Economics Bulletin

Volume 31, Issue 4

Estimating the impact of diabetes on employment in Taiwan

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Abstract

This paper investigates the impact of diabetes on employment based on the 2005 National Health Interview Survey in Taiwan using a recursive bivariate probit model. The findings show that diabetes has a negative and significant effect on employment, and that the magnitude is larger for men than for women. The results of this study also suggest that neglecting the potential endogeneity of diabetes will lead to an underestimation of the negative impact of diabetes on employment.

I would like to thank Dr. John P. Conley and an anonymous referee for their insightful comments and suggestions. Financial support from the Sapintia Culture and Education Foundation is gratefully acknowledged. The author is alone responsible for the views expressed.
Citation: Shin-Jong Lin, (2011) "Estimating the impact of diabetes on employment in Taiwan", *Economics Bulletin*, Vol. 31 No. 4 pp. 3089-3102.
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Submitted: July 01, 2011. **Published:** November 09, 2011.

1. Introduction

The prevalence of diabetes is increasing due to rapid economic growth, aging, the increasing prevalence of obesity, and changes in lifestyle. Diabetes is a chronic disease requiring careful life-long control that has become one of the leading causes of premature death worldwide. Without proper care, diabetes is likely to lead to various complications such as cardiovascular disease, kidney disease, vision disorder, and related complications including infections, autonomic and pregnancy problems, etc. The social and economic consequences of diabetes involves intensive medical treatments and costs, loss of work productivity, disability, and continuing supportive care, all of which impose a substantial burden on individuals, families, and society that is difficult to estimate. In order to respond to growing concerns about the threat to health posed by diabetes, to draw attention to issues of importance in caring for those suffering from diabetes, and to promote public awareness of the risks of diabetes, the International Diabetes Federation and the World Health Organization created World Diabetes Day (November 14) in 1991 and it became an official United Nations Day in 2007 (International Diabetes Federation).

There are two major types of diabetes: type 1 diabetes and type 2 diabetes. Type 1 diabetes is usually diagnosed in children and young adults. In most cases involving type 1 diabetes, people inherit genes from family (e.g., both parents) which put them at risk. Type 2 diabetes accounts for 90 to 95 percent of all diagnosed causes of diabetes in adults. Type 2 diabetes is strongly genetic in origin (especially in relation to first degree relatives), although lifestyle factors (e.g., exercise, diet, weight) and many medical conditions including hypertension, elevated cholesterol, metabolic syndrome, etc. can potentially give rise to type 2 diabetes as well. However, it may be difficult to identify whether the development of type 2 diabetes is due to genetic factors, or lifestyle choices, or other risk factors as it is most likely due to a combination of all of them. (American Diabetes Association, 2011).

In Taiwan, the prevalence of diabetes for all age-groups was estimated to be 9.2% in 2009 and 28.5% for individuals over the age of 65. Diabetes has been among the top five leading causes of death in Taiwan since 1987. The crude death rate was 9.0 per 100,000 population in 1981 and increased to 35.5 per 100,000 population in 2010. It has become one of the diseases for which the death rate in Taiwan has increased the most rapidly. Moreover, diabetes is ranked the 5th leading disease in terms of overall health care spending in Taiwan, thereby placing a heavy burden both on society and its patients.

Health status is an important driving force influencing the labor force participation decision of individuals. Type 2 diabetes is a progressive disease and, therefore, individuals who are diabetic may be less productive and less likely to be

employed than those without the disease. The extent to which diabetes affects an individual's employment has been an issue to which researchers have directed increasing attention in recent years. Prior studies have indicated that diabetes significantly affects the individual's labor market productivity, and most of these studies assume that diabetes is an exogenous variable in their regression analysis (e.g., Kahn, 1998; Kraut et al., 2001; Bastida and Pagán, 2002; Lavigne et al., 2003; Tunceli et al., 2005). For example, Bastida and Pagán (2002) used the 1994-1999 microdata for Mexican Americans on the US-Mexican border to examine the impact of diabetes on the labor market outcomes of adults 45 years of age and older. They found for females that diabetes had a significant and negative impact on earnings, and an insignificant effect on the probability of employment. For males, diabetes significantly reduced the employment propensity, but had no effect on earnings.

