THE IMPACT OF THE GENDER WAGE GAP ON THE AUSTRALIAN ECONOMY DURING 1990-2008[1]

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The persistence of the gender wage gap in Australia and overseas has been the subject of much research. However, few if any studies, and none for Australia, provide a comprehensive and detailed account of the impact of the gender wage gap to economic growth. This paper seeks to provide such an account. Using growth modelling techniques based on 1990-2008 data, we find that the gender wage gap has a substantial effect on Australia's economic performance, measured in terms of GDP per capita, and that the value of reducing the gap is substantial. A decrease in the gender wage gap of 1 percentage point from 17 per cent to 16 per cent is expected to increase GDP per capita by 0.5 per cent of total GDP, assuming that the Australian population is held constant. The results also indicate that eliminating the whole gender wage gap from 17 per cent to zero, could be worth around $93 billion or 8.5 per cent of GDP.

1 INTRODUCTION

The gender wage gap in Australia and overseas has been the subject of much research and government policy. In Australia, for example, important legislative changes, including the Commonwealth Conciliation and Arbitration Commission's 1969, 1972 and 1974 judgements in relation to the principle of equal pay for equal work and work of equal value, were important milestones in relation to wage discrimination and women's quest for equality (see Pocock 1999 for a review of relevant policy, legislative and practice developments). Increasingly, however, gender inequalities are being recognised as problematic not just in terms of equity and social justice, but also economically. Worldwide, feminist economists have been increasingly arguing for recognition of the importance of gender issues for the achievement of macroeconomic objectives (Cagatay *et al* . 1995). One key issue identified by such researchers has been the likelihood that gender differences in earnings (that is, the gender wage gap) can hinder an economy from achieving its macroeconomic objectives, and can be considered a cost to the economy (Cavalcanti and Tavares 2007).

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Little is known, however, about the costs to the economy of a sustained gender wage gap or indeed the value, in terms of macroeconomic benefits, of reducing the gap. Literature examining the impact of gender inequality on macroeconomic outcomes has more frequently focused on gender equality in education (e.g. Barro and Lee 1994; Barro and Sala-i-Martin 1995; Hill and King 1995; Klasen 1999; 2002; Dollar and Gatti 1999; Lagerlof 2003; Dowrick 2003), and less often on the gender wage gap . However, a small but growing body of international research (see for example Seguino 2000; Walby and Olsen 2002; Cavalcanti and Tavares 2007; Caro 2008) has begun to focus on the potential impacts of the gender wage gap on economic growth. Such work extends arguments about wage equality beyond issues of gender equity, and instead considers the implications of gender wage gaps for a society's economic performance. Dowrick (2003) is the only study that discusses the probable impact of gender inequality in on economic growth in Australia but the focus of his study is to evaluate the role of education (rather than wages) in Australia's long term income per capita and its growth.

This study follows on from this earlier work and examines the impact of gender wage gaps on Australia's economic performance. In this study we use gross domestic product (GDP) per capita as the best measure of economic performance (Mankiw 1997). GDP per capita is a better measure of the economic well-being of a country than total GDP, as it takes into account population size – very populous countries may have very large overall GDP, but when divided by population size the resultant GDP per capita figure will give a much clearer indication of the country's comparable wealth. While GDP is widely accepted as a measure of economic growth, it should nevertheless be noted that such a measure excludes the value of women's activities at home – that is, unpaid work such as looking after a household and family (Klasen 1999;2002), as these activities are not included in national accounts data. The exclusion of this unpaid work means that we are undervaluing women's total economic contribution (Klasen 1999; 2002).

We use data from a variety of Australian Bureau of Statistics sources. The variables we include in the model (along with a measure of the gender wage gap) are those common to macroeconomic analysis of the kind being undertaken here. They are GDP, investment, human capital, fertility, labour participation and hours worked. Issues related to data availability (common in single country studies where data points may be limited) have affected both our modelling approach and our results. In macroeconomic modelling, the longer the time period of data available, the more likely that such a time span smooths out the ups and downs of the business cycle. As one of our key variables – human capital – is only available from 1989 onwards, we are able to include only 20 data points in our analysis. However, we are able to test and adapt our model to address the issue of a relatively short span of data. Nevertheless, these data limitations should be kept in mind when interpreting our results.

Following this introduction, we describe the empirical model and the database used in our modelling, including details of our rationale for choosing particular variables and data (including issues of data availability), and the characteristics of the data. We then describe our estimation procedure, and present detailed results. Finally we discuss how we come up with an estimation of the total impact to the Australian economy of the gender wage gap, including details about the limitations of our modelling.

