The Economic and Social Review, Vol. 41, No. 2, Summer, 2010, pp. 149–172

A Quality Adjusted Measure of Labour Services for Ireland

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Abstract: This paper presents annual indices of labour input adjusted for the age, education and gender distributions of the Irish workforce for the period 1999-2008. Growth in labour services is divided between the increase in hours and improvement in the productive quality of these hours. Improvement in labour quality, as proxied by education, age and gender, has added on average 0.7 percentage points per year to the growth rate in total labour input. Changes in education account for two-thirds of the improvement in labour quality, with gender and age distributions equally sharing the remaining third. Even in the face of declining total employment, growth in labour services remained positive in 2008 due to past investment in human capital. A key application of this quality-adjusted labour series is that a proportion of growth usually attributed to total factor productivity growth can now be accounted for as an improvement in the quality of labour input.

I INTRODUCTION

This paper presents a new quality-adjusted measure of labour inputs in the Irish economy for the period 1999 to 2008. This approach is designed to help with assessing the extent to which labour productivity growth has been driven by the accumulation of, or changes in, human capital. The paper

* The views expressed in this paper are the personal responsibility of the author. They are not necessarily held by the Central Bank of Ireland, ECB or the ESCB. The author would like to acknowledge comments received from Karl Whelan, Kieran McQuinn and an anonymous referee and thank her colleagues in the Economic Analysis and Research Department at the Central Bank. Any errors are the sole responsibility of the author. Email: Mary.Keeney@centralbank.ie

examines a period of substantial structural changes – the total Irish labour force expanded considerably and there was, also, a significant change in the composition of the labour force mainly due to the growth in the relative importance of certain sectors during this period.

The number of workers in an economy is the simplest measure of labour input, which counts all workers equally. Because not everyone works equal amounts of time, a superior measure of aggregate labour input is the number of hours worked in an economy. However, hours of work are not homogenous: there are differences in the contribution to national output from one hour's work depending on the skills of the person offering it. Therefore any change in the composition of the labour force will affect the degree of heterogeneity or quality of hours worked and, therefore, the volume of "productive" hours. This means that any measure of labour input that does not take into account the changes in the number of hours for a given level of skill/quality will lead to a less precise measure of the effective labour input in the economy. If the contribution of labour quality changes to productivity measurement can be refined and isolated, estimates of growth from other sources that are captured by a Total Factor Productivity (TFP) residual would need to be revised.[1]

While it is widely accepted that adjusting factor inputs for quality is an important issue for productivity measurement, it tends to be ignored due to the difficulty in obtaining the required disaggregated data.[2] This paper adjusts a short series of disaggregated data on hours worked to obtain a recent Irish measure of Irish quality-adjusted labour input. In doing so, it builds on the results of Durkan *et al.* (1999) who found that the increase in educational attainment raised the growth potential of output by just under 1.0 per cent per year over the first half of the 1990s, but only 0.5 percentage points over the 1970s and 1980s. Hamilton (2005) merged LFS and QNHS data avoiding the need for extrapolation based on census data and introduced wages for his consideration of the labour quality effect of the educational and age composition of the Irish population on employment, unemployment and the supply potential of the Irish economy. He found that between 1994 and 2003, a quarter of the decline in the unemployment rate and two thirds of the increase in the employment rate could reflect a rise in labour quality alone.

[1] Combined with a quality-adjusted measure of capital services (see for example Keeney, 2007), the measurement of quality-adjusted labour inputs will allow the estimation of multi-factor productivity.

[2] Ho and Jorgenson (1999) report annual indices of quality adjusted labour input for the US civilian workforce during the period 1948-95. Since 1993, the US Bureau of Labor Statistics has reported official series on quality-adjusted labour input. Some attempts have also been made in the UK (O'Mahony and de Boer, 2002; Card and Freeman, 2004) but the ONS has recently undertaken a project to study the viability of constructing official series.

Our paper extends these considerations of labour quality to 2008 and uses a flexible methodology similar to that used by the US Bureau of Labor Statistics. A Tornqvist index is constructed by aggregating micro-data evidence on the hours worked by worker groups differentiated by their educational attainment and other descriptive factors to capture quality differences. The Tornqvist aggregation has the useful property that changes in the quality of hours can be attributed separately to the detailed individual characteristics using partial indices. The worker group contributions are weighted by their share of the total wage bill, which is assumed to reflect the average product of each type of worker (assuming firms behave competitively in the labour market).

Our results show that quality-adjusted labour services grew on average by 3.5 per cent per year over the period 1999 to 2008, with 0.7 per cent per year of this due to compositional effects due to improvements in labour quality. Labour quality grew because there was a sustained increase in the share of those in the labour force with tertiary education. At the same time, the accumulation of employed persons of prime age (reflecting labour market experience) also features due to record low rates of unemployment in the economy. However, the labour quality component grew somewhat more slowly during the peak construction boom years of 2005-2007 as there was a rapid increase in the numbers of young construction workers with low levels of educational qualifications. Our calculations also show that, in 2008, labour services growth remained positive just as younger, lower skilled workers in this sector began to lose jobs, thus implying a more positive contribution from the labour composition effect.

The structure of this paper is as follows. Evidence on the changing composition of the Irish workforce is presented in Section II. The data required for the construction of a quality-adjusted labour data series and the method for labour quality adjustment are outlined in Section III. Estimates of quality-adjusted labour inputs and productivity are produced in Section IV where a Mincer model of the earnings-education relationship is used to derive the weights used in the aggregation of the Tornqvist labour services index. Section V presents the results on the new measure of labour services.

II EVIDENCE ON WORKER CHARACTERISTICS

A key labour quality indicator is provided by the average education achievement of the Irish workforce. Large-scale investment in education in Ireland began in 1967 and has led to a dramatic increase in the relative supply of skilled labour over the past four decades. Rising education levels and an open labour market meant that the labour force expanded and incomes rose rapidly in the 1990s. Bergin and Kearney (2007) show that a differentiation of the labour force according to education provided a significant enhancement to their structural model of Irish output determination. The labour quality index derived below employs a more comprehensive approach to assessing labour quality by encompassing more detailed demographic characteristics from micro-data sources.