It is possible that the relationship observed between diabetes and employment behavior is due to some correlated unobserved behavioral factors that affect both diabetes and employment. For example, unmeasured personal motivation or self-interest may influence employment propensity and also influence lifestyle choices. A person could have a tendency toward a sedentary lifestyle, which may result in less productivity at work, and ultimately may be at risk for developing diabetes. If we ignore the unobserved behavioral factors, we may obtain biased estimated coefficients for diabetes in a regression to predict employment probability. Hence, to correctly assess the extent to which diabetes may affect an individual's labor outcome, it is important to take into account the potential endogeneity of diabetes. While a number of recent studies have addressed the issue of endogeneity in their empirical analysis of the effect of diabetes on the labor market outcome, the direction of how endogeneity could bias the true causal effect of diabetes on the individual's labor market decision, however, remains ambiguous. Brown et al. (2005) addressed the endogeneity problem associated with diabetes and employment by using an instrumental variables (IV) regression approach. They used the family history of diabetics as a genetic instrumental variable. In the IV probit model diabetes is found to have a significant negative effect on employment. Their findings suggest that failure to account for endogeneity will lead to an overestimation (underestimation) of the negative impact of diabetes on female (male) employment. In addition, Latif (2009) utilized a sample of people aged 15 to 64 from the 1998 Canadian National Population Health Survey and a recursive bivariate probit model which took into account the potential endogeneity of diabetes in estimating the employment outcome. Latif concluded that diabetes had a significant negative impact on the probability of female employment; furthermore, treating diabetes as exogenous proved to yield an overestimation of its impact on male employment. Minor (2011) extended the current

literature on the impact of diabetes on the US labor market by comparing the effects of type I and type II diabetes on female employment, respectively. The results of his analysis showed that while diabetes is harmful to most labor market outcomes, much of the negative effect on the female labor force decision is due to type II diabetes. In addition, by using the individual's biological mother's history of diabetes as an instrumental variable, Minor's estimates indicated that having diabetes reduced the probability of female employment by 45%. Minor suggests that the true effect of diabetes on the labor market may have been underrepresented by previous studies, which have not taken endogeneity into account.

Although the relationship between diabetes and the labor market outcome has been explored in the United States and other Western countries, there has been relatively little research undertaken in Asia or other developing countries in general. The objective of this paper is to investigate the effect of diabetes on employment by taking into account the possible endogeneity between them using data from Taiwan. The results of this study are thus able to add further insight into the current body of research on this topic from a different region.

2. Estimation Model

To estimate the effect of diabetes on the probability of employment and to account for the possible endogeneity of diabetes, following the approach by Brown et al. (2005), a recursive bivariate probit model is used which takes the following form:

$$E_i^* = X_i'\alpha_1 + D_i\beta + \varepsilon_i \quad (1)$$

$$D_i^* = X_i'\alpha_2 + Z_i'\gamma + \mu_i \quad (2)$$

where E_i^* is a latent variable representing the ith individual's propensity to be employed in the labor market. The corresponding observable binary variable E_i takes a value of one if $E_i^* > 0$ and a value of 0 if $E_i^* \leqq 0$. D_i^* represents a latent variable indicating that the ith individual is diabetic. If $D_i^* > 0$, then the individual is observed to be diabetic and the corresponding observable binary variable D_i equals one, otherwise D_i takes a value of 0 if $D_i^* \leqq 0$. X_i is a vector of the individual's observable characteristics and Z_i is a vector of instrumental variables. ε and μ are the error terms. The parameters to be estimated are α, β, and γ. It is possible that the unobserved factors of the individual's probability of being diabetic may be correlated with the unobserved personal traits or characteristics affecting the individual's propensity to be employed. Therefore, it is assumed that ε and μ are distributed bivariate normal, and E[ε]=E[μ]=0, Var[ε]=Var[μ]=1. Cov[ε, μ]= ρ where ρ is the correlation between the error terms in the diabetes and employment equations. If ρ=0, then the univariate probit model would be appropriate. If $\rho \neq 0$, i.e., ε and μ are not independent, the univariate probit model estimation will be biased, and the bivariate probit model approach should be used.

