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## Cost Efficiency in Japanese Local Governments: the Economic Effect of Information Technology in Japanese Local Governments

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**Paper for the 46th Congress of the European Regional Science Association**

**Cost Efficiency in Japanese Local Governments:  
“The Economic Effect of Information Technology in Japanese Local Governments”**

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**Cost Efficiency in Japanese Local Governments:  
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**1. Introduction**

At present, many Japanese local governments are confronted with a serious fiscal crisis due to an annual decrease of tax revenues of local governments. Unfortunately, tax revenues cannot increase drastically because of the slow Japanese economy. Therefore, local governments should make an effort to operate more cost efficiently and reduce fiscal expenditure.

In order to reduce fiscal expenditure, local governments attempt to implement policies, such as personnel reduction, private consignment of public services and so on. The introduction of information technology is also one of the policies related to cost reduction. Many people think that information technology contributes to increased productivity and cost saving. For example, we can administrate office work more rapidly and efficiently using computers, as well as communicate more effectively through computer network and telecommunication equipment. Further, information technology contributes to a paper-less environment and the reduction of staff, working hours, and so on.

Local governments attempt to use information technology to operate more cost efficiently. In 2000, the Ministry of Internal Affairs and Communications developed a plan about information technology investment in local governments. Local governments introduced personal computers and constructed a local area network (LAN) in own government and a wide area network (WAN) between other governments, for example: Osaka; and the Hyogo central government etc.

However, we believe that due to the current fiscal crisis faced by many local governments, the implementation of the information technology investment policy could contribute to a further financial burden because information technology investment is costly. Therefore, we think we should examine whether or not information technology investment within local governments is necessary and to what extent. So, if information technology investment is not effective we need to consider other alternative policies and ways to use the local government's financial resources more efficiently.

In this paper, we investigate whether or not information technology contributes to cost efficiency in municipal governments in the Kinki area in Japan. The hypotheses that we test are as follows. Firstly, the increased use of information technology equipment by local governments, results in greater cost efficiency. Secondly, increased staff engaged to specifically operate the information technology equipment results in greater cost efficiency. Thirdly, increased use of

outsourcing operations related to information technology by local governments results in greater cost efficiency.

The structure of this study is as follows. In the next section, we review about the overview of information technology investment in Japanese local governments. We describe the history and recent trend of information technology investment in Japanese local governments. In section 3, we review previous studies on the economic effect of information technology and cost efficiency in local governments. In section 4, we explain the empirical model and data that we used and the estimation results. Finally, in section 5, we provide concluding remarks.

## **2. Information Technology Investment in Local Governments**

### **2.1 The History of Information Technology Investment in Local Governments**

First, we explain about the history of information technology investment in Japanese local governments. In 1960, the Osaka city government introduced the mainframe computer for the first time in local governments in Japan. Following the Osaka city government, local governments in urban areas (e.g. Kyoto city government, Tokyo, Kanagawa prefectural government) started to use mainframe computers. In the period of high economic growth, local governments in urban areas needed to satisfy the rapidly increasing demand for public services. Although local governments in urban areas desired to engage new employees, it was difficult to attain them because many people sought jobs in the private sector. As a result, local governments in urban areas had to introduce the mainframe computer as an alternative for staff shortages. After that, the rapid technical progress in information processing and the increase of demand of public services made many local governments invest in information technology. In the mid 1970s, many local governments were confronted with a fiscal crisis and explicitly invested in information technology to promote rationalization and efficiency. Recently, local governments do not use personal computers in stand-alone mode but construct a local area network (LAN). In addition, a wide area network (WAN) was constructed between other governments in order to share information.

In 2000, the central government established the Fundamental Law for Formation of an Advanced Information Communications Network Society (the Fundamental Law of Information Technology) In 2001, the central government developed the “e-Japan Priority Policy Program” and the “e-Japan 2002 program” for the purpose of promoting use of information technology. For local governments, in 2000, the central government established the “Headquarters for Promotion of Information Technology in Local Government” and developed a plan relating to information technology investment in local government.