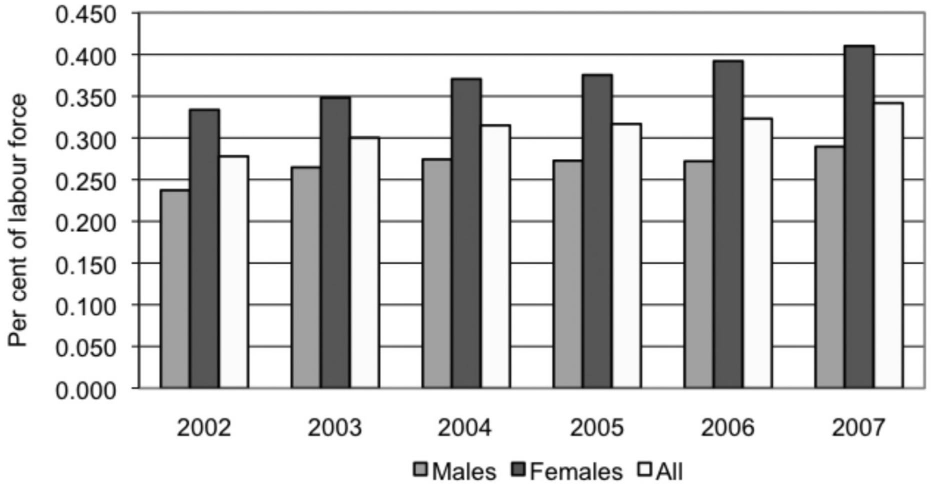
Skill is most likely to be related to educational attainment but could also include on-the-job training, work experience and general management ability. Educational attainment is often seen as a good indicator of human capital with the basic proposition that investment in education results in higher productivity and labour quality (OECD, 2001). A large body of evidence using micro-data has shown that investment in education does result in increased individual earnings, suggesting that the social return to education is also positive (Krueger and Lindahl, 2001). An approach to take educational attainment into account was pioneered by Jorgenson, Gollop and Fraumeni (1987) when they measured differences in labour quality (or skill) according to education and work experience. In this paper we employ an extended methodology developed by the US Bureau of Labor Statistics (BLS, 1993).

According to the Labour Force Survey (LFS), the precursor to the Quarterly National Household Survey (QNHS), persons with a third level qualification in 1994 constituted 15 cent of those in employment. Figure 1 shows that this proportion had almost doubled to 28 per cent by 2003 and by 2007 one in three of all those in the labour force had a third level degree or higher. The third level education figures also indicate a faster quality effect for females than males with the representation of males with third level qualifications increasing by five percentage points over the 6 year period, while the corresponding increase for females was 7.5 percentage points. This was compounded by the fact that the labour force participation rate for females with third level education increased by one point over the same period, compared with a half percentage point for males.

This increase in educational attainment suggests that we should find an increase in the quality of the labour input, all else being equal. It has been found that increasing labour quality in the US over the period 1948-95 contributed on average 0.59 percentage points annually to increasing labour services and that nearly all of this trend can be attributed to increasing levels of educational attainment (Ho and Jorgenson, 1999).

There are other factors, however, that may moderate any effect of an increase in average educational attainment. These may include age effects (the share of the workforce in prime age categories or the moderating effect of increasing younger or older cohorts) or a related work experience effect. A

Figure 1: *Persons Aged 15 to 64 Years in Employment (ILO status), with Third Level Education*



gender effect may be observed from increasing female participation, which tends to have more moderating effect if there is a tendency for females not to work full time or be concentrated in lower wage sectors. The following sections consider how these multivariate factors can all be taken into account when adjusting for labour quality.[3]

III METHODOLOGY

3.1 *Labour Composition Model*

Human capital theory relies on the use of labour composition models to quantify the contribution of different skills in the labour force to total labour inputs.[4] A quality-adjusted measure of labour input for the whole economy is implemented in two steps. A wage rate is derived to measure the average impact of skills on the wages of workers in a particular age-education-gender worker grouping (*aeg*). The wage rates derived are then used as weights to compile a new labour input index. The labour composition model is used

[3] Bergin and Kearney (2007), while proving the need to account for human capital accumulation in modelling aggregate labour input, did so with a two-way differentiation of the labour force into those who completed second-level qualification and those who did not. They did not account for other socio-demographic proxies of skill in their human capital index.

[4] Labour composition models are based on a general production function adjusted with quality-adjusted hours as the labour input.

within a growth accounting framework to measure the impact of changes in labour quality on aggregate labour inputs.

Following a standard production function,[5] the production process can be described as:

$$q = f(k_1, \ldots, k_n, H, A) \tag{1}$$

where q is output produced by n types of capital input K and a single type of labour input H. A represents total factor productivity. In this production function, labour inputs are assumed to be homogenous. In the standard model, there is no allowance for efficiency gains from improvements in labour quality.

To do so, the production function should allow for treatment of labour inputs with different characteristics and their unique contribution to output as follows:

$$q = f(k_1, \ldots, k_n, h_1, \ldots, h_m, A) \tag{2}$$

where $h_1, \ldots, h_m$ represent different labour inputs differentiated by quality.

Without any adjustment for improvements in labour quality or differentiation according to skill levels, the Solow residual of total factor productivity associated with equation (1) may give a biased measure of the true growth in aggregate productivity. The magnitude of the bias is proportional to the rate of change in the efficiency units per labour input and to the labour share in total production. It would be zero if per capita efficiency is constant over time.

