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PACIFIC TRADE AND DEVELOPMENT WORKING PAPER SERIES

Paper No. 35-04

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ACKNOWLEDGEMENTS: I am extremely grateful to Dr Francis Teal for his valuable and constructive advice and comments throughout this work. I would like to thank seminar participants at Tinbergen Institute (EUDN 2011), Nanyang Technological University (SERC 2011), and Seminar for PAFTAD Young Fellows for their helpful comments. All remaining errors are my responsibility.

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15 June 2011

Abstract

This paper examines the major sources of economic growth during the industrialisation process in Thailand as an example of small open developing economies. Given the underlying labour market implications of the two distinct macroeconomic growth models, namely the Solow growth model with total factor productivity-driven growth and the Lewis model of structural change, the sectoral earnings model is used as a test based on the micro-level data from the national Labour Force Surveys during the period 1985-2000. Firstly, the paper provides a framework that links the macroeconomic evidence to the labour market outcome in order that the available micro-level data can be used to assess the relevance of these macroeconomic growth models to the economy. Secondly, whilst the paper principally attempts to identify the effects of the sectoral total factor productivity on the economy, the relative importance of human capital accumulation as well as the roles of sectoral shifts is taken into account. To do so, the sectoral earnings model allows for the endogeneity of education and the individual sectoral choice optimisation process, and identifies the within-sector technological progress by the exogenous growth in sectoral earnings. The empirical results confirm the importance of human capital accumulation as well as the underlying technological progress within the agricultural and the service sectors as major sources of economic growth in Thailand during the high growth period. With controls for human capital and sectoral reallocation in place, the paper finds that the sectoral earnings unequally rose over time across sectors, and surprisingly declined for the manufacturing sector.

Keywords: Thai Economy; Sectoral Earnings; Returns to Human Capital; Labour Reallocation; Occupational Choice; Technological Progress

JEL Classification Numbers: J3, J6, I2, O1, O3, O4

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1 Introduction

During the 1980s and 1990s, Thailand provided an important instance of rapid economic progress in comparison with other developing economies within the region and beyond (Figure 1 on page 2). Thai Gross Domestic Product (GDP) per capita increased by a remarkable 6.49 per cent per annum over one and a half decades ending in 1996. Meanwhile, China's per capita income grew at 9.11 per cent annually, which drove the average growth rate for the East Asia and Pacific region to 7.05 per cent. Over the same period, the GDP per capita of Sub-Saharan Africa scarcely changed, while the growth of South Asia was 3.17 per cent per annum.

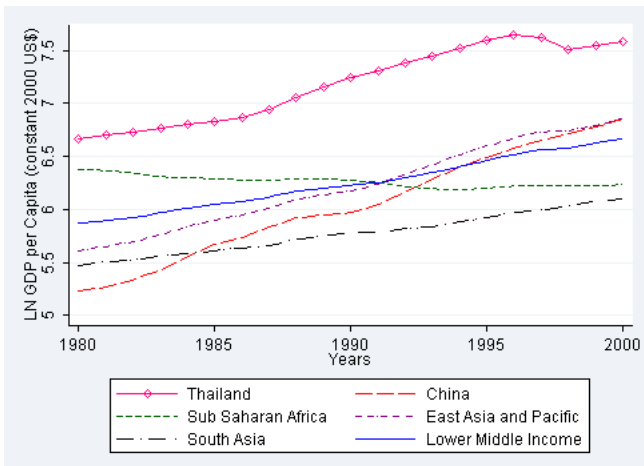


Figure 1: GDP per capita

The question posed in this study is how Thailand achieved such rapid economic growth over nearly two decades. While the common starting point for modern economic growth theory is the neoclassical Solow growth model (1956), the literature on developing economies mostly follows a framework of the dual economy models pioneered by Lewis (1954) and Ranis and Fei (1961), in which the different production functions are assigned to two sectors, namely the traditional and the modern sectors. In these dual economy models, production and employment move towards the modern sectors, thus spelling out the pattern of economic development. With the crucial assumptions of zero exogenous technological progress in the traditional sector and within-sector labour-experience complementarity, the literature on the Thai economy similarly concludes that the process of industrialisation in Thailand was due to the transitions of production and the workforce towards the advanced sector (Jeong and Townsend (2007); Jeong and Kim (2007)). Nonetheless, the restrictive presumptions resting on the Lewis dual economy strictly rule out the importance of sectoral technological progress formerly developed in the neoclassical Solow growth model. Additionally, to the author's knowledge, there have been only a few empirical studies of the impact of human capital accumulation on economic growth in Thailand.

This paper attempts to assess the importance of within-sector total factor productivity (TFP) and human capital accumulation, as well as focusing the attention on the potential relevance of the human capital-augmented Solow growth model to Thai economic development as an example of small open developing economies. Using the micro-level data from the national Labour Force Surveys during the year 1985-2000, the paper seeks to compare the labour market implications of these two above-mentioned distinct growth models, namely the Solow growth model with TFP driven growth and the Lewis model of structural change. The paper tests the assumptions of the reviewed literature that technological progress was confined to the modern sector and thus Thailand's development process was facilitated through transition of the workforce, as well as providing a framework that links these macroeconomic outturns to the labour market data. In particular, the proposed framework allows investigation of earnings determinations across three sectors, namely agriculture, manufacturing, and services. This investigation is carried out by looking at the roles of occupational sorting within the selection mechanism and the potential importance of human capital allowing for endogeneity and selection process into these sectors. This process is broken into three stages. Firstly, the model of sectoral earnings is derived from the human capital-augmented sectoral production function. This basic model of the labour market provides the insights about the mechanism and sources of economic growth, which are human capital and technological progress. In this model, the sectoral returns to education allude to the significance of human capital accumulation in the economy, while the exogenous growth in sectoral earnings over time identifies the within-sector technological progress. Secondly, the sectoral earnings model allows for the endogeneity of human capital and the sectoral selection process. Thirdly, as the paper proposes to test the importance to the Thai growth process of within-sector technological progress and human capital accumulation against the explanation of labour force reallocation, the roles of sectoral shifts are also investigated through the selection mechanism.

With the controls for sectoral selection and human capital, the connections between the labour market outcome and the macroeconomic evidence enable the sectoral technological progress to be identified as the exogenous over-time rise in sectoral earnings. We empirically test whether the rise in sectoral earnings in the Thai labour market markedly supports the Solow single-sector model as a determinant of economic growth or whether the rise was in fact the result of an increase in human capital and sectoral selection. The empirical results confirm the importance of human capital accumulation as well as the underlying technological progress within the agricultural and the service sectors as major sources of economic growth in Thailand during the high growth period. These results contradict the dual economy model that labour reallocation towards the advanced manufacturing sector contributes to economic growth.

The paper proceeds as follows. Section 2 briefly reviews the two economic growth models in question, which rest on different assumptions about labour markets and thus result in different labour market outcomes. Section 3 presents the nature and the descriptive statistics of the national Labour Force Survey, which are used for the empirical tests. Section 4 fleshes out the model of microeconomic determinants of income, which is linked with the macroeconomic growth models. This section also outlines the empirical model incorporating corrections to the possible econometric estimation problems. Section 5 tests the sectoral earnings model and interprets the results. Section 6 offers concluding remarks.

2 Solow and Lewis: Their Labour Market Implications

The paper considers two of the most important models of economic growth focusing on the different assumptions they make about labour markets. First of these is the neoclassical Solow growth model (1956) and its extension to a human capital-augmented feature by Mankiw et al. (1992) and Hall and Jones (1999). In these Solow-type models, the fundamental neoclassical assumptions regarding the production function, together with the assured specification on the form of technological progress, imply in the long run a constant level of capital per effective unit of labour, and hence, the system eventually achieves a state of balance growth in terms of per-effective unit of worker output, capital, and consumption. The most prominent feature of the dynamic Solow-type growth models is that the exogenous technological progress determines the long-run steady state of per-effective unit of worker output. In contrast, the savings rate, the rate of population growth, and human capital accumulation only have effects on the equilibrium level of income per effective unit of worker. Despite the Solow-type models being silent concerning the labour market, the assumption of a fully employed labour force implicitly points to a single competitive labour market, in which real wages equal the marginal productivities of workers. In this context of a competitive environment, capital per effective unit of labour, output per effective unit of labour, and thus, real wages grow constantly at a given positive rate of technological progress. A multiple-sector economy with an integrated labour market can also be viewed as a single-economy Solow-type comprising various firms, of which the marginal productivity of labour equalisation holds. The labour force is freely mobile and wage differentials are therefore instantaneously eliminated through competition. The equalised sectoral wages grow uniformly at the same rate as technological progress. The fundamental source of economic growth remains the same; the sectoral underlying technological changes.

An alternative to the single-economy Solow growth model is that of Lewis (1954), which consists of two sectors; the subsistence agricultural sector and the competitive modern sector. The competitive modern sector, which is often referred to as the manufacturing sector, behaves as do the Solow-type firms. On the other hand, the marginal productivity of labour in the traditional agricultural sector is much lower than real wages paid and possibly equals to zero. Reallocating the labour force from the traditional sector to the modern manufacturing sector increases the modern sector's productivity without losses in agricultural productivity. This so-called unlimited supply of labour will end at the point where the marginal productivity of labour in agriculture becomes positive (Ranis and Fei, 1961). The cost of further withdrawal of the agricultural labour force eventually equals to and increases with the sectoral marginal productivity of labour. When wages are set to marginal productivities of labour in all sectors, the effects of sectoral technological changes become more crucial. The difference in rates of technological progress results in the continual marginal productivity of labour differentials, and thus, real wages growth differences across sectors. It is possible that this can sustain the dual economy until the economy becomes specialised in the sector with higher technological progress, unless the economy is closed and the two sectors produce non-substitutes.