3. Data and Variable Definitions

The data used in this study are nationwide household data drawn from the 2005 National Health Interview Survey (NHIS) in Taiwan. This survey collected information on demographic and socio-economic characteristics, the utilization of health services, health behaviors, health status, and the limitation of activity of the population in Taiwan. A total of 30,680 sampled individuals completed the questionnaires, representing a completion rate of 80.59%. In this analysis, the sample was restricted to individuals aged 45 to 64 years. In total, the sample size comprised 5,297 individuals, of whom 2,668 were males and 2,629 females.

The employment variable is a binary variable which equals one if the individual is employed at the time of the interview and zero if the individual is unemployed or out of the labor force. The diabetes measure, which is the main focus of this study, is a dummy variable taking the value one if the sampled individual has been diagnosed with diabetes and zero otherwise. A dichotomous variable, married, that equals 1 if the respondent is married, and 0 otherwise is also included in the model. Two dummy variables equal to one were constructed for the senior-high school and college graduated groups, respectively. The reference group is the less than or equal to the junior-high school education group. Furthermore, an income variable which denotes the family income is included in the model. The NHIS has divided the family income into 7 categories, where the lowest income level is the family income level that is under NT$30,000 per month and the highest (7^{th}) level is the family income level that is more than two-hundred thousand New Taiwan dollars per month. Finally, three dummy variables that represent the family history of diabetes are used as instrumental variables in the diabetes equation. These variables separately equal 1 if the individual's father died of diabetes, mother died of diabetes, or grandparent died of diabetes, and 0 otherwise.

4. Results

Table 1 presents the descriptive statistics of the variables used in this study. The average age of the sample in this study was 53 years old. About 77% of the males were employed at the time of the interview, while only 47% of the females reported being employed. The majority of those in the sample were married (83%) and 23% of them had completed senior high school. A relatively larger proportion of men had graduated from college or above (21%) in comparison with women (10%). The average household income level was about NT$40,000 per month. In addition, about 7% of the full sample had been diagnosed with diabetes, 16% of the sample reported that their mother had died of diabetes, 8% reported that their father had died of diabetes, and 2% of them reported that one of their grandparents had died of diabetes.

Table 1. Descriptive statistics

	Full sample	Men	Women
Variable names	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
Employed (1=yes; 0=otherwise)	0.62 (0.48)	0.77 (0.41)	0.47 (0.49)
Age	53.37 (5.60)	53.38 (5.59)	53.37 (5.61)
Male (1=yes; 0=otherwise)	0.50 (0.50)	1 (0.00)	0 (0.00)
Married (1=yes; 0=otherwise)	0.83 (0.36)	0.87 (0.32)	0.79 (0.40)
Senior high school graduated (1=yes; 0=otherwise)	0.23 (0.42)	0.26 (0.43)	0.20 (0.40)
College graduated (1=yes; 0=otherwise)	0.16 (0.36)	0.21 (0.41)	0.10 (0.30)
Diagnosed with diabetes (1=yes; 0=otherwise)	0.07 (0.26)	0.07 (0.26)	0.07 (0.26)
Mother died of diabetes (1=yes; 0=otherwise)	0.16 (0.37)	0.16 (0.37)	0.15 (0.36)
Father died of diabetes (1=yes; 0=otherwise)	0.08 (0.27)	0.08 (0.28)	0.07 (0.26)
Grandparent died of diabetes (1=yes; 0=otherwise)	0.02 (0.15)	0.02 (0.15)	0.02 (0.15)
Income	2.63 (1.56)	2.77 (1.59)	2.49 (1.52)
N	5297	2668	2629

Note: Standard errors are in parentheses.