3.2 *Accounting for Labour Composition*

A comparison of the quality-adjusted and unadjusted measures of labour input yields a measure of the corresponding compositional or quality change in the stock of labour. A change in the labour composition is the difference between the new aggregate labour input and the old labour input (hours worked at $t-1$). The compositional change (or any intangible investment effect) in labour quality (LQ) is expressed below as the change in the indices of the new aggregate labour input and the quality-unadjusted sum of hours worked:

$$\Delta \ln LQ = \Delta \ln \frac{L}{H} = \Delta \ln L - \Delta \ln H \tag{3}$$

[5] Here we follow a brief model developed by the US Bureau of Labor Statistics (BLS, 1993) with minor modifications.

where L is the latest measure of aggregate labour input which accounts for changes in quality. The variable H represents the simple summation of hours worked.

Labour is typically measured in full-time equivalents or with hours as the unit of account. We would prefer to have aggregate labour input measured by L and not H which is aggregate hours worked. In this way we can then refine the change in aggregate productivity over the period into that related to changed labour efficiency – refined labour inputs measured by changes in an index of labour services. However, data on usual and actual hours worked are the standard labour measures available and to measure labour services, usual hours worked must be adjusted accordingly by labour quality.

We proceed by constructing an index for labour services that takes into account the heterogeneity as per the different efficiency levels of different types of labour. As firms substitute among hours worked by hiring relatively more highly skilled and highly compensated workers, labour quality increases. When the quality of labour improves ($\Delta \ln LQ > 0$) it has an effect of reducing the Solow residual productivity with other factors held constant. A deterioration of labour quality ($\Delta \ln LQ < 0$) has an effect of increasing Solow productivity with other factors held constant.

If the efficiency of one unit of labour is related first and foremost to the educational achievement of a worker, the model suggests that efficiency cannot be taken as constant over time. To obtain an indicator of the quality of labour input, we can compute (e.g. U.S. Bureau of Labor Statistics, 1993, p.13) – a Tornqvist index,[6] whereby the annual rate of growth in the quality of the labour input is Δe_t defined as:

$$\Delta e_t = \sum_{m=1}^{n} \frac{1}{2} \left(\frac{w_{m,t} E_{m,t}}{\sum^{n} w_t E_t} + \frac{w_{m,t-1} E_{m,t-1}}{\sum^{n} w_{t-1} E_{t-1}} \right) (\Delta e_{m,t} - \Delta H_t) \tag{4}$$

where $E_{m,t}$ is the number of persons with school level m in year t and E_t is the total labour force. $\Delta e_{m,t} = \Delta \log E_{m,t}$ is its rate of growth and $w_{m,t}$ is the valuation of school level m in year t. The index calculated according to equation (4) is a chained one reflecting year-on-year changes. It is not affected by the selection of an appropriate base year for comparison as the base moves with each subsequent year's data.

[6] Diewert (1976) showed that a change in output modelled by a translog production function can be represented by a Tornqvist index.

The value of the quality effect of each year it takes to achieve a level *m* of schooling would mean that the efficiency differentials between educational levels are substantial as it takes 10 years on average to achieve a lower secondary qualification compared with 18 years for a third level qualification on average, from the time a person starts school. Any adjustment method based solely on years of schooling would be quite restrictive as a university graduate is presumed to be *exactly* 80 per cent more productive than a person who achieved lower secondary education only i.e. 18 years compared with 10 years. These values are much higher than the estimated returns to education calculated by e.g. Barrett *et al.* (2002), which were in the order of 5-6 per cent more per year at school. Where wages reflect productivity, the differential between a graduate and a person with a junior certificate should vary from 50 to 60 per cent. Thus approximating skill with years at school incurs the risk of overestimating the contribution of the quality-adjusted input.[7] For this reason, we employ dummies for educational qualifications and not years of schooling. Further, in addition to education, there are other socio-demographic characteristics which can be considered as extensions to this framework including age and gender to classify workers by labour types into *aeg* groups – age, education and gender.

3.3 *Data Requirements*

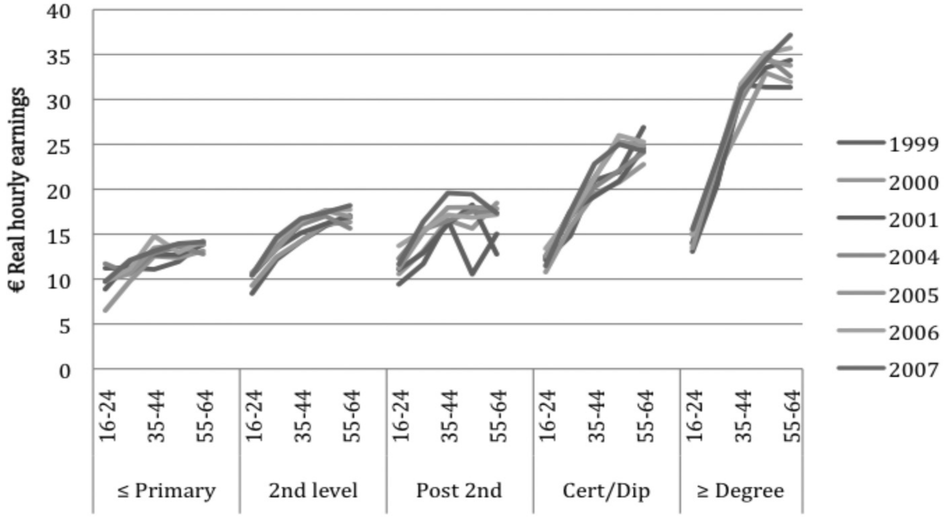
Micro data which distribute the number of total hours across different *aeg* types, by individual year are required for our labour quality adjustment. In addition, quantity measures of labour input have to be accompanied by wage per hour measures (relative average compensation) to construct weights for the Tornqvist aggregation. There is no single source of Irish labour force data giving individual wage rates *as well as* industry classification, hours worked, education, and other characteristic data affecting labour input such as sex, age, occupational class. We must resort to linking wage data from the Household Budget Survey (HBS) and other non-wage descriptive data from the Quarterly National Household Survey (available with education only from 1999).[8] In order to have common categories of labour by level of education across the two data sources, 48 *aeg* groupings were set from 4 educational levels, 6 age categories and gender. The educational classes used are: no formal/primary education only, lower secondary, upper secondary and sub-degree third level, 3rd degree level +. Age categories are <25, 25-34, 35-44, 45-54, 55-64 and 65+ years.