2 THE EMPIRICAL MODEL AND VARIABLES

2.1 The Growth Model

The empirical model used in this study is developed based on the basic growth model, developed by Solow in 1956. In particular, this empirical study follows Barro (1991) whose work pioneered growth regression developments in order to produce an endogenous growth model that could be applied empirically, abandoning the structure of the theoretical model and using one linear model to ascertain which variables actually determined growth according to the data. There are several different growth empirical models that have been used to examine the impact of particular socio-economic factors on economic growth (Durlauf *et al.* 2004). The model in this study was built based on the structure that is offered by Mankiw *et al.* (1992). The main reason for using this model is that, as we later reveal, we were not able to use the capital stock variable as it is not stationary in either a level (original) form or a first difference form. The Mankiw *et al.* (1992) model transforms the model so as to be able to use investment instead of capital in the form of:

$$Ln\frac{Y_t}{L_t} = Ln(A_t) + \beta_1 Ln\left(\frac{I_t}{Y_t}\right) + \beta_2 Ln(h_t) + \beta_3 Ln(n_t) + \varepsilon_t \qquad (1)$$

where A is Total Factor Productivity (TFP), Y is output (GDP), I is physical capital accumulation or investment, , L is labour[2], h is human capital level (proxied by the proportion of population with non-school qualifications) and n is population growth (proxied by the fertility rate) and t is the time period.

Following Seguino (2000), who estimated the impact of gender wage inequality to economic growth for semi-industrialized export-oriented economies, the technological or TFP change is constructed to capture the direct impact of the wage gap and therefore, is formulated in the form of:

$$A_{it} = C_i(1+\phi t)e^{\sigma_0 Wgap_t} \qquad (2)$$

where C_i is a country-specific variable which in our case should be constant because we only use one country, ϕ is the time effect and Wgap is the gender wage gap, calculated

[2] We have chosen the ratio of labour (measured by total employed) to total population instead of the labour force participation rate to represent labour input in order to be consistent with the dependent variable which is GDP per capita.

as $\left[\frac{w_m - w_f}{w_m}\right]$ where wm is average gross weekly earnings of male workers and wf is average gross weekly earnings of female workers.

Substituting this TFP formulation into equation (1), we will have

$$Ln\frac{Y_t}{L_t} = C + \phi t + \sigma_0 Wgap_t + \beta_1 Ln\left(\frac{I_t}{Y_t}\right) + \beta_2 Ln(h_t) + \beta_3 Ln(n_t) + \varepsilon_t \qquad (3)^3$$

The next step is to relax the assumption that the growth of labour will be equal to population growth, which allows us to better measure labour participation. This is done because we want to explore the impact of the wage gap on the economy based on the total hours of work that they offer, rather than just whether or not they work at all. With the need to include the gender wage gap in the equation, we then adjust equation (3) to be:

$$Ln\frac{Y_t}{P_t} = C + \phi t + \sigma_0 Wgap_t + \beta_1 Ln\left(\frac{I_t}{Y_t}\right) + \beta_2 Ln(h_t) + \beta_3 Ln(n_t) + \beta_4 Ln\left(\frac{L_t}{P_t}\right)$$
$$+ \beta_5 Ln\left(\frac{Hw_t}{L_t}\right) + \varepsilon_{0t} \qquad (4)$$

where Hw is hours of work and P is the total population so the average hours of work is calculated as $\left[\frac{Total\ hours\ of\ work(Hw_t)}{Labour(L_t)}\right]$. Equation (4) is the main growth equation used in this study.

2.2 Data and Variables

In this section we describe the ways in which we have operationalised variables for use within our growth model. We summarise the chosen variables and the data used in Table 1.

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[3] Given the fact that $Ln(1 + \phi t) \approx \phi t$

Economic Output

As discussed earlier, economic performance is the main variable of interest in this study and it is often measured by economic output, in particular gross domestic product (GDP). Furthermore, in this study, we use the constant price GDP which provides the representation of quantity produced in the economy where the change in the value of output is not merely caused by the current prices of those outputs. The Australian Bureau of Statistics (ABS) uses a chain volume measure of GDP in the Australian System of National Accounts as their measure of constant price GDP (Australian National Accounts: Concepts, Sources and Methods, 2000).

Capital and Investment

Capital stock is one of the two major inputs that produce economic output (the other is labour). With some modification in the model, 'investment' or the addition to capital stock can be used to replace this capital stock data (Mankiw et al. 1992). .The data for investment in this study is proxied by total capital accumulation and net lending (annually), since this takes into account changes in financial capital as well as in physical capital. The data is available as a part of the Australian System of National Accounts and we use this variable measured as a ratio of GDP (i.e. the rate of investment).