## 2.2 The Recent Trend of Information Technology Investment in Local Governments

Next, we explain about the overview of the recent trend of information technology investment in local government. The data of information technology investment is obtained from the statistical book issued by the Ministry of Internal Affairs and Communications. The data includes the amount that both the local government (e.g. fire, construction, welfare etc.) and the local public companies (e.g. water, transportation etc.) invest. However, we have excluded the amount that the local public companies invest because we are only focused on the local government. Subsequently, we do not know how much the local public companies invest in information technology. Further, the local public companies are owned by the local government and do not behave independently. In addition, the budget scale of the local public companies is not larger than that of the local government. As a result, we can disregard the amount that the local public companies invest and use the data issued by the Ministry of Internal Affairs and Communications.

Table 1 shows the trend of information technology investment in municipal governments in the Kinki area. From this table, we can see that local governments are increasing information technology investment. From 1985 until 1990, the annual average growth rate of the real cost for information-processing equipment is about 17% and from 1990 until 1997, it is about 12%. On the other hand, from 1999 until 2000, the growth rate is negative. Therefore we can not judge whether or not local governments decrease information technology investment, because, in the statistical book, the definition of information-processing equipment has been changed. For example, until 2000, information-processing equipment included main-frame computer, personal computer, mobile computer, word processor, facsimile, telex, and so on. After 2000, the definition does not include word processor, facsimile and telex.

Next, from 1995 until 1999 the growth rate of the real cost for the purchase and development of software also increase. However, in a similarity to the information-processing equipments, from 1999 until 2000, the growth rate is also negative.

As for the outsourcing of operations related to information technology, the real cost continuously increases from 1995 until 2000. The results show that local governments carry on private consignment of public services for the purpose of cost effective operations.

**Table.1 The Information Technology Investment in Municipal Governments**

Fiscal Year	The Real Cost for Information-processing Equipments	The Real Cost for Purchasing and Development of Software	The Real Cost for Outsourcing Operations
1985	0.45	—	—
1990	1.00	—	—
1995	1.80	1.00	1.00
1996	2.15	1.06	1.15
1997	2.41	1.18	1.21
1998	2.54	1.29	1.28
1999	2.86	1.59	1.40
2000	2.72	1.31	1.51

Source: *Local Government Computer Statistics (Chihojichi Konpyuta Soran)*.

Note: The data relating to large cities is not included because the range of public services that large cities provide differs from services that other cities provide. When we change nominal investment to real investment, we use the deflator for information technology issued by the Economic and Social Research Institute, Cabinet Office, Government of Japan (2003). However the deflator in 2000 is not available, so we estimate the deflator in 2000 using the change rate from 1998 to 1999.

### 3. Previous Studies

There are many previous studies that examine the economic effect of information technology at the aggregate level and in private sector. For example, Jorgenson and Motohashi (2003) compare sources of economic growth in Japan and the United States, focusing on the role of information technology. They provide the evidence that the contribution of information technology to economic growth was dramatically similar in Japan and the United States in the last half of the 1990's. Further, the Economic and Social Research Institute, Cabinet Office, Government of Japan (2003) estimate capital stock related to information technology in Japan and verify the contributions of information technology to economic growth.

On the other hand, William and Lichtenberg (1998) examine the impact of information technology on productivity in the public sector. They use the sample of the U.S. Federal government and verify that information technology had an effect on productivity.

However, we think that there are no studies that examine the effect of information technology on cost efficiency or productivity at the level of local government. In the past, many researchers study what factors affect cost inefficient behavior as well as the calculation of the cost efficiency index.

Hayes and Chuang (1990), Davis and Hayes (1993), and Grossman, et al. (1999) examine the relationships between cost efficiency between those local governments which have a city manager, as opposed to those which do not. Silkman and Young (1982), De Borger and Kerstens (1996), Grossman, et al. (1999), Kawasaki (2001), Yamashita et al. (2002), and Hayashi (2002) verify a hypothesis that intergovernmental grants promote cost inefficient behavior. Davis and Hayes (1993), De Borger and Kerstens (1996), Hayes, et al. (1998), Grossman, et al. (1999) and Kawasaki (2001) test whether or not resident monitoring or political factors affect cost efficiency in local government.

Therefore, we decide to calculate the effect of information technology in an effort to contribute to making the information technology investment policy more cost effective for local governments in Japan.