[7] Thereby reporting a lower level of *A* – TFP that would be more accurate.

[8] Micro data files from 1998 to 2008 were received from the Irish Social Science Data Archive at the Geary Institute, UCD. The QNHS provides actual and usual weekly hours worked for approximately 70,000 individuals on a quarterly basis. The Q2 each year microdata allows a classification by educational group as well as age category and gender.

HBS data are not available on an annual basis. Barrett *et al.* (2009) document real hourly earnings of native Irish employees by education and age categories from 1999 to 2001 Living in Ireland Surveys and 2004 to 2007 EU-SILC Surveys and these show that the wage structure did not change over time across education and age groupings (Figure 2). For our analysis, we assume that relative returns to individual characteristics, such as labour market experience hold over the period and can be represented by the latest HBS data available (2004/5).[9] Further, other empirical evidence for European countries suggest that returns to skills are more stable in the Euro Area than in other economic areas (Schwerdt and Turunen, 2007).

Figure 2: *Stability of Wage Structure Over Time by Education and Age (Experience) Categories*



Source: Derived from Barrett *et al.* (2009).

IV LINK BETWEEN WAGES AND PRODUCTIVITY

4.1 *Wages as Marginal Revenue Product of Labour*

Firms are assumed to combine all inputs including labour into the production process efficiently such that their marginal cost exactly equals the marginal product generated. Based on such a model of competitive labour

[9] It was fortunate that the Household Budget Survey falls towards the middle of the period under study (1999-2008). See Appendix Table 2 for detail of the earnings indices used to introduce a time varying dimension to the micro-level HBS wage estimates.

markets, worker groupings with higher productivity should receive higher compensation i.e. relative wages are equal to the relative marginal product of labour. Various characteristics of actual labour markets such as discrimination, union bargaining, signalling and mismatch, may result in violations of this assumption. However, due to lack of more direct measures, wages remain the best available proxy of worker productivity.[10]

The calculation of aggregate labour inputs based on a Tornqvist index depends on the availability of data on the share of total labour compensation for each worker group (s_{aeg}). Two methods can used to estimate these shares $\left(\sum s_{aeg} = 1\right)$.

The first method known as the average wage approach is easy and straightforward, especially if detailed wage and labour data are available from the same source and across time. It uses the average wage of each type of worker. Simple cross-classifications of key socio-demographic variables are extracted and average hours and wages are calculated for the selected worker groups. The wage bill for each group is calculated by taking their average hourly wage and multiplying by the average number of hours worked by that type of worker. Dividing by total labour input gives the share of labour input that is equivalent to the wage bill share. These data do not readily exist for Ireland, as remuneration data are not collected by the QNHS, which would give the best labour force descriptives over time.

4.2 *Estimation of Average Wage Model*

Alternatively, we can use econometric techniques to fit an earnings function or wage model to derive an estimated wage rate for each type of worker. Following previous literature in calculating the relevant hourly wage, we focus on usual hours worked instead of actual hours worked during the period corresponding with the gross wage period recorded. Compatible with the human capital theory, variables such as formal education, age, potential work experience, gender etc., can be modelled effectively without necessarily having all the data coming from the same data source. The growth rate of total, quality-adjusted labour input H would be measured below as h_{aeg} which stands for a particular type of labour (classified by age, education, gender and potential work experience).

Within the Tornqvist index, the total economy labour-quality adjusted labour input must be aggregated up from the 48 *aeg* worker groups using the appropriate s_{aeg} weight. Marginal productivity reflected in wages is assumed to reflect the differential efficiency of each of the worker groups. It is necessary

[10] Ho and Jorgenson (1999) discuss the potential effects of non-wage variables in detail.

to derive the average estimated wage for each *aeg* group. The key variable to derive skill-dependent wage differences (reflecting different productivity levels) is assumed to be education as per the human capital hypothesis. A survey of the literature indicates that Mincer's (1974) formulation of a log-linear earnings education relationship works well. However, additional controls for known wage differential factors including gender, age, work experience (defined as age minus years of completed schooling minus minimum school age[11]) can be included in the Mincerean wage model (BLS, 1993):

$$w_{aeg} \equiv \left(\sum_{aeg}^{N} \ln W_{ij} = a + bS_i + cX_j - dX_j^2 + fZ \right) / n_{aeg} \tag{5}$$

Logged wages W_{ij} is a function of i years of schooling or the ith level of educational attainment, j years of work experience X and other traits Z including age category. Second order X reflects diminishing returns to work experience as per a standard shaped earning profile. The intercept a can be interpreted as the starting wage. The remaining coefficients (b, c, and d) represent returns to education and work experience as per human capital theory. n is the number of workers in each *aeg* group.

Using Household Budget Survey (HBS 2004/5) microdata for individual workers, we estimate equation (5) separately for males and females. The dependent variable is the log of hourly gross wage based on usual hours worked. The use of gross wages is motivated by the use of the labour quality estimate primarily as an input to productivity analysis within a growth accounting framework (OECD, 2001). The independent variables are education (5 categories), age (6 categories), potential experience and its square to capture non-constant marginal returns due to the lifecycle effect.[12]

The results illustrate that in the calculation of labour quality, the hours of those with at least a third level degree will be given a larger weight than the hours of those with only secondary and/or primary education. In addition, the

[11] An additional adjustment is made to the potential experience variable for (notional) absence from the labour force by women with children. As post-school training is difficult to measure, the literature suggests using years of work experience as a proxy measure. The length of work experience (which may be imperfectly proxied by age) may be positively correlated with human capital because people improve their skills by working. However, a younger workforce with a lower average work experience might be more innovative and hence more productive.

[12] Barrett *et al.* (2008) found evidence that immigrants, particularly those from the new Member States of the EU, experience a significant pay gap compared with native Irish workers. It is especially pronounced for those with higher educational attainment. This was tested in our regression but found to be insignificant in our model results. This may be a sampling bias within the HBS data source which under-represents the immigrant community.