The two major macroeconomic growth models, which differ in the underlying labour market process, entail different influential sources of economic growth. Technological progress is the only factor driving the rate of income per capita growth in the Solow-type model, while the transition of the labour force towards the advanced sector accelerates the growth in income per capital in those of the Lewis type. The link between the macroeconomic evidence and the labour market implication yields an alternative way of testing the economic growth models through the microeconomic foundation and the use of the available micro-level data. This requires investigating the determinants of sectoral earnings, in which the relative importance of the sectoral exogenous technological progress can be identified by the exogenous growth in sectoral earnings, controlling for human capital and sectoral selection.

3 Data Source and Descriptive Statistics

3.1 The Thai Labour Force Surveys (LFS)

The data used in the empirical testing section come from the national cross-section Labour Force Surveys from the years 1985 to 2000 (NSO). The sample for each survey was drawn randomly from different households throughout the country using cluster random sampling stratified by geographic regions and provinces. The sample households accounted for around 0.5 per cent of the total population. The surveys contain a rich dataset at the micro-level, useful for an estimation of the sectoral earnings model. Survey questions include detailed information on employment and unemployment, such as labour force status, occupation, industry, hours worked, and earnings, as well as the characteristics of persons both in the labour force and economically inactive, for instance age, gender, relationship to household heads, marital status, migration status, and educational attainment.

3.2 Descriptive Statistics and their Relevance to the Two Economic Growth Models

The descriptive statistics illustrate many interesting characteristics of the Thai labour market, including the high labour force participation and low unemployment rate (Table 2 on page 6), which coincide with a low rate of underemployment in all sectors. These show substantial labour utilisation in Thailand, even in rural areas and the agricultural sector. While the share of manufacturing employment gradually increased, the essential proportion of the working population remained in agriculture. By the end of the high growth period, the agricultural sector still considerably accounted for 44.5 per cent of the total working population and remained the largest source of employment. Considering the sectoral shares of income to total GDP (Table 1 on page 6), while the country's manufacturing production had been increasing, the service sector dominated the Thai economy since prior to the early years of the high growth period and had remained relatively stable since then.

Table 1: GDP and Sectoral Production

Unit: Billions of Baht	Year						
(at constant 1988 prices), %	1980	1985	1989	1993	1997	1998	2000
GDP	913.7	1,191.2	1,749.9	2,470.9	3,072.6	2,749.7	3,008.4
GDP Growth	4.61%	4.65%	12.19%	8.25%	-1.37%	-10.51%	4.75%
Agriculture	184.5	227.3	276.5	289.1	286.8	282.6	309.9
(Share to GDP)	20.19%	19.08%	15.80%	11.70%	9.34%	10.28%	10.30%
Industry	275.4	375.9	633.7	1,001.8	1,329.0	1,156.2	1,334.3
(Share to GDP)	30.14%	31.56%	36.21%	40.54%	43.25%	42.05%	44.35%
Service	453.8	588.0	839.7	1,180.0	1,456.8	1,310.9	1,364.2
(Share to GDP)	49.67%	49.36%	47.98%	47.76%	47.41%	47.67%	45.35%

Sources: Bank of Thailand

Table 2: Total Population, Labour Force, and Sectoral Employment

Unit:	Year					
Thousand persons, %	1985	1989	1993	1997	1998	2000
Population	50,266	55,240	58,383	60,472	61,179	62,389
Age >=13	33,993	38,856	42,909	46,539	47,206	48,629
(of which were out of the labour force due to study)	20.20%	17.64%	19.53%	22.63%	23.69%	24.78%
Labour Force	26,026	30,295	32,187	32,756	32,718	33,380
Participation Rate	76.56%	77.97%	75.01%	70.38%	69.31%	68.64%
Employment	23,696	28,413	30,629	31,691	30,828	31,434
(of which were underemployed)	2.33%	1.84%	2.62%	1.76%	3.15%	3.17%
Agriculture	15,113	17,721	16,257	14,306	14,385	13,999
(Share to total employment)	63.78%	62.37%	53.08%	45.14%	46.66%	44.53%
Manufacturing	3,059	4,006	5,992	7,374	6,277	6,722
(Share to total employment)	12.91%	14.10%	19.56%	23.27%	20.36%	21.38%
Service	5,523	6,687	8,381	10,010	10,166	10,713
(Share to total employment)	23.31%	23.53%	27.36%	31.59%	32.98%	34.08%
Unemployment	1,252	1,087	841	494	1,355	1,204
Unemployment rate	4.81%	3.59%	2.61%	1.51%	4.14%	3.61%
Seasonal Inactive	1,078	794	717	571	535	743
(Share to the labour force)	4.14%	2.62%	2.23%	1.74%	1.64%	2.23%

Sources: Author's Calculation from the Labour Force Survey (using the weight variable from the same dataset)

Notwithstanding the presence of wage differentials (Table 3 on page 7), the rates in growth of earnings were comparable across sectors, with the fastest pace in the agricultural sector. The median earnings of agricultural workers rose 3.73 per cent per annually on average from 7.41 Thai baht per hour in 1985 to 12.83 baht per hour in 2000, whereas those of the manufacturing sector increased from 17.60 to 21.29 baht per hour (1.28 per cent annually on average) over the same period. This evidence held for men and women separately, with substantial premium earnings for men in the manufacturing and the service sectors. This fastest rate of hourly earnings growth in agriculture draws attention to the importance of exogenous technological progress in all sectors as a source of growth. This requires further examination of human capital across sectors and those characteristics that determine individual comparative advantage or preference in a particular sector.

As the explanation of human capital theory for differences in earnings involves the intrinsic productive capability differentials, the capability of the labour force here is identified by the highest level of education achieved by an individual. As the survey did not ask for the number of years an individual had spent in schooling, we convert the level of education into years of education with the strong assumptions that no one repeated the same level of education and no one attained two degrees. Table 4 on page 8 indicates the increase in years of education over time for the non-agricultural sectors. The service sector contained most educated workers on average, followed by manufacturing, with men having obtained more education than had women on average. Considering the median workers, years of education were unchanged in agriculture. The median years of education were lower than the mean in most sectors and across gender. The heterogeneity appeared most strongly for female service workers, whose median years of education were significantly less than average.

Table 3: Median Inflation Adjusted Hourly Earnings

Unit: Baht		Year					
(at constant 1988 prices)		1985	1989	1993	1997	1998	2000
Agriculture	Both	7.41	8.81	9.82	13.80	14.12	12.83
	Male	7.88	9.12	10.07	14.12	14.65	13.16
	Female	7.04	7.73	9.06	12.55	12.77	12.48
Manufacturing	Both	17.60	16.44	21.31	22.40	22.26	21.39
	Male	20.65	18.88	23.87	24.40	25.44	24.06
	Female	14.08	13.70	19.61	20.17	20.35	19.25
Service	Both	26.81	27.33	35.80	40.33	36.34	35.64
	Male	31.67	31.31	42.62	45.75	40.99	40.21
	Female	20.83	21.13	29.23	35.00	31.80	32.08

Sources: Author's Calculation from the Labour Force Surveys

Table 4: Mean and Median Years of Schooling

Unit: Years		1985		1989		1993		1997		1998		2000	
		P50	Mean	P50	Mean	P50	Mean	P50	Mean	P50	Mean	P50	Mean
Agriculture	Both	4	4.06	4	4.38	4	4.44	4	4.62	4	4.78	4	4.90
	Male	4	4.29	4	4.58	4	4.64	4	4.85	4	5.03	4	5.16
	Female	4	3.81	4	4.15	4	4.22	4	4.37	4	4.47	4	4.56
Manufacturing	Both	4	5.47	4	6.07	6	6.52	6	6.54	6	6.86	6	7.09
	Male	4	5.72	4	6.28	6	6.71	6	6.69	6	6.99	6	7.20
	Female	4	5.10	4	5.77	6	6.25	6	6.32	6	6.65	6	6.93
Service	Both	5	7.16	6	7.70	6	8.19	9	8.54	9	8.71	9	8.95
	Male	6	7.61	6	8.06	9	8.48	9	8.73	9	8.92	9	9.12
	Female	4	6.76	6	7.38	6	7.92	6	8.37	6	8.53	9	8.80

Sources: Author's Calculation from the Labour Force Survey

These stylised facts on production, the shifts in employment, and real wages across sectors draw attention to the explanation for the growth process as they do not thoroughly comply with the underlying labour market conditions of the multi-sector growth models as demonstrated by the earlier literature. This is possibly attributable to the heterogeneity within the service sector, as well as the modernisation in all sectors, which encourage workers to remain within their self-selected sector.

4 Empirical Methodology

4.1 The Sectoral Earnings Model

As discussed above, the relative importance of the sectoral exogenous technological progress can be identified by the exogenous growth in sectoral earnings. Controlling for human capital and sectoral selection, the microeconomic model of sectoral earnings is constructed for the three sectors that produce differentiated goods as follows:

$$\ln \tilde{w}^j_{Lit} = \beta^j_0 + \varphi^j\left(E^j_{it}\right) + \underline{X}^{j'}_{1it} \cdot \psi^j + \underline{T}^{j'}_t \cdot \lambda^j + u^j_{it} \qquad ;\forall j = a,\, m,\, s \tag{1}$$

where a superscript $j = a,\, m,\, s$ represents the agricultural, manufacturing, and service sectors respectively. The logarithmic observed sectoral earnings of individual i at time t, $\ln \tilde{w}^j_{Lit}$, is a function of educational attainment, E_{it}, and a vector of other observable heterogeneous capability-enhancing characteristics, $\underline{X}^{'}_{1it}$. $\varphi^j\left(E^j_{it}\right)$ is a function of efficient units of worker i working in sector j with E^j_{it} level of education. It is allowed to be non-linear and to take the form of $\varphi^j\left(E_{it}\right) = \beta^j_1 \cdot E^j_{it} + \beta^j_2 \cdot E^{j2}_{it}$. $\underline{T}_t$ is a column vector that contains the year dummies, controlling for exogenous change in earnings across time.

