5)**	0.666	0.589	8.634	2.9%
35	F	55_59	no q	0.544 (3)**		0.511 (4)**	-0.662 (4)**	0.542	0.444	5.532	2.9%
36	F	60_64	deg	-0.774 (1)***	2.668 (1)***		0.640 (1)***	0.685	0.629	12.304	13.4%
37	F	60_64	4+	-0.202 (6)**		0.256 (5)*		0.490	0.411	6.234	4.6%
38	F	60_64	sch	-0.544 (3)*	2.062 (3)**		0.867 (6)***	0.716	0.659	12.608	6.2%
39	F	60_64	no q	-0.368 (6)*		0.436 (4)*	0.827 (6)***	0.722	0.652	10.381	4.2%
40	F	65+	deg	-0.359 (4)**		0.875 (5)***	-0.999 (1)*	0.538	0.431	5.040	16.2%
41	F	65+	4+	-0.338 (6)**	-0.771 (6)*		-1.000 (1)***	0.642	0.553	7.182	13.3%
42	F	65+	sch	-0.412 (6)**	0.768 (6)**		-0.890 (4)***	0.642	0.553	7.186	6.9%
43	F	65+	no q	0.520 (3)***	-1.114 (1)**		-0.095 (2)***	0.527	0.432	5.569	10.7%

Appendix B: Historical LFPR (1993-2012) and Forecast LFPR (2013-15)