Labour and Fertility

In addition to capital, labour is the other major input to economic growth. There are several ways to measure labour input, including the number of people participating in the labour force, hours of work and their cost (i.e. wages). In this study, we use the number of employed persons by full-time and part-time status and their hours of work (available in the ABS publication - *Labour Force, Australia, Detailed, Quarterly*).

It is also important to include fertility in growth models such as the one we are using in this study. The Solow growth model (on which our estimation technique is based) has a strong assumption of diminishing marginal returns of labour. This means that although an increase in labour is likely to increase economic output, the increase in output will lessen as the amount of labour becomes larger (Mankiw *et al.* 1992; Renelt 1992). However, research has found that while the addition of labour from natural population growth as a result of the fertility rate generates decreasing amount of output, net migration can generate larger amountsof output given the human and financial capital migrants are bringing with them (Barro and Lee 1994). Therefore, the model will include fertility in the equation to recognise this difference.

Human Capital

Human capital is the most common additional variable used in growth estimations (Durlauf *et al.* 2004). Lucas (1988) defined human capital as a general skill level, indicating that human capital contributes to production by increasing worker productivity as well as directly increasing output through its contribution to technological improvement. Research has shown that the impact of human capital accumulation contributes to greater technical progress or Total Factor Productivity (TFP) growth by affecting knowledge accumulation (Romer 1990). The indirect impact of human capital accumulation mostly occurs through lower fertility or population growth (Becker *et al.* 1990; Galor and Weil 2000; Dowrick 2003).

There are various types of human capital measurement, which are based on (i) health – mostly using life expectancy as a proxy; and (ii) education, mostly using school attainment as a proxy. This study will concentrate to the latter. Annual data for this educational proxy of human capital is available in ABS data on educational attainment (*Education and Work, Australia*). Data begins in 1989, with details for the number of persons and workers by their highest educational attainment (in terms of non-school qualifications).

Gender Wage Gap

The gender wage gap is the main input variable of interest in this study as our primary aim is to estimate the impact of the gender wage gap on economic growth. The ABS conducts several surveys which have data and information about the gender wage gap. In this estimation we will use *Average Weekly Earnings, Australia*, which provides quarterly estimates of average gross weekly earnings of workers in Australia. Average Weekly Earnings data was chosen because it provides the longest time span of consistent data on wages.

Table 1 Summary of Variables, Proxy Used and their Sources

Variable	Proxy	Sources
Economic Output	GDP	Australian System of National Accounts (ABS Cat. No. 5204.0)
Economic Input		
Investment	Total capital accumulation and net lending	Australian National Accounts: National Income, Expenditure and Product (ABS Cat. No. 5206.0)
Labour	Labour participation (Number of employed persons full time and part time)	Labour Force, Australia, Detailed, Quarterly (ABS Cat. No. 6291.0.55.003)
	Hours of work	Labour Force, Australia, Detailed, Quarterly (Cat. No. 6291.0.55.003)

Fertility	Total fertility rate	Births, Australia (ABS Cat. No. 3301.0)
Human capital (education)	Proportion of persons with non-school qualifications	Education and Work, Australia (ABS Cat. No. 6227.0)
Gender wage gap	Ratio of wage difference between male and female to male wage	Average Weekly Earnings, Australia (ABS Cat. No. 6302.0)

3 ESTIMATION PROCEDURE

Analysing the impact of gender wage gap on economic output using only equation (4) would mean we measure the impact on the assumption that other variables are not changed by the changes in gender wage gap. However, our further investigation shows that we cannot ignore the important effect of gender wage gap through other variables (indirect effects). Therefore, our best estimation option was to conduct simultaneous equations using three-stage least squares in which the independent variables are mostly endogenous, allowing us to examine the direct and indirect channels together.

The use of time series data raises the issue of the stability of the data over time – referred to as stationarity (Durlauf *et al.* 2004). Our stationarity tests give a slightly inconclusive result in regard to the stationarity of our variables (the tests suggest a possible problem with stationarity, but when analysed carefully do not provide sufficiently strong evidence to absolutely reject the possibility that our data is stationary), we needed to conduct some initial modelling in order to further inform our understanding of possible problems with stationarity. If overall we considered stationarity to be a problem, then we would need to address this by using first difference terms of our variables (subtracting the equation at time t from the equation at time t-1), rather than the original (or level) variables.