This can be rewritten as:

$$\ln \tilde{w}^j_{Lit} = \varphi^j \left(E^j_{it} \right) + \underline{X}^{j'}_{it} \cdot \Psi^j + u^j_{it} \qquad ; \forall j = a,\, m,\, s \tag{2}$$

where $\underline{X}_{it}$ is a column vector of the explanatory variables specified in Equation (1) (apart from years of education) and Ψ^j is a column vector of their corresponding coefficients.

As this model of sectoral earnings is derived from the sectoral production function, it enables the labour market outcome to give an explanation of the macroeconomic evidence. The importance of sectoral technological progress is identified by the vector of time dummy variables. The time dummy coefficient estimates, λ^j , are expected to be uniformly significant across all sectors if technological progress is a crucial part of the growth process, and hence, the single-economy Solow model would be more relevant to the economy. On the other hand, if human capital is the answer to the economic growth, after controlling for it, the significance of the coefficient estimates of the time dummies would disappear. Conversely, if the industrialisation process was explained by labour reallocation as spelled out in the multi-sectoral economy model, the time dummy coefficients are expected to be higher in the advanced technology sector, as well as being insignificant in all sectors when controlling for the sectoral selection and occupational shifts. In addition, this model also allows the analysis of how the returns to human capital vary by sector, as well as pointing to the importance of this relative to the sectoral choice. The issues of sectoral selection and occupational shifts will be discussed in the following subsection.

In contrast to the earlier literature, the model of sectoral earnings allows for productive technology to change over time in all sectors. It also incorporates human capital in order to separate the effects of human capital and sectoral exogenous technological change. Nonetheless, by controlling for human capital and other observed capability-enhancing characteristics, the exogenous rise in sectoral earnings over time does not sufficiently signify the importance of technological progress, for instance, if the time dummy variables also capture other observable and unobservable heterogeneous individual characteristics that impact on productive capability or choice of education, however, have not been included in the model (Griliches, 1977; Card, 1999). Additionally, the estimations of the within-sector technological progress, as well as the returns to human capital may contain bias - supposing the comparative advantage and sector characteristics affect a worker's decision on sectoral choice (Roy, 1951) or unobserved heterogeneity influences an individual's sectoral choice optimisation process (Heckman, 1979). The latter also contributes to the explanation of labour reallocation-driven growth in the multi-sector economy. The estimation of the sectoral earnings model must therefore keep these issues in view in order to ensure it fully accounts for connections between the over time rise in sectoral earnings and the importance of sectoral technological progress.

4.2 Control Function Approach: The Endogenous Choice of Education

The identification of returns to education is essential as they imply the relative importance of human capital in determining the mechanism of economic development. The microeconomic labour studies on estimating earnings functions have been continuously developed since the formulation of the human capital earnings function by Mincer (1974). The individual Mincerian returns to education is fairly similar to $\varphi^{j'}(E_{it})$ in the model of sectoral earnings. The major concern of the estimation involves potential bias due to the endogenous choice of education. Firstly, an educational choice is very likely to be correlated to productivity-related unobservable characteristics such as ability (See Griliches (1977) and Card (1999) for the hypothesis of education-ability complementarity; and Ashenfelter et al. (1999) for the proposal that education is compensatory for earnings capacity.). Secondly, educational attainment is often measured with errors (Griliches, 1977) and the number of years spent in schooling may not well reflect the actual human capital obtained from education (Card and Krueger, 1992).

The primary bias corrections involve adding ability proxies (Griliches, 1977). More recently, many studies apply the methods of instrumental variables (IV), which require the exogenous variables used for instrumenting the level of educational attainment to be informative and valid. These instruments used in literature range from family background including parental education (Denny and Harmon, 2000) to natural controls such as proximity to schools (Card, 1993), seasons of birth, and national educational laws (Angrist and Krueger, 1990; Harmon and Walker, 1995)).

Notwithstanding the case of valid and informative instruments, the IV technique only allows for heterogeneity in unobserved ability (an intercept) but not heterogeneity in returns to education (i.e. a slope) (Card, 1999). Under this circumstance, the IV approach can still provide consistent coefficient estimates, but with the stronger assumption on a conditional covariance of unobserved heterogeneous returns to education and years of education (Imbens and Wooldridge, 2007) or by assuming homoskedasticity of returns to education as well as linearity in effect of education (Wooldridge, 1997).

Due to a very limited number of instrument being available and to the assumption of non-linear effect of education, we employ the alternative methods of control function (Garen, 1984; Card, 1999). The control function approach treats endogeneity as an omitted variable problem, which can be improved by including a control for correlation between the omitted unobserved heterogeneity and years of education. As shown in Card (1999), the methods additionally allow the model to specify a random coefficient of education. This is to say that the error term, u_{it}^{j}, in Equation (2) contains an unobserved difference in returns to education across individuals as well as unobserved ability, that is:

$$u_{it}^{j} = \theta_{i}^{j} \cdot E_{it}^{j} + e_{it}^{j} + \epsilon_{1it}^{j} \tag{3}$$

where θ_i^j is the unobserved random coefficient of educational attainment; e_{it}^j is the unobserved ability correlated with educational attainment; and ϵ_{1it}^j is the exogenous error with $E\left(\epsilon_{1it}^j \mid \underline{X}_{it}^j\right) = 0$. Both e_{it}^j and ϵ_{1it}^j have a zero mean and are normally distributed.

From Equation (2), let $\underline{X}_{2it}$ be a column vector of exogenous variables, of which $\underline{X}_{it}$ is a strict subvector. The first stage regression of an endogenous choice of education, as a function of the variables in vector $\underline{X}_{2it}$ is given by:

$$E_{it}^j = \underline{X}_{2it}^{j'} \cdot \pi^j + v_{2it}^j \tag{4}$$

with the three requirements of exogeneity conditions and substantive restrictions on the error terms as follows.

1. $E\left(v_{2it}^j \mid \underline{X}_{2it}^j\right) = 0$ and $E\left(\epsilon_{1it}^j \mid \underline{X}_{2it}^j\right) = 0$
2. $E\left(\theta_i^j \mid \underline{X}_{2it}^j\right) = E\left(\theta_i^j \mid v_{2it}^j\right) = \xi^j \cdot v_{2it}^j$
3. $E\left(e_{it}^j \mid \underline{X}_{2it}^j\right) = E\left(e_{it}^j \mid v_{2it}^j\right) = \alpha^j \cdot v_{2it}^j$

From Equation (2), the conditional expectation of the logarithmic sectoral earnings is therefore:

$$E\left(\ln \tilde{w}_{Lit}^j \mid \underline{X}_{2it}^j\right) = \varphi^j\left(E_{it}^j\right) + \underline{X}_{it}^{j'} \cdot \Psi^j + E\left(\theta_i^j \mid \underline{X}_{2it}^j\right) \cdot E_{it}^j + E\left(e_{it}^j \mid \underline{X}_{2it}^j\right) \qquad ;\forall j = a,\, m,\, s \tag{5}$$

Hence, the sectoral earnings equation with the controls for endogeneity of the years of education and its quadratic term, as well as allowing for heterogeneity in its returns is:

$$\ln \tilde{w}_{Lit}^j = \varphi^j\left(E_{it}^j\right) + \underline{X}_{it}^{j'} \cdot \Psi^j + \xi^j \cdot \left(v_{2it}^j \cdot E_{it}^j\right) + \alpha^j \cdot \left(v_{2it}^j\right) + \epsilon_{1it}^j \qquad ;\forall j = a,\, m,\, s \tag{6}$$

The controls, $\left(v_{2it}^j \cdot E_{it}^j\right)$ and $\left(v_{2it}^j\right)$, are included - of which v_{2it}^j can be obtained from the consistent residual estimate of the first stage regression of educational attainment (Equation (4)), $\hat{v}_{2it}^j$. Then, the coefficient estimates can be unbiasedly estimated using the OLS method on Equation (6).

The first identification requirement for the application of the control function is similar to that of the IV approach; the instruments must be uncorrelated with the error term in the outcome sectoral earnings and must explain the endogenous variable. Additionally, the exclusion restriction must be satisfied. Following the reviewed literature, the paper exploits the exogenous change in a national education policy as an instrument for the control function method. Before the 1990s, the major educational policy reform was to raise the compulsory years of schooling from four years of lower primary to six years of primary. The policy was implemented within the country in 1977. The reform affected equally the entire population of school ages, regardless of their ability levels. The first stage regression of educational attainment (Equation (4)) therefore signifies the relationship between education and influencing informative regressors, including exogenous dummy variables - indicating whether an individual was under the new 1977 education scheme and the region dummies - as instruments, as well as other included exogenous controls from the outcome earnings equation. The model treats the education policy reform as an exogenous shock affecting individual choice of education, and also uses it together with the region dummies as identifiers for the exclusion restriction requirement.

While there is no restriction on the endogenous variable in the IV estimation, the substantive restriction of the linearity between e_{it}^{j} and v_{2it}^{j} in the control function method implies that the unobserved ability, e_{it}^{j}, and the first stage regression error term, v_{2it}^{j}, are jointly independent of the exogenous instruments[1]. The additional restriction is the linear conditional expectation of the random coefficient, θ_{i}^{j}. Nonetheless, the control function approach treats endogeneity as an omitted variable problem that can be improved by including the controls for correlation between unobserved heterogeneity and levels of educational attainment. Therefore, it is more efficient when the assumptions mentioned earlier hold. The approach is less robust than the IV approach as the IV approach does not impose any restrictions on either the function of the estimated equation error terms or the endogenous variable (Imbens and Wooldridge, 2007).