## 4. Empirical Analysis

### 4.1 Econometric Model

We use the stochastic cost frontier method in order to examine our hypotheses. The stochastic cost frontier method was developed by Aiger, et al (1997) and Meeusen and van den Broeck (1977). This method is used by many researchers that study cost efficiency. When we calculate cost efficiency, some researchers use the non-parametric method, DEA. The DEA method's advantage is that we do not need to specify the functional form of the cost/production function and assume the probability distribution of error term. However, the disadvantage of the DEA method is that it can not test the estimated results statistically. On the other hand, the stochastic frontier method can test the estimated results statistically, but we need to specify the functional form of the cost/production function when estimating the stochastic frontier function and the calculation of the cost efficiency index.

Firstly, we estimate the stochastic cost frontier function and measure the cost efficiency index of all local governments. We represent the cost frontier model as follows.

$$C = C ( Y, \boldsymbol{w} ) \exp ( v + u ) \tag{1}$$

where  $C$ : actual total cost,

$Y$ : public service output,

$\boldsymbol{w}$ : input factor price vector,

$v$ : random error term following the normal distribution,

$u$ : cost inefficiency term, non-negative value.

$C$  is the local government's observable actual cost and  $C(Y, \mathbf{w}) \exp(v)$  is hypothetical cost that the local government incurs if it operates the most efficiently.

We modify the cost inefficiency term to investigate whether or not information technology affects cost efficiency based on Battese and Coelli (1995)'s model. We rewrite  $u_i$  as follows.

$$u = \theta_0 + \sum_i \theta_i Z_i + \eta \quad (2)$$

where  $\theta_0, \theta_i$ : coefficients

$Z_i$ : explanatory variables related to cost efficiency,

$\eta$ : random error term following the half-normal distribution.

As for input factor prices, we can assume that local governments input labor and capital to provide public services. However, the data related to capital input price is not available. In similarity to DeBorger and Kerstens (1996), we assume that the capital input price is constant for all local governments and therefore we can disregard it. If we assume that (1) is log-linear type, we can express (1) as follows.

$$\ln C = c_0 + \alpha_Y \ln Y + \alpha_w \ln w_L + v + u \quad (3)$$

where  $w_L$ : labor input price.

We require the data on the public service output to estimate the stochastic cost function. However, the public service output is not directly measurable. Therefore, we use the public production process developed by Bradford, Malt and Oates (1969) to define the public service output. This framework is built on the distinction between the direct public service output provided by a local government, "D-output," and the outcome that is of interest to the citizens, "C-output". The D-output is produced by inputs such as labor and capital. The C-output is a function of the level of the D-output and the set of socio-economic factors that influence the transformation of the D-output into the C-output. In fact, we refer to Duncombe (1992) and can represent the relationships between the D-output and the C-output as the following equations.

$$X = Y N^{-\beta} \prod_j E_j^{-\gamma_j} \quad (4)$$

where  $Y$ : public service output (D-output),

$X$ : outcome that is of interest to the citizen (C-output),

$E_j$ : socio-economic factor.

Thus, we can solve equation (4) for  $Y$  and transform the both sides of (4) into log-type,



$$\ln Y = \ln X + \beta \ln N + \sum_j \gamma_j \ln E_j. \quad (5)$$

As for (5), we assume that “C-output” consists of the quality of several public services, because our analysis covers overall public services. We assume that “C-output” is a log-liner function of the quality of several public services.

$$\ln X = \sum_k \alpha_{1k} \ln Q_k \quad (6)$$

where  $Q_k$ : quality of  $k$ -th public service.

From (3), (5), and (6), we can obtain the following equation.

$$\ln C = \alpha_0 + \sum_k \alpha_Y \alpha_{1k} \ln Q_k + \alpha_Y \beta \ln N + \sum_j \alpha_Y \gamma_j \ln E_j + \alpha_w \ln w_L + v + u \quad (7)$$

Next, we explain about the factors ( $Z_j$ ) that affect cost efficiency of local governments. The first factor, that is the main purpose of this study, is the effect of information technology. In previous studies, researchers estimate capital stock related to information technology and investigate whether or not the accumulation of information technology in Japan contributes to the economic growth or productivity. As is the case with those studies, we examine whether or not the accumulation of information technology in local governments contributes to cost efficiency. If the local government employs more staff who are professionally engaged to operations related to information technology, then the local government may use the information technology equipment more efficiently. Therefore, when we test the effect of the accumulation of information technology, we assume that the effect of information technology is affected by the ratio of skilled workers related to information technology. In addition, we verify whether increased use of outsourcing operations related to information technology by local governments results in greater cost efficiency.