To estimate the equation using a first difference equation, we subtract equation (4) at time t with the condition at time t-1 or

$$Ln\frac{Y_{t-1}}{P_{t-1}} = C + \phi(t-1) + \sigma_0 Wgap_{t-1} + \beta_1 Ln\left(\frac{I_{t-1}}{Y_{t-1}}\right) + \beta_2 Ln(h_{t-1}) + \beta_3 Ln(n_{t-1}) + \beta_4 Ln\left(\frac{L_{t-1}}{P_{t-1}}\right) + \beta_5 Ln\left(\frac{Hw_{t-1}}{L_{t-1}}\right) + \varepsilon_{0t-1} \tag{5}$$

and produce

$$\Delta Ln\left(\frac{Y_t}{P_t}\right) = \phi + \sigma_0 \Delta Wgap_t + \beta_1 \Delta Ln\left(\frac{I_t}{Y_t}\right) + \beta_2 \Delta Ln(h_t) + \beta_3 \Delta Ln(n_t) + \beta_4 \Delta Ln\left(\frac{L_t}{P_t}\right) + \beta_5 \Delta Ln\left(\frac{Hw_t}{L_t}\right) + \Delta\varepsilon_{0t} \tag{6}$$

The next step is to build the system to recognise the endogeneity of the growth determinants and hence the indirect effect of the wage gap through other growth determinants. As with the main growth equation, we also estimate all equations in this system using the first difference form, especially given the variables we use in these subsequent equations are simply the first difference terms of those used in the main growth equation. This system can be written as:

$$\Delta Ln\left(\frac{I_t}{Y_t}\right) = \alpha_1 + \beta_6 \Delta Ln\left(\frac{I_{t-1}}{Y_{t-1}}\right) + \beta_7 \Delta Ln\left(\frac{I_{t-2}}{Y_{t-2}}\right) + \beta_8 \Delta Ln\left(\frac{I_{t-3}}{Y_{t-3}}\right) + \beta_9 \Delta Ln(h_t)$$
$$+ \beta_{10} \Delta Ln(n_t) + \beta_{11} \Delta Ln\left(\frac{L_t}{P_t}\right) + \beta_{12} \Delta Ln\left(\frac{Hw_t}{L_t}\right) + \beta_{13} \Delta Ln\left(\frac{Y_t}{P_t}\right) + \sigma_1 \Delta Wgap_t + \Delta\varepsilon_{1t} \tag{7}$$

$$\Delta Ln(n_t) = \alpha_2 + \beta_{14} \Delta Ln(n_{t-1}) + \beta_{15} \Delta Ln(n_{t-2}) + \beta_{16} \Delta Ln(n_{t-3}) + \beta_{17} \Delta Ln(n_{t-4})$$
$$+ \beta_{18} \Delta Ln(h_t) + \beta_{19} \Delta Ln\left(\frac{I_t}{Y_t}\right) + \beta_{20} \Delta Ln\left(\frac{L_t}{P_t}\right) + \beta_{21} \Delta Ln\left(\frac{Hw_t}{L_t}\right) + \beta_{22} \Delta Ln\left(\frac{Y_t}{P_t}\right)$$
$$+ \sigma_2 \Delta Wgap_t + \Delta\varepsilon_{2t} \tag{8}$$

$$\Delta Ln\left(\frac{L_t}{P_t}\right) = \alpha_3 + \beta_{23} \Delta Ln\left(\frac{L_{t-1}}{P_{t-1}}\right) + \beta_{24} \Delta Ln\left(\frac{L_{t-2}}{P_{t-2}}\right) + \beta_{25} \Delta Ln\left(\frac{L_{t-3}}{P_{t-3}}\right) + \beta_{26} \Delta Ln(h_t)$$
$$+ \beta_{27} \Delta Ln(n_t) + \beta_{28} \Delta Ln\left(\frac{I_t}{Y_t}\right) + \beta_{29} \Delta Ln\left(\frac{Hw_t}{L_t}\right) + \beta_{30} \Delta Ln\left(\frac{Y_t}{P_t}\right) + \sigma_3 \Delta Wgap_t + \Delta\varepsilon_{3t} \tag{9}$$