4.3 Selectivity Model: Non-Random Sectoral Selection Bias

In spite of controlling for human capital and correcting for the endogeneity bias, the presence of the rates of technological progress across sectors identified by the time dummy coefficients is presumably not a sufficient condition for the acceptance of either the technological progress-driven economic growth as articulated by the single-economy Solow growth model or the human capital accumulation-driven growth. The coefficient estimates of the sectoral earnings model can be biased as the subsample in each sector is non-randomly selected (Heckman, 1979). In general, the observed higher wages or returns to education in the manufacturing sector do not necessarily imply the wages or returns agricultural workers would have earned had they switched to work in the manufacturing sector. This is because an individual optimises their utility by self-selecting the sector that yields maximum expected utility with regard to his/her comparative advantage (Roy, 1951) and other variables related to preferences that do not influence productivity and thus earnings directly.

More importantly, as the multi-sector growth model explains the economic growth process by the workforce transition towards the high productivity sector in which sectoral returns to human capital and exogenous

[1] Together with the linear model of the first stage regression, this rules out kinds of discreteness of the endogenous variables. Nonetheless, the paper follows Garen (1984) and Card (1999) by taking education choice as roughly continuous.

wages growth are expected to be higher, omission of the factors influencing the decision on sectoral choice can lead to economic growth being mistakenly attributed to technological changes or human capital rather than to sectoral shifts. Hence, this correction additionally provides an explanation for the relevance of the multi-sector growth model to the economy. If the sectoral shifts played a crucial role in the growth process, the within-sector technological progress would be expected to considerably less significant and its difference across sectors should be significant but diminishing over time when controlling for this non-random sectoral selection bias.

The analysis and correction of self-selection into sectors follows the generalised multiple choice selectivity of Lee (1983), which does not restrict the specification of correlation between the error terms of the outcome sectoral earnings and the sectoral choice models. The multinomial logit model of sectoral choice represents the sample selection rule. That is, the relative probability of sorting into sectors depends on the comparison of the expected utility one would obtain in each sector. Expected utility is conventionally dependent upon expected wages, viz regressors in the simple earnings model (Equation (2)), as well as individual preferences for sectors, which are influenced by other individual and household characteristics, and which may or may not be productivity enhancing.

The model of sectoral earnings in Equation (2) is hence conditional on sector j providing the highest utility to the worker i in period t. The multiple choice selectivity model can be written as follows:

$$\ln \tilde{w}^j_{Lit} = \varphi^j\left(E^j_{it}\right) + \underline{X}^{j'}_{it} \cdot \Psi^j + u^j_{it}\,, \qquad \text{if and only if} \qquad U^j_{it} > \max_{\mathrm{k}\neq\mathrm{j}} U^k_{it} \qquad ;\forall j = a,\, m,\, s,\, n \tag{7}$$

where a, m, s, and n represent the four sectoral alternatives of agriculture, manufacturing, services, and being without employment[2] respectively.

Alternatively, it can be rewritten in a conditional expectation term as follows:

$$E\left(\ln \tilde{w}^j_{Lit} \mid E^j_{it},\, \underline{X}^{j'}_{it},\, U^j_{it} > \max_{\mathrm{k}\neq\mathrm{j}} U^k_{it}\right) = \varphi^j\left(E^j_{it}\right) + \underline{X}^{j'}_{it} \cdot \Psi^j + E\left(u^j_{it} \mid U^j_{it} > \max_{\mathrm{k}\neq\mathrm{j}} U^k_{it}\right) \;;\forall j = a,\, m,\, s,\, n \tag{8}$$

where U^j_{it} is the expected utility of individual i working in sector j in period t, and is assumed to take the reduced form of:

$$U^j_{it} = \underline{Z}'_{it} \cdot \gamma^j + v^j_{it} \tag{9}$$

[2]This category includes both unemployed labour force and unpaid workers.

where $\underline{Z}_{it}$ is a column vector of individual and household characteristics affecting the utility of working in each sector, and γ^j is a column vector of the corresponding coefficients.

Considering the conditional expectation of the error term, $E\left(u_{it}^j \mid U_{it}^j > \max_{\mathrm{k}\neq\mathrm{j}} U_{it}^k\right)$, it is equivalent to $E\left(u_{it}^j \mid \underline{Z}_{it}' \cdot \gamma^j > \varepsilon_{it}^j\right)$ where $\varepsilon_{it}^j = \max_{k\neq j} U_{it}^k - v_{it}^j$. The conditional expectation of the error term depends on the bivariate distribution of $\left(u_{it}^j, \varepsilon_{it}^j\right)$, and hence on the marginal distributions of u_{it}^j and ε_{it}^j.[3] Therefore, the endogenous sector choice can result in the biased sectoral wage differentials if the error terms from the two equation of the outcome sectoral earnings, u_{it}^j, and the sector selection, v_{it}^j , are correlated, for example, by unobserved heterogeneity in ability, which directly affects productivity and thus sectoral earnings as well as the expected utility.

We assume that the sectoral choice decision follows the conditional multinomial logit model.[4] The probability of individual i sorting into sector j in period t are therefore expressed as:

$$P\left(U_{it}^j > \max_{\mathrm{k}\neq\mathrm{j}} U_{it}^k\right) = P\left(\varepsilon_{it}^j < \underline{Z}_{it}' \cdot \gamma^j\right) = \frac{\exp\left(\underline{Z}_{it}' \cdot \gamma^j\right)}{\sum_k \exp\left(\underline{Z}_{it}' \cdot \gamma^k\right)} \; ; \forall j = a,\, m,\, s,\, n \tag{10}$$

This multinomial logit model used for capturing the effect of individual sectoral choice optimisation can be estimated by the maximum likelihood estimation. The paper applies the selectivity correction method proposed by Lee (1983), which requires the normality transformation of the two marginal distributions of u_{it}^j and ε_{it}^j. Assuming $F_j(\varepsilon_{it})$ and $G_j(u_{it})$ to be their marginal distributions, Lee (1983) specifies the standard normal transformation $J_{1j}(\varepsilon_{it}) = \Phi^{-1}(F_j(\varepsilon_{it}))$ and $J_{2j}(u_{it}) = \Phi^{-1}(G_j(u_{it}))$, where $\Phi(.)$ is a standard normal cumulative distribution function and $\phi(.)$ is a standard normal density function. With the additional assumption of a normal distribution of u_{it}^j with mean equal to zero and variance equal to σ_{it}^j, the conditional expectation of the error term, u_{it}, is shown to be:

$$E\left(u_{it}^j \mid U_{it}^j > \max_{\mathrm{k}\neq\mathrm{j}} U_{it}^k\right) = -\sigma_{it}^j \cdot \rho^j \frac{\phi\left(J_{1j}\left(\underline{Z}_{it}^{j'} \cdot \gamma^j\right)\right)}{F_j\left(\underline{Z}_{it}^{j'} \cdot \gamma^j\right)} \tag{11}$$

The sectoral earnings equation with selectivity correction is therefore:

$$E\left(\ln \tilde{w}_{Lit}^j \mid E_{it}^j, \underline{X}_{it}^{j'}, U_{it}^j > \max_{\mathrm{k}\neq\mathrm{j}} U_{it}^k\right) = \varphi^j\left(E_{it}^j\right) + \underline{X}_{it}^{j'} \cdot \Psi^j - \sigma_{it}^j \cdot \rho^j \frac{\phi\left(J_{1j}\left(\underline{Z}_{it}^{j'} \cdot \gamma^j\right)\right)}{F_j\left(\underline{Z}_{it}^{j'} \cdot \gamma^j\right)} \tag{12}$$

or

$$\ln \tilde{w}_{Lit}^j = \varphi^j\left(E_{it}^j\right) + \underline{X}_{it}^{j'} \cdot \Psi^j - \sigma_{it}^j \cdot \rho^j \frac{\phi\left(J_{1j}\left(\underline{Z}_{it}^{j'} \cdot \gamma^j\right)\right)}{F_j\left(\underline{Z}_{it}^{j'} \cdot \gamma^j\right)} + \epsilon_{2it}^j \tag{13}$$

[3] The distribution of ε_{it}^j can be implied from the distribution of the error term of the sector choice equation, v_{it}^j.

[4] I.e. the error term, v_{it}^j, is identically and independently type I extreme value distributed (McFadden, 1973).

where $E\left(\epsilon_{2it}^{j} \mid E_{it}^{j}, \underline{X}_{it}^{j}\right) = 0$ and $E\left(\epsilon_{2it}^{j} \mid \underline{Z}_{it}^{j}\right) = 0$. This sectoral earnings equation with selectivity correction can be estimated by the two-stage method, similar to that of Heckman (1979). The correction term can be obtained from the consistent estimate of parameter from the maximum likelihood estimation of the multinomial logit model of sectoral choice (Equation (10)), $\hat{\gamma}^{j}$. Then, Equation (13) can be estimated by the standard OLS.

The identification requirement for the selection process is the condition of exclusion restriction. The exclusion restriction identifiers of the sectoral choice model are the number of children in different age groups, spouse's earnings, the number of household members, and the region and the area of residence. These household characteristics are likely to have an effect on the labour supply decision and individual choice of occupation while being exogenous in general, and thus, non-pecuniary factors (Cunningham, 2001).[5]

Through the Monte Carlo experiments, Bourguignon et al. (2007) show that the selection bias correction following the framework of the multinomial logit model provides a reasonably good correction for the outcome equation, in spite of the violation of the independence of irrelevant alternatives hypothesis. They also point out the restrictive assumptions that the correlation between u_{it} and $\left(v_{it}^{k} - v_{it}^{j}\right)$ are of the same sign for all k; and $\left(v_{it}^{k} - v_{it}^{j}\right)$ is independent and identically distributed.