The second factor relates to fiscal condition. Many researchers have focused on the relationships between intergovernmental grants and cost inefficient behavior (Silkman and Young, 1982, De Borger and Kerstens, 1996, Grossman, et al., 1999, Kawasaki, 2001, Yamashita et al., 2002, Hayashi, 2002). We consider that intergovernmental grants are an important factor that contributes to cost inefficiency in local governments. Therefore, we decide to test the hypothesis that increasing the ratio of the Local Allocation Grant (Chihokoufuzei) in the general-account budget promotes cost inefficient behavior. Additionally, we consider the borrowing condition. Recently many local governments issued a local bond to compensate for the shortage in local revenues. As a result, perhaps the local governments operate more inefficiently and have been dependent on the local bond revenue. Therefore we consider that the borrowing condition has an impact on the inefficient behavior.

Therefore, we represent the inefficiency equation as follows.

$$u = \theta_0 + (\theta_1 + \theta_2 RSTAF) \ln KIT + \theta_3 ROUT + \theta_4 RLAG + \theta_5 RLB + \eta \quad (8)$$

where *RSTAF*: the ratio of staff who specifically engage in information technology operations,

*KIT*: the accumulation of information technology,

*ROUT*: the ratio of outsourcing expenditure related to information technology in total non- personnel cost,

*RLAG*: the ratio of the Local Allocation Grant in the general-account budget,

*RLB*: the ratio of the local bond revenue in the total revenue.

## 4.2 Data

We use the cross-section data set of 317 municipal governments in the Kinki area in Japan for FY2001. We explain the definition of variables. The statistical information for the variables is summarized in Table 2. The total cost (*C*) used here is the sum of labor cost, capital cost and other costs (non-personnel costs). Labor input price ( $w_L$ ) is the labor cost divided by the number of workers. The data relating to costs and the number of workers is obtained from the *Financial Statements on Municipal Governments (Shi-Cho-Son Betsu Kessanjokyo Shirabe)* issued by the Ministry of Internal Affairs and Communications.

As for the quality of public services ( $Q_k$ ), we define the followings from available data on public services that municipal governments mainly provide.

$Q_1$  = Social assistance expenditure / Number of households,

$Q_2$  = Number of waiting toddlers for nursery school / Number of nursery school toddlers,

$Q_3$  = Number of teachers / Number of students,

$Q_4$  = Length of main roads / Area,

$Q_5$  = Number of people who live in areas needing the treatment of human waste / Total population,

$Q_6$  = Number of fire buildings / Total population.

$Q_1$  is “social assistance expenditure per household,” that is the level of living.  $Q_2$  is “ratio of the waiting toddler for nursery school” that is the quality of welfare.  $Q_3$  is “teacher-student ratio of compulsory education,” that is the quality of education.  $Q_4$  is “the length of paved main roads per area,” that is the quality of road.  $Q_5$  is “the ratio of the treatment of human waste,” that is the quality of urbanization.  $Q_6$  is “the ratio of fire,” that is the level of safety. Social assistance expenditure and area are obtained from the *Financial Statements on Municipal Governments (Shi-Cho-Son Betsu Kessanjokyo Shirabe)* issued by the Ministry of Internal Affairs and Communications. The number of waiting toddlers for nursery school and nursery school toddlers,

the number of teachers and students, the length of paved main roads, the number of people who live in areas needing the treatment of human waste, and the number of fire building are from *Statistical Observations of City, Town and Village (Tokeidemiru Shi-Ku-Cho-Son No Sugata)* published by the Ministry of Internal Affairs and Communications. Total population and number of household is obtained from the *Basic Resident Register (Jumin Kihon Daicho)* compiled by the Ministry of Internal Affairs and Communications.

We use population ( $N$ ), area ( $E_1$ ), the growth of population from 1995 until 2000 ( $E_2$ ), the ratio of people under 15 years of age ( $E_3$ ), and the ratio of people over 65 years of age ( $E_4$ ) as socio-economic factors. Population and area are as described above. The growth of population is the total population in 2000 divided by the total population in 1995. The ratio of people under 15 (over 65) years of age is defined as the number of the people under 15 (over 65) years divided by the total population in 2000. The number of the people over 65 years in 2000 and the total population in 1995 and 2000 are obtained from the *Census of Population (Kokusei-Chosa)* published by the Ministry of Internal Affairs and Communications.