$$\Delta Ln\left(\frac{Hw_t}{L_t}\right) = \alpha_4 + \beta_{31} \Delta Ln\left(\frac{Hw_{t-1}}{L_{t-1}}\right) + \beta_{32} \Delta Ln\left(\frac{Hw_{t-2}}{L_{t-2}}\right) + \beta_{33} \Delta Ln\left(\frac{Hw_{t-3}}{L_{t-3}}\right)$$
$$+ \beta_{34} \Delta Ln(h_t) + \beta_{35} \Delta Ln(n_t) + \beta_{36} \Delta Ln\left(\frac{L_t}{P_t}\right) + \beta_{37} \Delta Ln\left(\frac{I_t}{Y_t}\right) + \beta_{38} \Delta Ln\left(\frac{Y_t}{P_t}\right)$$
$$+ \sigma_4 \Delta Wgap_t + \Delta\varepsilon_{4t} \tag{10}$$

$$\Delta Wgap_t = \alpha_5 + \beta_{39} \Delta Wgap_{t-1} + \beta_{40} \Delta Wgap_{t-2} + \beta_{41} \Delta Wgap_{t-3} + \beta_{42} \Delta Ln(h_t)$$
$$+ \beta_{43} \Delta Ln(n_t) + \beta_{44} \Delta Ln\left(\frac{L_t}{P_t}\right) + \beta_{45} \Delta Ln\left(\frac{I_t}{Y_t}\right) + \beta_{46} \Delta Ln\left(\frac{Y_t}{P_t}\right) + \beta_{47} \Delta Ln\left(\frac{Hw_t}{L_t}\right) + \Delta\varepsilon_{5t} \tag{11}$$

4 ESTIMATION RESULTS

Tables 3 to 8 show the estimation results of equations (6)-(11). The system is estimated using the data described above with time periods (t) from 1990 to 2008. We utilise the coefficients from these tables to generate the impact coefficient that we use to estimate the impact of the gender wage gap on economic growth as shown in Table 5.

Table 3 shows the results of our main growth equation. These results produced the expected signs that have been predicted by growth theory (Mankiw et al. 1992). Furthermore, these results point to the investment rate, labour participation rate and average hours of work as the significant main engines of Australian economic growth while human capital is not found to be statistically significant. The non-significance of human capital contrasts with Dowrick's (2003) findings in relation to the role of education in developed countries' (including Australia's) economic growth, and there are two possible reasons for this. First, the school attainment data used in this paper as a proxy for human capital is the proportion of persons with non-school qualifications rather than the average years of schooling used by Dowrick. As we do not know what level of schooling contributes most to growth, the use of different proxy variables may go a long way to explaining the differences between our results and Dowrick's (2003) in this regard. Second, different observation periods may affect the apparent impact of human capital on growth. Most of our observation periods fall into the period of economic boom in Australia, possibly explaining the dominance of labour participation in determining economic growth, whereas Dowrick's study observed the 1970-1990 period of 51 countries.

Our results also show that fertility and the *direct* impact of gender wage gap do not significantly hamper economic growth. However, as noted above, we also examine the *indirect* effects of the gender wage gap through other growth determinants and these results, discussed below, demonstrate that the gender wage gap operates indirectly on economic growth.

Table 3 Growth Equation

$\Delta Ln\left(\frac{Y_t}{P_t}\right)$ (GDP per capita)	$R^2 = 0.7693$		
Variable	**Notation**	**Coefficient**	**Standard Error**
Investment/GDP	$\Delta Ln\left(\frac{I_t}{Y_t}\right)$	0.081**	0.032
Human capital	$\Delta Ln(h_t)$	0.060	0.065
Average hours of work	$\Delta Ln\left(\frac{Hw_t}{L_t}\right)$	0.222***	0.077

Labour Participation	$\Delta Ln\left(\frac{L_t}{P_t}\right)$	0.695***	0.117
Fertility	$\Delta Ln(n_t)$	-0.182	0.082
Gender wage gap	$\Delta Wgap_t$	-0.250	0.313
	constant	0.017	0.002

Note: *, **, *** is the10%, 5% and 1% significance level, respectively
Source: The result of estimating equation (6)

Table 4 shows the impact of the gender wage gap on other growth determinants - investment per GDP, average hours of work, labour participation and fertility - as channels to economic growth. These results indicate that the gender wage gap significantly affects average hours of work but does not have a significant effect on the other determinants. The absence of a statistically significant effect is caused by either a small impact of the gender wage gap on the determinant (in the case of the labour participation rate), the high standard error of the estimated impact on the growth determinant (in the case of fertility), or both (in the case of the investment rate). This means that we can only have strong confidence in the impact of the gender wage gap on hours of work, and hence this channel is the only one of the channels examined through which we can confidently state that the gender wage gap significantly affects economic growth. It should be noted, however, that average hours of work is the second main growth engine in Australia after the labour participation rate (Table 3), and that the strong impact of the gender wage gap through this channel thus has important economic implications.