4.4 The Final Estimating Model of Sectoral Earnings

Combining both econometric corrections into the earnings model, the final estimating sectoral earnings model can therefore be written as:

$$\ln \tilde{w}_{Lit}^{j} = \varphi^{j}\left(E_{it}^{j}\right) + \underline{X}_{it}^{j'} \cdot \Psi^{j} + \xi^{j} \cdot \left(\hat{v}_{2it}^{j} \cdot E_{it}^{j}\right) + \alpha^{j} \cdot \left(\hat{v}_{2it}^{j}\right) - \sigma_{it}^{j} \cdot \rho^{j} \frac{\phi\left(J_{1j}\left(\underline{Z}_{it}^{j'} \cdot \hat{\gamma}^{j}\right)\right)}{F_{j}\left(\underline{Z}_{it}^{j'} \cdot \hat{\gamma}^{j}\right)} + \epsilon_{it}^{j} \tag{14}$$

where ϵ_{it}^{j} is the true error term which has a zero mean and satisfies the assumption of strict exogeneity. $\hat{v}_{2it}^{j}$ is a residual estimate from the control function first stage regression of educational attainment, while $\hat{\gamma}^{j}$ is a consistent parameter estimate from the multinomial logit model of sectoral choice. This corrected model of sectoral earnings will be used for the final empirical investigation and the paper will compare these results with the basic OLS estimation to identify the relevance of the growth models as well as human capital accumulation to the economy of Thailand.

[5] It is to be noted that some of them, for instance, the region variables, may affect earnings through local cost of living and thus the based salary for wage employment workers.

5 Results

We investigate the explanation of Thai economic development by testing the model of sectoral earnings with the micro-level data from the national Labour Force Surveys. The underlying empirical questions of the paper on the labour market outcome of the Thai macroeconomic evidence are therefore whether there exists a uniform rate of exogenous growth in sectoral earnings, how they change after controlling for human capital and occupational optimisation, and how the returns to human capital vary across sectors.

5.1 Standard OLS Estimation of the Sectoral Earnings Model

Within this framework, the econometric investigation begins with the simple estimation of a sectoral earnings equation, controlling for observed human capital and productive characteristics as specified in Equation (2). The basic OLS estimation documents the start-off depiction of the growth in earnings over time and the returns to human capital by sector. This is shown in Table 5 on page 17. The first column displays the pooled earnings estimation with the additional sectoral dummy variables (of which agriculture is the omitted category). The pooled sample contains all the working population whose earnings were observed, in other words those selected to work. The returns to education are significantly convex, while the age earnings profile is concave. Agricultural workers earned substantially less than those in the other two sectors by nearly two folds *ceteris paribus*. The year dummies also indicate growth in real hourly earnings about 1.4 per cent per annum, holding other things constant. The separated sectoral earnings estimation (as shown in the subsequent columns) confirms the difference in returns to human capital across sectors. While the manufacturing sector exhibits the highest degree of convexity, the service sector yields the highest returns for workers with low and middle levels of education. Meanwhile, despite being less convex than is the case in the manufacturing sector, the returns to education in the agricultural sector are still comparable to those from the pooled regression. The age earnings profiles are concave in all sectors. Interestingly, considering the year dummies, the sectoral earnings growth after controlling for human capital is considerably less than what can be observed from the descriptive statistics - implying the importance of human capital accumulation to the economy. Furthermore, the rates of growth in earnings of agriculture and services are comparable and higher than those of the manufacturing sector. Between 1985 and 2000, earnings in the agricultural sector exogenously grew 1.67 per cent annually on average, while the rates of earnings growth in services and manufacturing were 1.13 and 0.59 per cent per annum respectively.

While imposing controls in line with the human capital theory, the basic OLS estimations show the differentials in returns to human capital across sectors, as well as the relative importance of human capital accumulation. In spite of being less relevant, the fact that the highest rate of growth of hourly earnings was within the agricultural sector to some extent challenges the assumption that Thailand underwent a labour force transition in the multi-sector economy. However, as discussed earlier, the estimates of returns to education as well as other coefficients may be subject to endogeneity and selectivity biases. The empirical investigation requires further corrections on endogeneity and selectivity issues in order to obtain the real growth of earnings within the sector with the unbiased coefficient estimates of the model.

Table 5: Standard OLS Estimation for the Pooled and Sectoral Earnings Functions

Ln(Hourly Earnings)	Pooled	Agri.	Manufac.	Service
Educ(years)	0.0487***	0.0373***	0.0439***	0.0825***
Educsq/100	0.266***	0.264***	0.381***	0.131***
Ln(hours worked per week)	−0.915***	−1.068***	−0.783***	−0.766***
Age	0.0603***	0.0341***	0.0755***	0.0895***
Agesq/100	−0.0606***	−0.0332***	−0.0824***	−0.0877***
1[Wage employed]	0.112***	0.287***	0.0505***	−0.0628***
1[Male]	0.241***	0.227***	0.336***	0.235***
1[Manufacturing]	0.607***			
1[Service]	0.750***			
1[Married]	0.0511***	0.0342***	0.0555***	0.0545***
1[Year1986]	−0.0537***	−0.0442**	−0.0280	−0.0630***
1[Year1987]	−0.0710***	−0.0886***	−0.0870***	−0.0670***
1[Year1988]	0.0141	0.0910***	−0.108***	−0.0288**
1[Year1989]	0.0527***	0.148***	−0.0922***	0.000771
1[Year1990]	0.0975***	0.186***	−0.0509***	0.0819***
1[Year1991]	0.0659***	0.0915***	−0.0121	0.0770***
1[Year1992]	0.169***	0.210***	0.0511***	0.180***
1[Year1993]	0.206***	0.183***	0.135***	0.264***
1[Year1994]	0.226***	0.238***	0.134***	0.258***
1[Year1995]	0.288***	0.298***	0.198***	0.321***
1[Year1996]	0.335***	0.396***	0.196***	0.353***
1[Year1997]	0.350***	0.403***	0.231***	0.369***
1[Year1998]	0.296***	0.423***	0.175***	0.236***
1[Year1999]	0.220***	0.276***	0.113***	0.200***
1[Year2000]	0.206***	0.248***	0.0881***	0.198***
Constant	3.863***	5.041***	3.732***	3.322***
R-squared	0.497	0.218	0.399	0.552
# Observations	1,652,443	444,123	397,978	810,342

Pooled Regression: Omitted sectoral category is Agriculture.
All Regressions: Omitted year for the year dummies is the Year 1985.
All Regressions: The results are robust to gender.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (with the robust standard errors)

5.2 Control Function Estimation

Due to there being only a single well-grounded instrument available as well as the assumptions of non-linearity in the endogenous regressor and random coefficient, the control function approach is applied for the endogeneity correction. The first stage regression of the years spent in education as a dependent variable is shown in Table 6 on page 18. The first column shows the estimation for the pooled sample. The 1977 education policy reform significantly increased educational attainment by 0.26 year on average. The population in the north region (the omitted category) spent fewer years in schooling relative to other regions. *Ceteris paribus*, people in cities had about one more year of schooling than those in rural areas. The coefficients on age variables imply that education increased slowly with age among the young population and declined with age among the old. In the separated sectoral estimation, the reform affected most those in agriculture, followed by manufacturing workers. Nonetheless, holding other things constant and controlling for time effects, the reform had negative effects on workers in the service sector. These could possibly be attributable to the fact that the reform affected population with less than six years of primary schooling while service workers had relatively higher education.

Table 6: First Stage Regression of Educational Attainment

Years of Education	Pooled	Agri.	Manufac.	Service
1[1977Reform]	0.263^{***}	0.655^{***}	0.281^{***}	-0.342^{***}
Age	0.0922^{***}	-0.106^{***}	0.0434^{***}	0.326^{***}
Agesq/100	-0.190^{***}	0.0646^{***}	-0.163^{***}	-0.503^{***}
1[Male]	0.556^{***}	0.433^{***}	0.622^{***}	0.146^{***}
1[Municipality]	0.948^{***}	0.382^{***}	0.942^{***}	1.088^{***}
1[Northeast]	0.488^{***}	0.428^{***}	0.0426	0.290^{***}
1[South]	0.282^{***}	0.411^{***}	0.413^{***}	0.145^{***}
1[Central]	0.257^{***}	0.466^{***}	0.709^{***}	-0.165^{***}
1[Bangkok]	0.831^{***}	0.994^{***}	1.160^{***}	0.280^{***}
1[Manufacturing]	0.317^{***}			
1[Service]	2.456^{***}			
Constant	8.746^{***}	6.611^{***}	8.399^{***}	11.73^{***}
R-squared	0.340	0.200	0.197	0.304
# Observations	1,652,443	444,123	397,978	810,342

Pooled Regression: Omitted sectoral category is Agriculture.
All Regressions: Omitted region dummy is the North Region.
All Regressions: The results are robust to gender.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (with the robust standard errors)

By imposing linear restrictions on the error terms and the random coefficient of education, the residual from the first stage regression and its interaction with years of education are used as controls for the endogeneity of education. Table 7 on page 21 shows the OLS estimation incorporated with the controls of an endogenous choice of education. The control functions dramatically change the results of the estimation. In comparison to the standard OLS estimation, made using the pooled estimation in the first column, the returns to education become significantly concave. Holding other things constant and considering the coefficient estimates of sectoral dummy variables, workers in the manufacturing sector become the highest earners, and the earnings gap between those in agriculture and services drops significantly. From the separated earnings estimations, the returns to education in agriculture and manufacturing convert to being significantly concave, while the convexity remains in the service sectors. The concavity in manufacturing possibly appears to be consistent with the expansion of the labour-intensive manufactured exports, which required mostly a low- and medium-skilled workforce. Nonetheless, the returns to education in all sectors are higher than those of the standard OLS for almost every level of education, except those that have attained the tertiary level of education in agriculture and manufacturing. The gap in returns to education between agricultural and manufacturing workers slightly narrows with years of education. The service sector yields higher returns to education than the agricultural sector for the working population who have attained higher than the primary level, while it only yields higher returns than manufacturing for workers who completed at least the lower secondary level. The age earnings profiles remain concave for agriculture and manufacturing.