Table 1: *Aggregated Coefficient Estimates – w_{aeg}*

	Male		*Female*	
Age 15-24 years	–0.22	**	–0.34	***
Age 25-34 years	0.13	**	0.13	***
Age 45-54 years	0.22	***	0.23	***
Age 55-64 years	0.34	***	0.24	***
Age 65+ years	0.25	*	0.23	*
Primary	–0.25	***	–0.46	***
Junior Certificate/equivalent	–0.10	***	–0.26	***
3rd Level	0.15	***	0.17	***
3rd Level Postgraduate	0.40	***	0.55	***
Potential experience	0.02	*	0.02	**
Lifecycle effect	–0.00	**	–0.00	***
Constant	2.57	***	2.66	***

*** Significant at 1 per cent level, ** Significant at 5 per cent level, * Significant at 10 per cent level.
Note: Age 35-44 years and leaving certificate or equivalent education are the reference categories. Wages are logged.

results show that in line with previous evidence earnings generally peak with the prime age category (35-44 years) and with women's wages suffering more of an age penalty in age categories older than 44 years. These results should not be interpreted as providing an exact measure of the causal effect of education on earnings in Ireland. For example, the equation does not take into account the possible impact of unobservable individual characteristics on the returns to education. However, for the measurement of average labour quality the exact causal effect of education on individual earnings is less relevant than arriving at a good proxy for the aggregate impact of increased education on human capital.[13]

To introduce a time-varying element to the estimated hourly wage rates by *aeg* grouping, an appropriate earnings index can be applied to the cross-sectional 2004/5 HBS estimates. An attempt was made to make the earnings index as refined as possible by referring to the occupational status (manager, clerical, managerial and clerical) and broad economic sector (one-digit NACE code) where individuals work.[14] In most cases information will be provided by the CSO Earning and Employment Survey, which can be used to derive the appropriate earnings indices. Data on sectoral earnings are available from

[13] Card (1999) undertakes a good survey of the returns to education literature and has an in-depth discussion of the measurement difficulties relating to measuring the causal effect of education.
[14] See Appendix Table 2 for details of earnings indices applied.

CSO statistical releases on Earnings and Hours Worked in Construction; similar for Financial Intermediaries, Business Service and Distribution sectors; earnings of agricultural workers and details of hourly rates for those employed in the public sector. In each case, we set 2005 as the base year (2005=100) to correspond with the HBS wage rates per *aeg* category and index the estimated wage rates forwards to 2008 and backwards to 1998 according to the appropriate earnings index.

V LABOUR INPUT MEASURES

5.1 *Hours Worked*

We use data from the Quarterly National Household Survey (QNHS) to construct measures of hours worked for the detailed worker groups. Total hours worked have been calculated for different age-education-gender groups annually from the QNHS using information on employment and usual weekly hours. These will be weighted to represent the entire labour force situation. Full information on the detailed *aeg* groups are extracted on an annual basis (Quarter 2) from 1999 to 2008 inclusive.

The growth rate of aggregate labour inputs must be adjusted for quality to show the sum of the individual developments for each labour type weighted by the labour type's share in total labour compensation. In this study we use a chained Tornqvist formula to produce the labour input index number for each period:

$$\ln T_t \equiv \Delta \ln L = \frac{1}{2} \sum_{aeg} (s_{aeg,\, t-1} + s_{aeg,\, t}).\ \ln \frac{H_{aeg,\, t}}{H_{aeg,\, t-1}} \tag{6}$$

where $s_{aeg,\, t}$ and $s_{aeg,\, t-1}$ represent the weights for the current period and the previous (base) period. As time increases by one period, so too do the current and previous period's weights. Thus, the resulting index is linked through successive base periods.

We use the predicted wages $\widetilde{W}_{aeg}$ based on coefficient estimates from equation (1)[15] to construct weights for each worker group *aeg* as the share of each worker group in total compensation year 2004/5 when the HBS data were collected. The share is given by:

$$s_{aeg} = \frac{\widetilde{W}_{aeg}\ H_i}{\sum_{aeg} \widetilde{W}_{aeg}\ H_i} \tag{7}$$

where H refers to total (usual) hours worked by individual i.

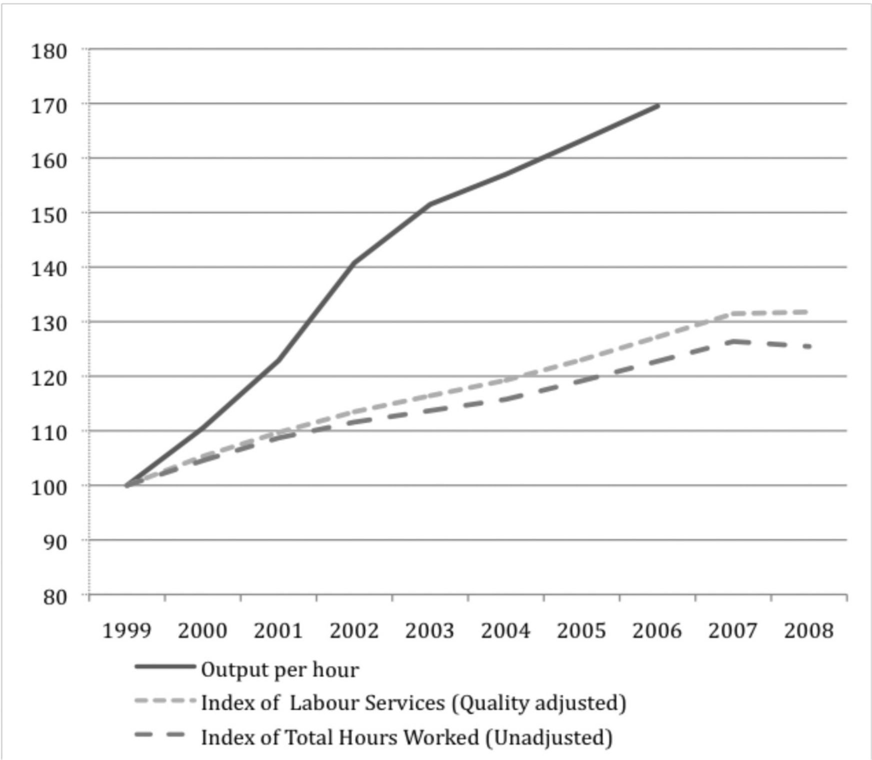
[15] Results are shown in Appendix Table 1.