Table 4 Channels of Indirect Effect Estimation

	Endogenous Variable	Investment rate	Average hours of work	Labour Participation	Fertility	Gender wage gap
	notation	$\Delta Ln\left(\frac{I_t}{Y_t}\right)$	$\Delta Ln\left(\frac{Hw_t}{L_t}\right)$	$\Delta Ln\left(\frac{L_t}{P_t}\right)$	$\Delta Ln(n_t)$	$\Delta Wgap_t$
	R^2	0.7139	0.7102	0.7593	0.5038	0.5516
Explanatory Variables						
Lag of the endogenous variable (t-1)		-0.097 (0.205)	0.101 (0.168)	0.013 (0.115)	0.259 (0.188)	-0.463** (0.182)
Lag of the endogenous variable (t-2)		-0.263 (0.180)	-0.270** (0.115)	-0.132 (0.102)	0.921** (0.372)	-0.087 (0.179)
Lag of the endogenous variable (t-3)		-0.024 (0.149)	-0.330*** (0.122)	-0.033 (0.087)	-0.200 (0.339)	0.352* (0.188)
Lag of the endogenous variable (t-4)					-1.038*** (0.365)	
GDP/capita	$\Delta Ln\left(\frac{Y_t}{P_t}\right)$	4.722*** (1.288)	1.449*** (0.429)	1.029*** (0.175)	-0.567 (0.709)	0.032 (0.140)

Investment/GDP	$\Delta Ln\left(\frac{I_t}{Y_t}\right)$		-0.064 (0.073)		0.231* (0.123)	0.037 (0.027)
Human capital	$\Delta Ln(h_t)$	-0.485 (0.434)	-0.156 (0.134)	0.013 (0.076)	0.019 (0.170)	-0.006 (0.042)
Average hours of work	$\Delta Ln\left(\frac{Hw_t}{L_t}\right)$	-0.913 (0.593)		-0.241** (0.103)	0.187 (0.226)	-0.118** (0.050)
Labour Participation	$\Delta Ln\left(\frac{L_t}{P_t}\right)$	-1.124 (1.373)	-0.886** (0.441)	-0.033 (0.041)	0.420 (0.492)	-0.034 (0.121)
Fertility	$\Delta Ln(n_t)$	0.751 (0.542)	0.457** (0.210)	0.294*** (0.093)		
Gender wage gap	$\Delta Wgap_t$	-0.261 (2.377)	-1.432** (0.563)	0.378 (0.355)	0.993 (0.747)	0.141** (0.056)
constant		- 0.088*** (0.029)	-0.027*** (0.008)	-0.016*** (0.004)	0.008 (0.013)	-0.001 (0.003)

Note: *, **, *** is the10%, 5% and 1% significance level, respectively. Standard errors of coefficients are within parentheses.
Source: The result of estimating equation (7)-(11)

To sum up, while the coefficient estimates of our main growth equation have relatively low standard errors (which meant that coefficients were statistically significant) and thus support the direction expected by the theoretical growth model, we do however find high standard errors when estimating the impact of the gender wage gap directly on growth and most of its components. This is a drawback of our model. The lack of observations available to us is the likely cause of this. The high standard errors mean that our impact estimate has wide confidence intervals. Nevertheless, the coefficient estimate of the main growth equation (equation (6)) is significant and shows a relationship between the gender wage gap and GDP per capita that is supported by growth theory. Therefore, despite data availability issues and high standard errors, our result is one which makes sense theoretically.

5 ESTIMATING THE IMPACT

5.1 Estimation Coefficients

The coefficients that have been produced from the regression system above allow us to calculate the impact of the wage gap on economic growth. For example the coefficient σ_0 in the main growth equation (i.e., equation (4)) represents the impact of the wage gap on economic growth while holding other variables constant (referred to as partial impact). This impact can be estimated as follows:

$$\partial Ln\frac{Y_t}{P_t} = \sigma_0 \partial Wgap_t \Rightarrow \frac{\partial y_t}{y_t} = \sigma_0 \partial Wgap_t \Rightarrow \partial y_t = \sigma_0 \partial Wgap_t y_t \quad \text{where } \frac{Y_t}{P_t} = y_t \qquad (12)$$

In the same way, the partial impact of other growth determinants on economic growth can be estimated.