The control function estimation suggests a significant downward bias for all sectors, as well as a convex bias for the agricultural and the manufacturing sectors, in the standard OLS estimates of the returns to education. These downward biases are in opposition to most of the IV literature on ability bias (Card, 1999). However, they are in line with the pseudo-panel estimation of returns to education in Thailand by Warunsiri and McNown (2009), which suggests the effects of the opportunity costs of education, meaning the more able workers have fewer years of education due to the higher opportunity costs. The concavity in returns to education in agriculture and manufacturing indicates that the opportunity costs were high for able workers up to the middle level of education, then dropped in compensation for higher returns for those with a higher level of education. Under the conditions that the 1977 education reform is a valid and informative instrument, the estimates are qualified subject to endogeneity. Furthermore, the coefficient estimates of the residual control function are negative, while those of the residual interacting with education are positive for all sectors. Garen (1984) interprets this as the "comparative advantage hypothesis" of Willis and Rosen (1979). The negative effects on earnings of positive unobservables in the first stage regression decline as years of education increase. Moreover, these negative effects diminish faster in the manufacturing sector.[6]

On another important aspect of sectoral technological changes, after the endogeneity problem correction, the coefficient estimates on the year dummies (up to the year 1996, before the financial crisis) are approximately halved in all sectors and become negative for manufacturing. The negative rate of exogenous earnings growth in the advanced sector further raises the concerns about the relevance of the structural transformation in explaining the economy. Additionally, the substantial declines in the exogenous growth after controlling for human capital also continue to support the view that human capital accumulation appeared to make a major contribution to the development process.

[6]Further investigation reveals that the results of the concavity in returns to education is sensitive to the inclusion of the residual interacted education control function, underlying the interactions between unobserved heterogeneity and the endogenous explanatory variable. (The result is not shown here.)

5.3 Multinomial Logit Model of Sectoral Choice

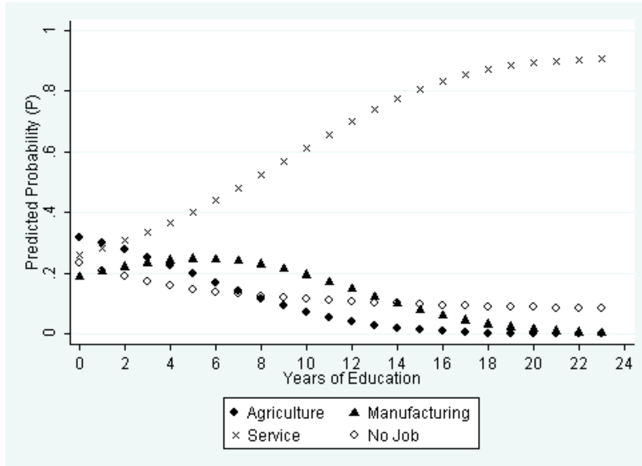
As the OLS estimates of the sectoral earnings model are estimated from the non-randomly selected samples, the examination of the relative importance of human capital accumulation against the within-sector technological progress to the economy further requires correction for the possible bias resulting from workers self-selecting their own sectors. Additionally, the sectoral selection implies the labour movement across the sector over the period, and thus, captures the effects of labour transition on economic growth. After the selectivity correction, if labour reallocation was the answer for the Thai economic development process, the exogenous growth in sectoral earnings would expected to be less significant and higher in the modern sectors. A multinomial logit model, capturing the sectoral optimisation process, is constructed for the selectivity correction, as well as to take the process of sectoral shifts into account. Table 9 on page 31 in the Appendix shows the maximum likelihood estimation of the multinomial logit model of sectoral choice, in which the based category is being without employment. The sectoral choice model is driven to a significant degree by a non-linearity specification in human capital regressors. However, interpretation of the coefficient estimates is complicated in the multinomial logit model since marginal effects are not linear in the independent variables. In addition, the basic estimation of marginal effects does not apply to some of them (including years of education and age) as the squared terms are included in the model. The effects of years of education and age are presented alternatively in terms of the predicted probability of sorting oneself into each sector due to the variation in these two variables, holding other regressors at their mean values. Figure 2 on page 22 shows that as years of education increase, the predicted probabilities of being in agriculture and without job decline and that this is more significant among female workers. The probability of being in the service sector rises substantially with years of education, while that of being in the manufacturing sector gradually rises with higher levels of educational attainment until reaching six years of schooling, which is equivalent to completion of primary education, then diminishes continually with more years of education. The age effects on the probability of being in each sector are shown in Figure 3 on page 23. The patterns are concave for both male and female workers in the manufacturing and the service sectors, and convex for the without employment category. The predicted probability of being in services is the highest among the three employment sectors and increases more rapidly for the middle-aged workers.

Table 7: Control Function Estimation for the Pooled and Sectoral Earnings Functions

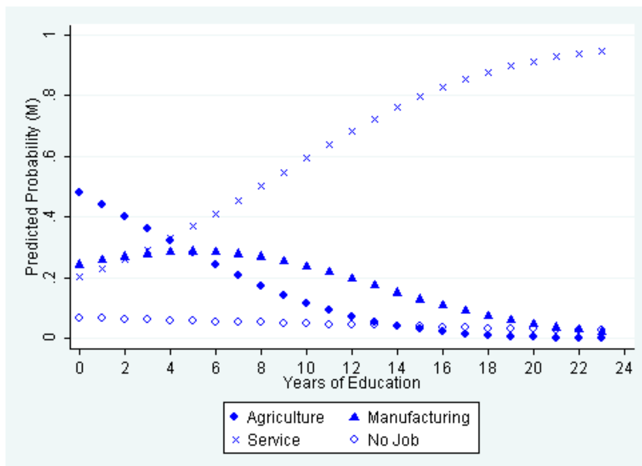
Ln(Hourly Earnings)	Pooled	Agri.	Manufac.	Service
Educ(years)	0.350^{***}	0.444^{***}	0.563^{***}	0.307^{***}
Educsq/100	-0.446^{***}	-1.276^{***}	-1.422^{***}	0.0634^{*}
Ln(hours worked per week)	-0.565^{***}	-1.041^{***}	-0.399^{***}	-0.143^{***}
Age	0.0398^{***}	0.0709^{***}	0.0512^{***}	0.00941^{***}
Agesq/100	-0.0178^{***}	-0.0587^{***}	-0.0161^{***}	0.0315^{***}
1[Wage employed]	-0.183^{***}	0.403^{***}	-0.0136	-0.754^{***}
1[Male]	0.125^{***}	0.104^{***}	0.167^{***}	0.208^{***}
1[Manufacturing]	0.415^{***}			
1[Service]	0.0879^{***}			
1[Married]	0.156^{***}	0.0582^{***}	0.258^{***}	0.207^{***}
1[Year1986]	-0.0921^{***}	-0.0829^{***}	-0.0643^{***}	-0.138^{***}
1[Year1987]	-0.124^{***}	-0.148^{***}	-0.163^{***}	-0.149^{***}
1[Year1988]	-0.0807^{***}	0.0158	-0.310^{***}	-0.152^{***}
1[Year1989]	-0.0581^{***}	0.0450^{***}	-0.298^{***}	-0.143^{***}
1[Year1990]	-0.0185^{**}	0.0714^{***}	-0.251^{***}	-0.0654^{***}
1[Year1991]	-0.0631^{***}	-0.0305^{**}	-0.248^{***}	-0.0806^{***}
1[Year1992]	0.0102	0.0558^{***}	-0.189^{***}	-0.0342^{***}
1[Year1993]	0.0341^{***}	0.0115	-0.143^{***}	0.0409^{***}
1[Year1994]	0.0416^{***}	0.0423^{***}	-0.159^{***}	0.0324^{***}
1[Year1995]	0.0944^{***}	0.0868^{***}	-0.125^{***}	0.0949^{***}
1[Year1996]	0.142^{***}	0.174^{***}	-0.109^{***}	0.116^{***}
1[Year1997]	0.131^{***}	0.163^{***}	-0.144^{***}	0.129^{***}
1[Year1998]	0.0208^{***}	0.136^{***}	-0.286^{***}	-0.0893^{***}
1[Year1999]	-0.0909^{***}	-0.0334^{*}	-0.450^{***}	-0.156^{***}
1[Year2000]	-0.130^{***}	-0.0945^{***}	-0.499^{***}	-0.192^{***}
Residual	-0.275^{***}			
Resid*Educ	0.00964^{***}			
Residual-Agri		-0.357^{***}		
ResidAgri*educ		0.0173^{***}		
Residual-Manu			-0.444^{***}	
ResidManu*educ			0.0208^{***}	
Residual-Serv				-0.226^{***}
ResidServ*educ				0.00100^{***}
Constant	1.673^{***}	2.685^{***}	0.0800	0.887^{***}
R-squared	0.510	0.224	0.493	0.570
# Observations	1,652,443	444,123	397,978	810,342