The accumulation of information technology ( $KIT$ ) is obtained from information technology investment in consideration of depreciation. We assume that the durable period of information technology equipment is 5 years and the depreciation ratio is 20%. The ratio of staff specifically engaged to operations related to information technology ( $RSTAF$ ) is defined as the number of staff specifically engaged to operations related to information technology divided by the total number of workers. The ratio of outsourcing expenditure related to information technology in the total non-personnel cost ( $ROUT$ ) is defined as the outsourcing expenditure related to information technology divided by the total non-personnel cost in 2000 because we can not use the data on outsourcing expenditure in 2001. We obtain the data related to the staffs who specially engage to operations related to information technology and the outsourcing expenditure from the *Local Government Computer Statistics (Chihojichi Konpyuta Soran)* issued by the Ministry of Internal Affairs and Communications. The ratio of the Local Allocation Grant in the general-account budget ( $RLAG$ ) is the Local Allocation Grant divided by the general-account budget. All data concerning this variable is reported by the *Financial Statements on Municipal Governments (Shi-Cho-Son Betsu Kessanjokyo Shirabe)* issued by the Ministry of Internal Affairs and Communications.

**Table.2 Statistics for Used Variables**

		Mean	Standard Deviation	Maximum	Minimum
<i>C</i>	Total cost	7,037	12,097	98,332	531
<i>Q</i> <sub>1</sub>	Social assistance expenditure per household	72	32	188	14
<i>Q</i> <sub>2</sub>	Ratio of the waiting toddlers for nursery school	1.00	0.02	1.19	1.00
<i>Q</i> <sub>3</sub>	Teacher-student ratio of compulsory education	86.56	51.02	450.98	46.68
<i>Q</i> <sub>4</sub>	Length of paved main roads per area	0.80	0.38	2.52	0.21
<i>Q</i> <sub>5</sub>	Ratio of the treatment of human waste	1.33	0.23	1.97	1.00
<i>Q</i> <sub>6</sub>	Ratio of fire	1.30	0.25	3.19	1.00
<i>N</i>	Population	47,660	92,988	786,882	578
<i>E</i> <sub>1</sub>	Area	78.24	72.77	672.35	3.86
<i>E</i> <sub>2</sub>	Population Growth	0.99	0.05	1.27	0.84
<i>E</i> <sub>3</sub>	Ratio of people under 15 years of age	0.15	0.02	0.21	0.09
<i>E</i> <sub>4</sub>	Ratio of people over 65 years of age	0.22	0.07	0.43	0.10
<i>w</i> <sub>L</sub>	Labor input price	5,140	906	7,098	1,927
<i>RSTAF</i>	Ratio of staff specifically engaged to operations related to information technology	0.02	0.05	0.57	0.00
<i>KIT</i>	Accumulation of information technology	774	1,432	11,516	14
<i>ROUT</i>	Ratio of outsourcing expenditure	0.01	0.02	0.13	0.00
<i>RLAG</i>	Ratio of the Local Allocation Grant	0.50	0.24	0.93	0.00
<i>RLB</i>	Ratio of the Local Bond Revenue	0.10	0.06	0.31	0.00

### 4.3 Estimation Result

We estimate parameters of (7) and (8) using Maximum Likelihood Method. In estimating, we refer to Coelli (1996) and use FRONTIER Version 4.1 that he developed. As we can not estimate  $\alpha_Y$ , we search for the estimate that maximizes the likelihood function<sup>1</sup>. Table 3 shows the estimation result. Firstly, as for coefficients of the quality of public services ( $Q_k$ ) in cost function, coefficients of social assistance expenditure per household, teacher-student ratio of compulsory education, and ratio of the treatment of human waste are statistically significant. The coefficient of social assistance expenditure per household is negative. If the local government supplies more social assistance expenditure per household, the level of living in the municipality is lower. We can

<sup>1</sup> When we search for the estimate of  $\alpha_Y$ , we assume that the range of the estimate is from 0 to 1, because the cost elasticity of D-output is estimated from 0.2 to 0.5 by previous Japanese studies.

see that the C-output is lower if social assistance expenditure per household is higher. The coefficient of teacher-student ratio of compulsory education is positive. As this variable means the quality of education, the result is reasonable. The coefficient of ratio of the treatment of human waste is negative. This means that the lower level of urbanization results in the lower level of C-output.