The impact of investment: $\frac{\partial y_t}{y_t} = \beta_1 \partial Ln\left(\frac{I_t}{Y_t}\right)$ (13),

The impact of fertility: $\frac{\partial y_t}{y_t} = \beta_3 \partial Ln(n_t)$ (14),

The impact of labour participation: $\frac{\partial y_t}{y_t} = \beta_4 \partial Ln\left(\frac{L_t}{P_t}\right)$ (15),

The impact of average hours of work: $\frac{\partial y_t}{y_t} = \beta_5 \partial Ln\left(\frac{Hw_t}{L_t}\right)$ (16),

The equations (7)-(10) in the system provide further information about how much these growth determinants will change if there is change in the wage gap. This can estimated as,

The impact on investment: $\partial Ln\left(\frac{I_t}{Y_t}\right) = \sigma_1 \partial Wgap_t$ (17),

The impact on fertility: $\partial Ln(n_t) = \sigma_2 \partial Wgap_t$ (18),

The impact on labour participation: $\partial Ln\left(\frac{L_t}{P_t}\right) = \sigma_3 \partial Wgap_t$ (19),

The impact on average hours of work: $\partial Ln\left(\frac{Hw_t}{L_t}\right) = \sigma_4 \partial Wgap_t$ (20).

By substituting the equations in (17)-(20) into the equations in (13)-(16), we will be able to estimate the impact of the wage gap through other growth determinants as follows:

The impact through investment: $\frac{\partial y_t}{y_t} = \beta_1 \sigma_1 \partial Wgap_t$ (21)

The impact through fertility: $\frac{\partial y_t}{y_t} = \beta_3 \sigma_2 \partial Wgap_t$ (22)

The impact through labour participation: $\frac{\partial y_t}{y_t} = \beta_1 \sigma_1 \partial Wgap_t$ (23)

The impact through average hours of work: $\frac{\partial y_t}{y_t} = \beta_3 \sigma_2 \partial Wgap_t$ (24)

Therefore, the total differential of growth on the wage gap provides the total impact of the wage gap on growth as

$$\frac{\Delta y_t}{y_t} = (\sigma_0 + \beta_1\sigma_1 + \beta_3\sigma_2 + \beta_4\sigma_3 + \beta_5\sigma_4)\Delta Wgap_t \quad (25)$$

Table 5 shows the impact estimate of the gender wage gap on economic growth, showing that, having taken into account the impact of all channels – both significant and non-significant in calculating the total gap we get -0.507 as our impact coefficient. This means every percentage point change in the wage gap will cause a change of 0.507 percent GDP per capita in the opposite direction i.e., an increase of the gender wage gape by 1 percentage point will decrease GDP per capita by 0.507 percent. Excluding the channels that are not statistically significant at the 95% confidence level will reduce the impact coefficient to -0.318. This impact is coming only from the decline in average hours of work as a result of the gender wage gap.

Table 5 The impact coefficients of the gender wage gap on economic growth

	σ	β	**Impact Coefficient**
Wage gap → economic growth	-0.25		-0.250
Wage gap→investment→economic growth	-0.261	0.081**	-0.021
Wage gap→fertility→economic growth	0.993	-0.182	-0.181
Wage gap→average hours of work→economic growth	-1.432**	0.222***	-0.318
Wage gap→labour participation→economic growth	0.378	0.695***	0.263
Total effects			**-0.507**

Note: *, **, *** is the10%, 5% and 1% significance level, respectively
Source: The coefficient from tables E2 to E7

5.2 Estimating and quantifying the total impact on GDP

The previous section has shown the total impact coefficient of the wage gap on GDP. The final step is to calculate the total volume of GDP change (in dollars) which would result from a decrease or increase of the wage gap. To do so, we should rearrange equation (25) as

$$\Delta y_t = (\sigma_0 + \beta_1\sigma_1 + \beta_3\sigma_2 + \beta_4\sigma_3 + \beta_5\sigma_4)\Delta Wgap_t \times y_t \quad (26)$$

and multiply both the right hand side and the left hand side of equation (26) by P_t to get

$$\Rightarrow \Delta Y_t = (\sigma_0 + \beta_1\sigma_1 + \beta_3\sigma_2 + \beta_4\sigma_3 + \beta_5\sigma_4)\Delta Wgap_t \times Y_t \quad (27).$$

Knowing that the wage gap is 0.17 in 2008 and the chain volume GDP is at $1,084,146.00 million in 2007 dollars we can calculate the impact of a change of one percentage point in the gender wage gap, as well as the cost of the whole 17 per cent of the gender wage gap as seen in Table 6. The calculation shows that an increase in the gender wage gap of one percentage point is estimated to decrease GDP per capita by around $260, which equates to around $5,497 million of GDP in total, assuming the population is held constant at 21.21 million. This also means that if the whole gender wage gap were to be eliminated (that is, reduced from 17 per cent to zero), such a change could be worth around $93 billion of GDP.