Using QNHS data the change in Irish aggregate labour input is calculated according to equation (6) where $\Delta \ln L$ represents the first difference of logged aggregate labour, which is derived as the difference of logarithms of usual hours worked by category groups between time t and $t-1$ weighted by chained $\bar{s}_{aeg}$, the average value contribution of the *aeg* worker group labour input in total labour cost.

5.2 *Comparison of Labour Productivity Indices*

In this section we compare the new quality-adjusted labour input with traditional measures of labour productivity. Figure 3 shows a comparison of the index of labour services (quality-adjusted aggregate labour) T_t and output per hour together with an index showing the increase in total hours worked. The comparison shows that the quality-adjusted labour index increases at a lower rate than the current labour productivity index. From 1999 to 2006, the latest year for which CSO data is available, labour productivity increased from 100 to 122.7. For the same period, output per hour not adjusted for quality increased to 169.5.

Figure 3: *Comparison of Labour Indices*



5.3 *Labour Composition*

A useful feature of the Tornqvist index is that it allows the calculation of the separate contributions to the growth in quality-adjusted labour input of each of the characteristics considered. Movements in labour quality is decomposed into changes in the composition of each worker group (n_{aeg}) and changes in the average hours worked by each type of worker (h_{aeg}) (Hamilton, 2005).

$$\Delta \ln L_t = \sum_{aeg} s_{aeg} * \left[\ln\left(\frac{n_t^{aeg}}{n_{t-1}^{aeg}}\right) - \ln\left(\frac{N_t^{aeg}}{N_{t-1}^{aeg}}\right) \right] + \sum_{aeg} s_{aeg} * \left[\ln\left(\frac{h_t^{aeg}}{h_{t-1}^{aeg}}\right) - \ln\left(\frac{H_t^{aeg}}{H_{t-1}^{aeg}}\right) \right] \quad (8)$$

This decomposition captures the change in labour input that is not attributable to a change in hours worked. That is, the growth in labour services as a result of an increase in the skill (education or experience) of the workforce is forced to be neutral for the purposes of isolating how a change in labour composition affected the overall level of labour services. The labour composition effect is derived as the growth in labour input (services) minus the growth in hours worked and it represents the gap between the existing labour inputs definition and the quality-adjusted labour inputs.

Table 2 shows the changes in labour composition. The quality adjusted labour input (labour services) is derived using the estimated wage equation method. During the entire period hours worked increased by 25.5 per cent

Table 2: *Decomposing Changes in Quality-Adjusted Labour Services*

Year		*Decomposed into:*	
	Growth Rate of Labour Services	*Labour Quality Component*	*Aggregate Hours Worked*
1999-2000	5.3	0.8	4.5
2000-2001	4.4	0.2	4.2
2001-2002	3.8	0.9	2.9
2002-2003	2.9	0.8	2.1
2003-2004	2.8	0.8	2.1
2004-2005	3.7	0.4	3.4
2005-2006	4.2	0.6	3.6
2006-2007	4.3	0.6	3.6
2007-2008	0.3	1.2	–0.9
Cumulative (1999-2008)	31.8	6.3	25.5

while labour services is calculated to have exceeded this at 31.8 percentage points. This translates into a labour quality enhancement effect of 6.3 percentage points and reflects the relationship between the increase in economic activity (i.e. increased labour hours) and the flow of labour services accounting for the human capital or skill of the accumulated workforce.

These results report a consistent rate of growth in the quality of the Irish labour force which is very similar to rates reported by Schwedt and Turunen (2006) for the EU on average. The results were expected a priori given the increasing proportion of workers with higher education (Figure 1). Nonetheless, the rate of growth in the economy's human capital moderated after 2004. This tends to happen in times of excess labour demand and confirms reports of skill shortages. Coupled with this, during the construction boom years, there was an increase in employment among lower skilled worker groups. This may have moderated the growth in the average skill and quality-adjusted labour productivity of the labour force.

In the last year of the analysis, total hours worked in the economy declined by 0.9 per cent as the unemployment rate increased. Despite this, labour services growth remained positive and the skill set of the aggregate labour force continued to increase. This indicates that worker groups with a lower weighting in labour services terms have a higher probability of unemployment as the economy goes into decline.

Table 2 indicates the superiority of the labour services volume measure, which accounts characteristics of heterogeneous worker groups, as the appropriate indicator of aggregate labour input for the purposes of charting labour and total factor productivity. Labour services, as a measure of the accumulated stock of human capital, captures more labour-specific embodied productivity that would have previously been captured through mis-measurement by the TFP residual. Employing this labour services volume measure of aggregate labour input will have the effect of reducing the traditional TFP residual, all else equal, when used in a multifactor growth accounting exercise.

5.4 *Partial Indices by Education, Age and Gender*

Following Ho and Jorgenson (1999), a detailed breakdown of individual worker characteristics is possible – according to a first-order partial index by characteristic *aeg*. For example, the first-order education index would refer to workers with education category *e* and ignores substitution among the other characteristics of gender and age group. There are as many partial volume indices as characteristics considered in calculating the labour input (in this case three). The partial index of the volume of labour services according to education is:

$$\Delta \ln L_t^e = \sum_e \bar{v}_e \, \Delta H_e = \sum_e \bar{v}_e \, \Delta \ln(\sum_a \sum_g H_{aeg}) \tag{9}$$

where $\bar{v}_e = \frac{1}{2}\left[v_{e,t} + v_{e,t-1}\right]$ and $v_e = \sum_a \sum_g v_{aeg}$.