Pooled Regression: Omitted sectoral category is Agriculture.
All Regressions: Omitted year for the year dummies is the Year 1985.
Residual terms denote the residual controls.
Resid*Educ terms denote the residuals' interaction with education.
All Regressions: The results are robust to gender.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (with the robust standard errors)

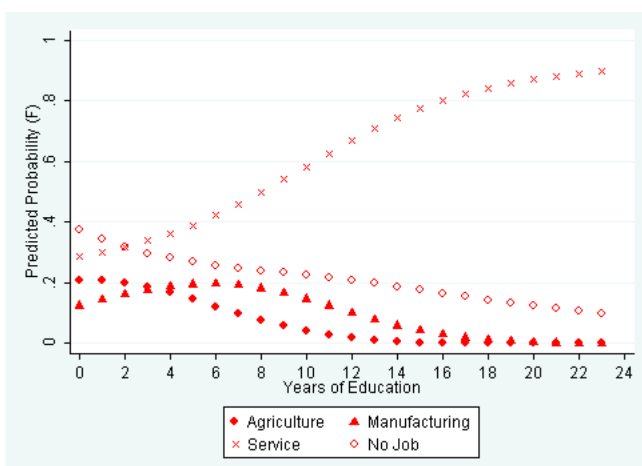
Figure 2: Effects of Education on the Predicted Probability of the Sectoral Choices



(a) Predicted Probability for the Pooled Sample



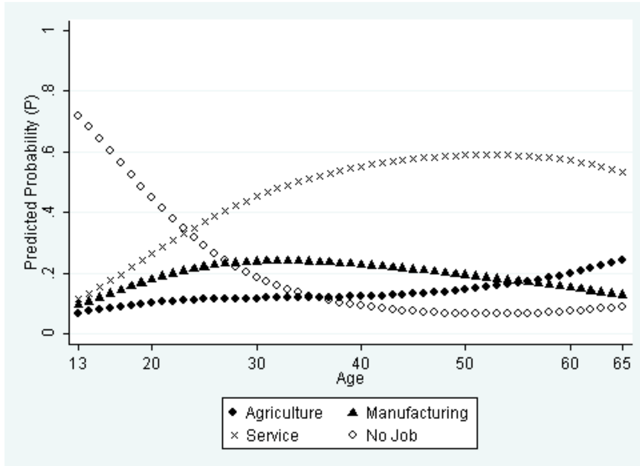
(b) Predicted Probability for Male Workers



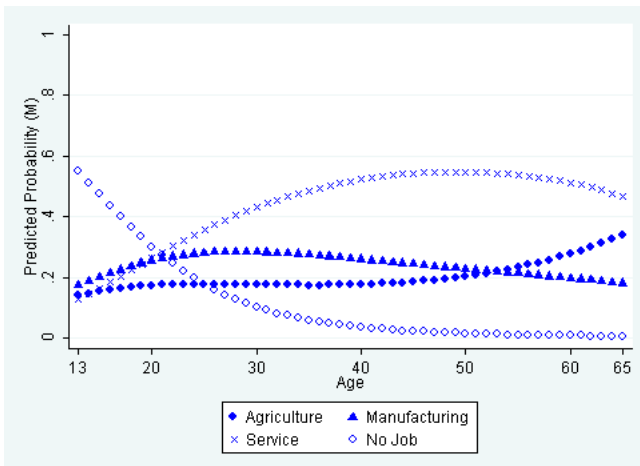
(c) Predicted Probability for Female Workers

Notes: The service sector comprises of heterogeneous activities ranging from government and banking employment to retail trading and personal services.

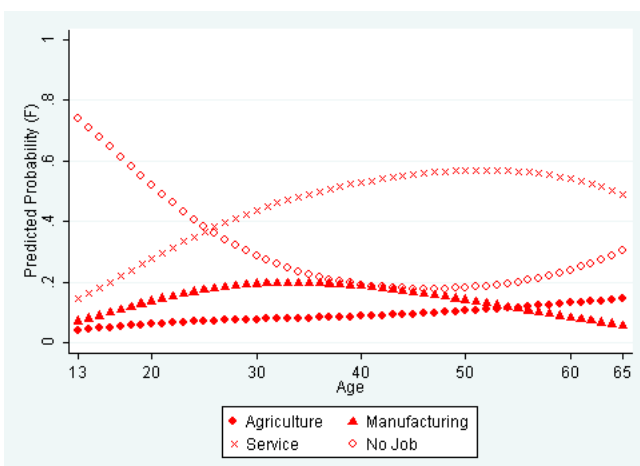
Figure 3: Effects of Age on the Predicted Probability of the Sectoral Choices



(a) Predicted Probability for the Pooled Sample



(b) Predicted Probability for the Pooled Sample



(c) Predicted Probability for the Pooled Sample

Notes: The service sector comprises of heterogeneous activities ranging from government and banking employment to retail trading and personal services.

5.4 The Final Estimation Model of Sectoral Earnings

The sectoral earnings model with selectivity correction after the multinomial logit estimation follows the method of Lee (1983) as discussed previously. The selectivity bias correction terms are formulated from the standard normal transformed marginal distributions and the marginal distributions of the error terms from the sectoral choice model. The marginal distribution of the error terms is obtained from the probability of sorting into a sector (Equation (10)). The correction terms are calculated separately for each sectoral earnings equation.

The second, third, and fourth columns of Table 8 on page 25 show the sectoral earnings model with corrections for both endogeneity of education and sectoral selection.[7] In comparison to the OLS estimation with the endogeneity correction, the returns to education in all sectors decline, however they remain significantly higher than the standard OLS estimation. The concavity remains in agriculture and manufacturing, while the education-earnings profile in services continues to be convex. The selection process exhibits biased estimates of the returns to education in the standard OLS and the OLS with the endogeneity correction, relatively more for lower educational levels. The coefficients of the selectivity correction terms are significantly negative in the sectoral earnings model for the manufacturing and the service sectors, but appear positive in the case of agriculture. The unobserved productive ability (in the outcome earnings equation) is therefore negatively correlated with the unobservables in the sectoral selection process for agricultural workers, and positively correlated with those in the other two sectors. This implies that agricultural workers would earn less than those in non-agricultural sectors had they migrated into these sectors. The opposite holds for non-agricultural workers had they been in the agricultural sector, with the coefficient of the selectivity correction term in services being of the greatest magnitude.

While the concavity in returns to education remains, the selectivity correction suggests downward bias when allowing for endogeneity. The effect of human capital accumulation to the economy continues to be relatively significant. The objective of the selectivity correction is also to examine whether the sectoral selection process explained the economic growth in Thailand. Most interestingly, after all controls for human capital and other observed characteristics as well as the sectoral shifts had been carried out, the exogenous growth in the sectoral earnings remains different across sectors and less substantial. This is of crucial importance. The service sector became the highest earnings growth sector. Moreover, the exogenous rises in agricultural earnings were higher than those of manufacturing sector (of which the exogenous earnings growth was negative). *Ceteris paribus*, earnings increased nearly 2.08 per cent per annum in agriculture and 2.84 per cent per annum in services by 1996 which was the year before the financial crisis. Meanwhile, in spite of the higher sectoral returns to education, the manufacturing sector attained an exogenous negative

[7] In order to allow a direct comparison of the selectivity bias from the standard OLS estimation, the econometric results for the estimation of the model with only the correction of selectivity are provided in Table 10 on page 32 in the Appendix.

growth in earnings of 1.17 per cent per annum over the same period. These results contradict the importance of the multi-sector economic structural changes to the development process of Thailand. While the relevance of within-sector technological progress is still ambiguous, the human capital accumulation process become of attention as it had predominantly explained the earnings growth in all sectors.

Table 8: Endogeneity and Selectivity Correction for the Pooled and Sectoral Earnings Functions

Ln(Hourly Earnings)	Pooled	Agri.	Manufac.	Service
Educ(years)	0.268***	0.333***	0.479***	0.119***
Educsq/100	−0.339***	−1.241***	−1.112***	0.158***
Ln(hours worked per week)	−0.643***	−1.037***	−0.452***	−0.589***
Age	0.0422***	0.0650***	0.0501***	0.0434***
Agesq/100	−0.0245***	−0.0545***	−0.0182***	−0.0300***
1[Wage employed]	−0.181***	0.347***	−0.257***	−0.411***
1[Male]	0.201***	0.272***	0.167***	0.246***
1[Manufacturing]	0.925***			
1[Service]	0.765***			
1[Married]	0.131***	0.0461***	0.229***	0.135***
1[Year1986]	−0.0817***	−0.0658***	−0.0598***	−0.0854***
1[Year1987]	−0.108***	−0.124***	−0.150***	−0.0856***
1[Year1988]	−0.0529***	0.0415***	−0.277***	−0.0530***
1[Year1989]	−0.0242***	0.0835***	−0.280***	−0.0200*
1[Year1990]	0.00867	0.103***	−0.254***	0.0649***
1[Year1991]	−0.0350***	0.000635	−0.251***	0.0530***
1[Year1992]	0.0460***	0.0977***	−0.195***	0.151***
1[Year1993]	0.0725***	0.0571***	−0.145***	0.222***
1[Year1994]	0.0792***	0.0871***	−0.165***	0.219***
1[Year1995]	0.132***	0.135***	−0.140***	0.280***
1[Year1996]	0.177***	0.226***	−0.129***	0.308***
1[Year1997]	0.174***	0.215***	−0.150***	0.321***
1[Year1998]	0.0863***	0.212***	−0.260***	0.166***
1[Year1999]	−0.0134	0.0539**	−0.402***	0.117***
1[Year2000]	−0.0443***	0.00851	−0.452***	0.111***
Lee-Agri	0.269***	0.257***		
Lee-Manu	−0.145***		−0.258***	
Lee-Serv	−0.208***			−0.382***
Residual	−0.209***			
Resid*Educ	0.00840***			
Residual-Agri		−0.254***		
ResidAgri*educ		0.0151***		
Residual-Manu			−0.386***	
ResidManu*educ			0.0193***	
Residual-Serv				−0.0704***
ResidServ*educ				−0.000215
Constant	2.024***	2.944***	1.227***	3.724***
R-squared	0.516	0.229	0.495	0.577
# Observations	1,652,443	444,123	397,978	810,342