Secondly, coefficients of population ( $N$ ), population growth ( $E_2$ ), ratio of people over 65 years of age ( $E_4$ ) are statistically significant. Area ( $E_1$ ) is significant but the significant level is lower than other variables. The ratio of people under 15 years of age ( $E_3$ ) is not significant.

Thirdly, we focus on coefficients in inefficiency equation. The coefficient of the accumulation of information technology ( $\ln KIT$ ) is negative with statistical significance. This result means that the main hypothesis of our study is acceptable. In addition, the coefficient of  $RSTAF$  is negative with a weak statistical significance. We can not strongly support the hypothesis that more staff professionally engaged to operations related to information technology will make information technology equipment used more efficiently. However, the coefficient of the ratio of outsourcing expenditure related to information technology operations ( $ROUT$ ) is not significant. We can not accept the second hypothesis. Because we think that the data on the outsourcing of operations is inappropriate. We use the outsourcing expenditure in 2000. However, outsourcing operations directly affects to cost efficiency and we think that we should use the data in 2001. As for fiscal conditions, the coefficient of the ratio of the Local Allocation Grant ( $RLAG$ ) is not statistically significant but positive. On the other hand, the coefficient of the local bond revenue ( $RLB$ ) is positive with statistical significance. We conclude that local governments that have large debts are cost inefficient.

## 5. Concluding Remarks

The main purpose of this study is to evaluate whether or not information technology contributes to cost efficiency in local governments in Japan. The data set for this study is municipal governments in the Kinki area in Japan for FY2001. From our analysis, we have reached the following conclusions:

Firstly, increased use of information technology equipment results in greater cost efficiency. This result is consistent with William and Lichtenberg's (1998) study relating to the impact of information technology on productivity in the U.S. Federal government.

Secondly, the ratio of staff professionally engaged to operations related to information technology has a negative impact on cost inefficiency but the coefficient is not statistically significant.

Thirdly, increased use of outsourcing operations related to information technology by local

governments does not result in greater cost efficiency.

In addition, as for the fiscal condition, the Local Allocation Grant does not promote cost inefficient behavior but local governments that have large debts are cost inefficient.

In conclusion, we indicate future issues. In this paper, we use the data set for a subset of Japanese municipal governments. We should use all municipal governments in Japan in order to investigate the effect of information technology. Furthermore, we should consider the impact of information technology on organizational reform. It is important for local governments to reorganize in order to use information technology more efficiently as well as to introduce information technology. We should focus on whether or not local governments reform the organization and reallocate workers efficiently by the introduction of information technology.

**Table.3 Estimation Result**

Variables	Estimate	t-value	Variables	Estimate	t-value
$\alpha_0$	3.143***	( 5.138)	$\theta_0$	-1.707**	( 2.089)
$\ln Q_1$	-0.317*	( 1.940)	<i>RSTAF</i>	-0.365	( 1.515)
$\ln Q_2$	3.102	( 0.925)	$\ln KIT$	-0.337***	( 2.688)
$\ln Q_3$	2.139***	( 5.291)	<i>ROUT</i>	2.481	( 0.684)
$\ln Q_4$	0.287	( 1.548)	<i>RLAG</i>	0.648	( 1.198)
$\ln Q_5$	-1.405***	( 3.335)	<i>RLB</i>	3.142***	( 2.892)
$\ln Q_6$	-0.004	( 0.010)	$\sigma^2$	0.156***	( 3.042)
$\ln N$	4.678***	(36.418)	$\lambda$	0.885***	(19.611)
$\ln E_1$	0.212*	( 1.833)	$\alpha_Y$		0.200
$\ln E_2$	4.818***	( 3.097)	<i>log likelihood</i>		55.024
$\ln E_3$	-1.167	( 1.522)	<i>observations</i>		317
$\ln E_4$	1.295***	( 2.680)			
$\ln w_L$	0.105*	( 1.792)			

Note:  $\sigma^2 = \sigma_v^2 + \sigma_u^2$ ,  $\lambda = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$ .  $\sigma_v^2$  is variance of  $v$ .  $\sigma_u^2$  is variance of  $u$ .

\*\*\* is significant from zero at the 99% level. \*\* is significant from zero at the 99% level.

\* is significant from zero at the 90% level.

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