Table 6. Estimates of the gender wage gap impact on economic output

	Current GDP ($ millions)	Change in GDP economic growth (%)	Change in GDP ($ millions)
Gender wage gap increases by one percentage point	1,084,146.00	-0.51	-5,496.65
Total cost of wage gap (wage gap is eliminated by 17 percentage points)	1,084,146.00	8.50	93,443.06

However, we know that not all of the channels are statistically significant. Therefore, it is also important to examine what would the gap look like if we only took into account the impact of the one significant channel (hours of work)? We tested this and, as shown in Table 7, the impact of the gender wage gap is still in the same direction, and still very substantial. As noted earlier, if we take only the significant channel into account, we still see that for an increase in the gender wage gap of one percentage point, GDP falls by 0.318 per cent. Thus we find that just this single channel accounts for 62.7 per cent of the total expected impact.

Another way of considering these issues is to think about what would happen to the apparent impact of the gender wage gap on GDP if we lowered our confidence level to 80%.

Would we still see only one significant channel, and would the apparent impact change? We did this (see Table 7), and found that this added another significant channel to the model. With a confidence level of 80% we found that the gender wage gap affected both fertility and hours of work significantly. If we then use the impact of these two channels only to estimate the effects of the gender wage gap on GDP, we find that this effect (at -0.499) is very similar in magnitude to the total effect when all channels are used.

These results provide further support for our overall findings – they suggest that even when we adjust various aspects of the assumptions built into our modelling, the overall story about the impact of the gender wage gap on GDP per capita remains much the same.

Table 7. The impact of wage gap with different confidence levels

Gender wage gap increases by one percentage point	Change in GDP economic growth (%)	Compared to total impact (%)	Change in GDP ($ millions)
Total Impact with all channels	-0.507		-5,496.65
Total Impact with only channels significant at 95% confidence level	-0.318	62.7	-3,447.58
Total Impact with only those channels significant at 80% confidence level	-0.499	98.4	-5,409.89

Source: Authors' calculations

6 CONCLUSION

This study set out to examine the impact of the gender wage gap on GDP per capita. Our estimations show that, holding other variables constant (*ceteris paribus*), and including the effect of all the channels in our model, the average impact of the gender wage gap on GDP per capita is -0.507. This means that on average, a one percentage point increase in the gender wage gap would decrease economic growth by 0.507 per cent. This effect, however, should be treated as indicative only. It is an average figure, and is calculated by adding up all the effects of each of the modelled pathways. Not all these modelled pathways had a statistically significant effect on economic growth in our model. However, an examination of the individual pathways through which the gender wage gap affects economic growth does provide us with additional evidence about the substantial negative effects of the wage gap on growth. In particular, the impact on growth of average hours of work (the only statistically significant pathway in our model) is negative and substantial. If the gender wage gap increased by one percentage point, average hours of work would decrease, and thus GDP per capita would fall by 0.318 per cent.

This finding makes intuitive sense, as an increased gender wage gap (thus lower female wages compared to male wages) is likely to act as a disincentive for women to work more hours. This effect is likely to be particularly noticeable as so many Australian women work part-time. Reduced working hours in turn lead to lower economic growth. Conversely, these findings suggest that a decrease in the gender wage gap would be significantly associated with an increase in women's hours of work. It should be noted, however, that women's ability to work more hours is likely to be affected by a range of factors, including unemployment rates, the availability of appropriate and affordable child care and access to flexible working hours. Given the importance in our model of hours of work, these factors may be critical to consider if a narrowing of the gender wage gap is to be translated into greater economic growth.

While the other pathways in our model do not have statistically significant effects, each of the factors except labour participation has an effect on economic growth which is in the same direction as the (significant) effect of average hours of work, providing further support for the hypothesis that the wage gap affects growth negatively. However, the non-significance of these relationships means that we cannot draw any conclusions about underlying processes.

This study has demonstrated the application of economic growth modelling to estimate the impact of the gender wage gap on Australian economy. Despite challenges presented by the relatively short span of data for time series modelling, resulting in wide confidence intervals around our results and high standard errors for many pathways, our testing suggests that the overall thrust of our results related to the impact of the wage gap on GDP per capita would not change dramatically even if, for example, only statistically significant channels of impact were taken into account in our calculations. This supports the notion that Australia's persistent gender wage gap has implications for overall economic growth, as well as for individual economic well-being and equity.

7 Reference List

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