Following on from the partial volume index, the contribution of the growth of labour quality by changes in the composition of hours worked by age, education and gender characteristics defined as:

$$\Delta \ln Q^e = \Delta \ln L^e - \Delta \ln H \tag{10}$$

Similarly, the rate of growth of the second-order contribution of each pair of characteristics of individual workers as the difference between the rates of growth of the corresponding partial index of labour input and hours worked, less the sum of the growth rates of the two first-order contributions. For example, the second-order contribution of education and gender takes the form:

$$\Delta \ln Q^{e,g} = \Delta \ln L^{e,g} - \Delta \ln L^e - \Delta \ln L^g - \Delta \ln H \tag{11}$$

This index reflects the impact of changes in the composition of hours worked by education and gender on the growth of labour quality, excluding the first-order effects of these characteristics. However, in most cases, the first-order partial indices account for most of the variation in the total index (Ho and Jorgenson, 1999).

Education Impact

As a proxy for skills, qualifications either act of as a signal of ability to employers or they provide a competency for specific job requirements. Due to the increasing prevalence of third level degrees and their growing association with higher pay, educational attainment is found to have had the greatest impact on labour quality. The strongest growth in hours worked occurred, consistently, for those with higher levels of education which are also confirmed in the data to be the highest paid groups. This has been further strengthened by the fact that the group with the lowest marginal product (as measured by wage per hour), those with less no formal educational qualifications/primary education only, experienced a reduction of 11 per cent in the number of hours contributed to aggregate hours worked over the period. Next, those with a lower secondary qualification reduced their contribution by 3 per cent between 1999 and 2008 while those with a third level degree or higher accounted for 37 per cent of aggregate employment in 1999 which by 2008 had increased to 49 per cent. The partial contribution results from Table 3 confirm the above and indicate that of the cumulative growth in labour quality between 1999 and 2008 of 6.3 percentage points, education could account for close to two-thirds of this enhancement in human capital. Lau (2002) also showed for the UK that educational attainment is the main contributor to labour quality while age and gender effects have a smaller role.

For the last year of the period under study, aggregate hours declined as unemployment began to increase economy wide. Those with third level education were the least affected of all the educational groups and explain how the level of quality-adjusted labour services of the workforce continued to increase despite a decrease in aggregate labour (unadjusted).

Age Impact

Age was included in our analysis as a proxy for work experience. Although imperfect, as it takes no account of periods of unemployment or inactivity, the assumption is that older workers tend to be more productive due to their greater experience. Further, the survey data confirm that hourly wage rates increase with age. However, the human capital contribution of the age distribution of the workforce is less significant when compared with the general upskilling of the labour force as measured by education.

Some observations worth a mention relate to a sharp fall in the hour share of 16-24 year olds, from 18.6 per cent in 1999 to 13.1 per cent in 2008. As this group of workers are counted as least productive according to their hourly wages (35-44 year olds earned 57 per cent more in 2008), this phenomenon did not make a large impact in the overall human capital measurement. A second observation relates to an increase in the total hours' share of older workers (in categories close to and past retirement age). The share of those aged 55 years and older increased from 8.6 per cent in 1999 to 11.7 per cent in 2008. These workers tend to have wage rates above the average rate because they are more experienced, and hence more productive. Furthermore, the wages of the most productive age group (35-44 year olds) relative to the least productive group rose from 1.51 to 1.57 between 1999 and 2008 (driven by the earnings index applied). However, these redistributive effects were not significant to the overall labour quality measure due to the fact that the peak productive age group did not disproportionately increase their share of total hours worked during the period.

Two factors can explain why adjusting labour quality for age is nonetheless important. First this was a period of rapid labour force growth, led by a positive rate of inward migration. This in turn tends to be concentrated in the younger cohorts and may or may not imply a more experienced workforce. Second, more people are remaining in education rather than joining the labour market after school. This has reduced the pool of young

Table 3: *First Order Partial Contributions to Overall Growth in Labour Quality*

Year	*Labour Quality*	*First Order Partial Contributions:*		
		Age	*Education*	*Gender*
1999-2000	0.8	0.0	0.7	0.1
2000-2001	0.2	0.1	–0.1	0.2
2001-2002	0.9	0.3	0.4	0.3
2002-2003	0.8	0.2	0.6	0.1
2003-2004	0.8	0.1	0.6	0.1
2004-2005	0.4	0.0	0.3	0.1
2005-2006	0.6	0.0	0.4	0.1
2006-2007	0.6	0.1	0.5	0.1
2007-2008	1.2	0.4	0.8	0.0
Cumulative (1999-2008)	6.3	1.1	4.1	1.1

workers in the economy and so contributed to the significant fall in the hours share of 16-24 year olds from 1999 to 2008. The decline in hours worked in the last year of the analysis period was concentrated in the younger age groups and was probably driven by the downturn in the construction sector in particular. This is confirmed in Table 3 which shows that for this 2008, age made a disproportionately higher contribution to the labour quality increase despite an economy-wide reduction in the total hours worked.

Gender Impact

The Tornqvist index that is used to derive labour quality assumes that workers are paid their marginal product and makes no allowance for any discrimination that may exist in the market. Adjusting labour input for gender composition indicated that gender had a positive effect on the growth of labour quality in the period 1999-2008. It is important to note, however, that this result simply reflects the relative wage levels of men and women in the labour force and may proxy hidden characteristics such as an increased tendency by women to take career breaks or to fulfil part-time posts that are not as well paid.[16] Throughout our analysis period there was an increase in the participation of women in the labour market from 43.5 per cent in 1999 to 46.3 per cent in 2008. However, their share of total hours worked has not increased by the same proportion while their wage-bill share grew from 37.6 to 43.2 per

[16] This however cannot be tested using Irish data, as information on lifetime employment does not exist.

cent reflecting a narrowing of earning differentials between males and females but also an increase in the labour quality attributable to the increased female participation, all else equal.