Pooled Regression: Omitted sectoral category is Agriculture.
All Regressions: Omitted year for the year dummies is the Year 1985.
Residual terms denote the residual controls.
Resid*Educ terms denote the residuals' interaction with education.
Lee terms denote the selectivity correction terms.
All Regressions: The results are robust to gender.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (with the robust standard errors)

6 Conclusion

To conclude, the paper has examined the major sources of economic growth in Thailand during the period of industrialisation - the Solow technological progress; the Lewis sectoral reallocation; and the human capital accumulation - by exploiting the connection between the macroeconomic evidence and the labour market outcomes. The sectoral earnings model obtained from the human capital-augmented sectoral production is used as a test based on the micro-level data from the national Labour Force Survey during the period 1985-2000. With this approach, the analysis initially takes into account both the effects of labour reallocation on and the relative importance of the inter- and intra-sectoral differences in technological progress. This is in contrast to the reviewed literature which presumes no technological progress in the traditional sector and thus focuses only on the explanation of an economic structural change, that is the effects of labour reallocation towards the advanced sector on the economy (Jeong and Townsend, 2007; Jeong and Kim, 2007). With the controls for human capital and sectoral reallocation in place, we find that the sectoral earnings substantially rose over time only for the service and the agricultural sectors while those of the manufacturing sector surprisingly declined. The empirical results of the study therefore contradict the importance of labour reallocation to economic growth in Thailand during the high growth period. Although the sectoral exogenous technological progress in the agricultural and the service sectors did interestingly play some role in the booming Thai economy, this was not a major part compared to the contribution of human capital accumulation.

Nonetheless, there are some potential gaps in the analysis that lead the paper to further constructive extensions. These involve techniques to strengthen the results with regards to the sectoral selection process and the endogeneity problems, as well as a parallel study of the labour demand in Thailand. Firstly, while the paper has modelled the potential bias in returns to human capital and in other coefficients from selection into sectors, it has not addressed the question as to whether the sectoral selection process and human capital could have dynamic consequences. Therefore, there is reason to further develop the model of a sectoral selection process that affects time dummy variables as well as to develop the model that allows for changes in returns to human capital over time. Secondly, the endogeneity correction on educational attainment entirely rests on the validity of our instrument, the education policy reform. While imposing the method of control function to correction an endogeneity problem, the single available instrument risks bias from a weak instrument if it is also correlated with the unobservables in the outcome sectoral earnings function. Another possible extension is thus to test the proposed hypothesis using the cohort analysis, tracking different cohorts through repeated cross-sectional surveys.[8] The synthetic cohort data can be constructed from a repeated cross-

[8] Warunsiri and McNown (2009) point to the weakness of using cross-sectional data to capture age effects and employ the cohort analysis for their study of returns to education in Thailand. Their estimates suggest a downward bias, which can be explained by high opportunity costs of schooling with higher returns for urban workers. In addition, their estimations do not focus on the variation in educational returns across sectors and the exogenous growth of sectoral earnings. By ignoring the sectoral selection process, their analysis is potentially subject to selectivity bias. Covering the period 1986-2005 allows their study to follow only the earnings of wage employees while the proportion of self-employment in the LFS was nearly one half.

sectional survey and such an approach enables “the possibility of following groups of people from one survey to another” (Deaton, 1997). Thirdly, in attempting to raise concerns about the common acknowledgement of the dual economy growth model as a characteristic of a small open developing country, such as Thailand, in the labour supply aspect, the additional extension is plausibly a parallel study of the labour demand evolution in Thailand using the firm-level data from the Industrial Survey. The research questions posed are then how changes in firm-size distribution, skilled and unskilled labour, capital intensity, and employment creation played a role in Thailand’s economic growth. This is expected to provide a comprehensive analysis of Thailand’s labour market in models of economic growth.

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Table 9: Multinomial Logit Estimation of the Sectoral Choice Model

Sectoral Choice	Agri.	Manufac.	Service
Educ(years)	0.0731***	0.218***	0.200***
Educsq/100	−1.509***	−1.450***	−0.449***
Age	0.168***	0.240***	0.269***
Agesq/100	−0.134***	−0.250***	−0.256***
1[Married]	0.703***	0.585***	0.520***
1[Divorced]	2.052***	1.835***	1.905***
#Children<6yrs	0.336***	0.157***	0.226***
#Chiledren6-13yrs	0.291***	0.102***	0.153***
Spouse's wage	−0.0240***	−0.00685***	−0.00482***
1[Male]	2.000***	1.626***	1.280***
#HH members	−0.170***	−0.0499***	−0.118***
1[Northeast]	−0.0577***	−0.203***	−0.241***
1[South]	0.229***	0.179***	0.385***
1[Central]	0.0330	0.595***	0.172***
1[Bangkok]	−1.729***	1.018***	0.666***
1[Municipality]	−0.556***	0.831***	1.357***
1[Wage employed]	3.200***	5.188***	4.028***
1[Year1986]	0.0831**	0.0147	−0.0132
1[Year1987]	0.148***	0.152***	0.0898**
1[Year1988]	0.0391	0.0330	−0.0797**
1[Year1989]	0.0686***	0.141***	−0.0920***
1[Year1990]	0.0477*	0.399***	−0.00148
1[Year1991]	0.0945***	0.558***	0.137***
1[Year1992]	0.0499*	0.528***	0.00654
1[Year1993]	0.0566**	0.626***	0.119***
1[Year1994]	0.0923***	0.765***	0.198***
1[Year1995]	0.0996***	0.908***	0.286***
1[Year1996]	0.111***	0.958***	0.300***
1[Year1997]	−0.00505	0.822***	0.194***
1[Year1998]	−0.0479*	0.543***	0.0414
1[Year1999]	−0.0188	0.504***	0.0361
1[Year2000]	0.0534**	0.601***	0.0387
Constant	−5.265***	−9.598***	−9.068***
Chi-squared		115170	
Pseudo R-squared		0.3594	
# Observations		2,243,511	

Based category : Being without employment

All Regressions:The results are robust to gender.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (with the robust standard errors)

Table 10: OLS Estimation with Selectivity Correction for the Pooled and Sectoral Earnings Functions

Ln(Hourly Earnings)	Pooled	Agri.	Manufac.	Service
Educ(years)	0.0296^{***}	0.0326^{***}	-0.0338^{***}	0.0444^{***}
Educsq/100	0.286^{***}	0.0829^{**}	0.993^{***}	0.142^{***}
Ln(hours worked per week)	-0.896^{***}	-1.053^{***}	-0.766^{***}	-0.801^{***}
Age	0.0561^{***}	0.0425^{***}	0.0606^{***}	0.0644^{***}
Agesq/100	-0.0543^{***}	-0.0393^{***}	-0.0578^{***}	-0.0640^{***}
1[Wage employed]	0.00171	0.265^{***}	-0.823^{***}	-0.217^{***}
1[Male]	0.301^{***}	0.382^{***}	0.247^{***}	0.259^{***}
1[Manufacturing]	1.252^{***}			
1[Service]	1.452^{***}			
1[Married]	0.0572^{***}	0.0305^{***}	0.0651^{***}	0.0925^{***}
1[Year1986]	-0.0529^{***}	-0.0388^{**}	-0.0277	-0.0603^{***}
1[Year1987]	-0.0669^{***}	-0.0823^{***}	-0.0812^{***}	-0.0564^{***}
1[Year1988]	0.0192^{**}	0.0924^{***}	-0.0974^{***}	-0.00886
1[Year1989]	0.0603^{***}	0.154^{***}	-0.134^{***}	0.0333^{***}
1[Year1990]	0.0940^{***}	0.178^{***}	-0.163^{***}	0.121^{***}
1[Year1991]	0.0587^{***}	0.0805^{***}	-0.142^{***}	0.111^{***}
1[Year1992]	0.162^{***}	0.199^{***}	-0.0932^{***}	0.231^{***}
1[Year1993]	0.198^{***}	0.170^{***}	-0.0154	0.303^{***}
1[Year1994]	0.212^{***}	0.214^{***}	-0.0404^{***}	0.302^{***}
1[Year1995]	0.270^{***}	0.272^{***}	-0.0200	0.362^{***}
1[Year1996]	0.314^{***}	0.370^{***}	-0.0301^{**}	0.394^{***}
1[Year1997]	0.330^{***}	0.369^{***}	0.0155	0.408^{***}
1[Year1998]	0.287^{***}	0.399^{***}	0.0187	0.281^{***}
1[Year1999]	0.214^{***}	0.256^{***}	-0.0215	0.242^{***}
1[Year2000]	0.202^{***}	0.233^{***}	-0.0661^{***}	0.249^{***}
Lee-Agri	0.362^{***}	0.310^{***}		
Lee-Manu	-0.210^{***}		-0.891^{***}	
Lee-Serv	-0.300^{***}			-0.478^{***}
Constant	3.609^{***}	4.465^{***}	5.926^{***}	4.801^{***}
R-squared	0.509	0.227	0.455	0.577
# Observations	1,652,443	444,123	397,978	810,342

Pooled Regression: Omitted sectoral category is Agriculture.
All Regressions: Omitted year for the year dummies is the Year 1985.
Lee terms denote the selectivity correction terms.
All Regressions: The results are robust to gender.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ (with the robust standard errors)