An explanation why women despite working fewer hours than men tend to increase the labour quality index is that, on average, they are better educated and tend to be attracted to service and public sectors where average wages are higher. The second-order partial index of labour services by gender and education reveals that there was no discernible differentiation between men and women at the higher educational levels.

VI CONCLUSION

This paper has empirically examined the change in labour productivity during the period of the "Celtic Tiger". This period was characterised by a large expansion in the total Irish labour force and also a significant change in sectoral employment composition due to an unprecedented boom in employment in the construction sector. The standard measure of the total economy's labour input is to aggregate the number of people employed. A related measure of labour inputs is to aggregate the number of hours worked by each person in the economy. Both of these labour measures assume that all workers in the economy are equally productive. The results in this paper show that in order to achieve a more accurate measure of the total labour input, such standard labour input indicators must be adjusted for labour quality. A quality-adjusted volume measure of labour services in the Irish economy was derived for the period 1999 to 2008.

Our results confirm that the increases in human capital are driven primarily by tertiary education with positive additional contributions from accumulated labour market experience and increased female participation in the labour market. There was a sustained increase in the share of those with tertiary education and in the share of workers of prime age during the Celtic Tiger era of Irish history. In the last year of the newly calculated labour quality series, the rate of growth in labour quality remained positive despite a fall in the total hours worked in the economy. This is partly due to returns to past investment in education as well as a readjustment seeing the share of lower-skilled workers declining sharply and inexperienced younger people finding it more difficult to get established in the labour force.

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APPENDIX

Appendix Table 1: *Average Estimated Hourly Wage Rate (€/hour) – HBS Regressions*

Age/Education Grouping	*Male*	*Female*
<25; Primary Education	–	6.07
25-34; Primary Education	11.42	8.73
35-44; Primary Education	12.33	9.90
45-54; Primary Education	11.71	9.90
55-64; Primary Education	12.46	9.59
65+; Primary Education	11.35	9.50
<25; Lower Sec Education	10.13	7.48
25-34; Lower Sec Education	13.29	10.96
35-44; Lower Sec Education	14.71	12.84
45-54; Lower Sec Education	14.45	12.68
55-64; Lower Sec Education	14.59	11.70
65+; Lower Sec Education	13.30	11.57
<25; Higher Sec Education	10.86	9.98
25-44; Higher Sec Education	14.59	14.84
25-44; Higher Sec Education	16.42	16.94
45-54; Higher Sec Education	16.10	16.91
55-64; Higher Sec Education	16.30	15.34
65+; Higher Sec Education	14.67	15.04
<25; 3rd Level Education	12.35	11.65
25-34; 3rd Level Education	16.99	17.99
35-44; 3rd Level Education	19.62	20.30
45-54; 3rd Level Education	19.95	20.26
55-64; 3rd Level Education	18.92	18.35
65+; 3rd Level Degree Education	17.03	17.76
<25; Postgraduate Education	15.72	15.95
25-34; Postgraduate Education	21.19	25.55
35-44; Postgraduate Education	24.15	29.87
45-54; Postgraduate Education	25.02	30.62
55-64; Postgraduate Education	24.99	27.37
65+; Postgraduate Education	22.04	26.23
Overall	15.88	16.19

Source: Predicted wage rates per *aeg* category based on HBS 2004/5. Observations were excluded where usual hours were 0 or greater than 80 per week.

Appendix Table 2: *Earning Index Applied to HBS Hourly Wage Estimates (2005=100)*

NACE	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*
A	84.3875	84.6294	75.3653	82.9786	83.3120	78.5492	80.1216	84.2960	100	89.2353	99.1468	88.4704
C	66.0002	66.6069	69.7849	72.7173	77.1315	91.0052	89.8185	97.4497	100	96.9138	102.989	105.473
D	65.3536	68.7988	72.5404	77.9856	84.4749	87.4207	92.6115	97.0871	100	101.938	107.901	115.039
E	55.3326	59.2971	59.9784	63.9605	65.0167	83.7789	90.8670	97.7304	100	108.837	110.185	111.778
F	50.2599	56.2681	58.9254	66.0889	74.2923	81.4558	88.2149	91.7966	100	99.8844	106.643	109.358
G	60.6909	64.2168	59.0361	69.8795	75.3012	90.7228	106.987	118.554	100	111.084	103.253	123.734
H	65.1715	68.6974	73.3188	76.0426	81.6769	82.3118	88.1061	94.3293	100	103.717	107.689	111.573
I	70.3197	73.8455	75.9590	79.2493	86.5621	89.3013	91.5201	98.9355	100	106.413	113.479	118.155
J	67.8567	71.3826	74.3016	79.1075	84.7306	86.9014	90.7442	96.8912	100	104.686	110.604	113.694
K	52.7681	56.2940	59.6105	64.1791	69.2702	79.2077	84.1499	92.8964	100	107.217	114.276	113.558
L	62.3993	64.7260	68.6526	70.9128	79.0956	82.7771	86.2221	94.5205	100	106.226	110.233	114.681
M	66.3701	67.9657	71.3099	73.4222	80.0782	82.4157	87.4507	92.8643	100	102.822	108.145	109.730
N	63.5548	63.3390	69.6924	71.8506	80.3928	84.9512	87.9624	95.6093	100	107.429	108.173	116.606
O	62.2936	65.8195	69.6462	74.8741	81.1718	85.6249	92.1031	96.7998	100	103.003	108.296	109.248
Adjustment by occupational group = earnidx(1+occidx/100)*												
Clerical & Managerial	2.244	2.490	2.597	1.902	2.026	1.658	0.195	–0.177	–	–0.078	–1.458	–1.458
Clerical	0.899	1.148	3.031	3.838	1.199	2.097	–4.902	–5.570	–	–2.131	–3.369	–3.369
Managerial	3.166	3.322	1.754	0.125	1.718	0.950	0.266	0.024	–	0.400	0.226	0.226

Notes: Occupational level earnings index not available for 2008 so 2007 adjustment repeated.