The main purpose of this study is to investigate the effect of diabetes on employment. Table 2 presents the estimates of the main employment probit equation, assuming that diabetes is an exogenous variable. The coefficient on the diabetes variables and their marginal effect are reported for the full sample, and the male and female samples, respectively. For simplicity, only the coefficient for diabetes is shown, whereas the coefficients for the other explanatory variables such as age, gender, marital status, education level, and income are suppressed in the table. First, the results show that being diabetic has a negative and statistically significant effect on

employment. The effect is such that having a diabetes health problem will result in a 11 percentage point larger decrease in the probability of being employed than in the case of the non-diabetics. Meanwhile, in males diabetes has a statistically significant negative effect on employment, with a marginal effect of −0.09, which means that diabetic males are associated with an employment probability that is 0.09 lower than that of non-diabetic males. In females the effect of diabetes on employment is smaller but remains significantly negative.

Table 2. The effect of diabetes on employment: Univariate probit regression

	Full sample		Men		Women	
	Coefficient	M.E.	Coefficient	M.E.	Coefficient	M.E.
Diabetes	−0.29***	−0.11***	−0.33***	−0.09***	−0.28	−0.11
	(0.07)	(0.02)	(0.09)	(0.03)	(0.10)	(0.03)
Pseudo R^2	0.18		0.17		0.08	
Log likelihood	−2861.34		−1166.40		−1660.08	
N	5297		2668		2629	

Note: M.E. stands for marginal effect. Standard errors are in parentheses. Explanatory variables such as age, gender, education level, marital status, and income are included in the full sample regression model. The gender variable is excluded in the estimation models for men and women, respectively.

* Statistically significant at the 10% level, ** at the 5% level, and *** at the 1% level.

The results of the likelihood ratio tests of the correlation coefficients of the error terms indicate that the disturbances are correlated, i.e., they suggest that diabetes is endogenous. Hence, estimating the employment equation based on a probit model may result in a biased and inconsistent estimate of the parameter β in equation (1). Therefore, in order to obtain unbiased and consistent estimates of the effect of diabetes on employment, a recursive bivariate probit regression which estimates the employment and diabetes equations jointly is used in this study.

Before we can accept the results of the IV analysis, it is important to examine the validity of the instruments and the assumption of exogeneity (the test results are available from the author upon request). First, the instruments and the endogenous variable must be correlated. Family members' diabetes measures have been used as instruments for the individual diabetes variable in previous studies (see for example, Brown et al., 2005; Latif, 2009; Minor, 2011). While the reason for using the family history of diabetes is that it is related to whether a person is genetically predisposed to developing diabetes, it is, however, not likely to influence the individual's

employment decision on a significant scale (Minor, 2011). In addition, several recent studies in the medical literature have shown that there is a link between genetics and diabetes (e.g., Velho and Froguel, 2001; Barrett et al., 2009; Hu et al., 2009; Voight et al., 2010; Chiefari et al., 2011). Hence, there is evidence to support a link between individual diabetes and the family members' history of diabetes. Furthermore, the t-tests for each instrumental variable exhibit positive and statistical significance at the 1% level. A likelihood ratio test also rejects the null hypothesis of the joint insignificance of the family history of diabetes instrument at the 1% level. The condition for the instrument to be relevant to the endogenous variable is thus fulfilled. The second requirement for the validity of the instrument is that it be uncorrelated with the error term of the employment equation. It is suspected that the genetics could also influence the severity of comorbidities, which may in turn influence the individual's employment propensity (Brown et al., 2005). Therefore, following the method proposed by Brown et al. (2005) and Latif (2009), this study examines the independence of the instrumental variables and the unobserved factors in the employment equation by estimating probit models of the association between the family instrumental variables and health conditions both related to diabetes (e.g., high blood pressure, visual problems, heart disease) and unrelated to diabetes (e.g., cancer, hearing problems, arthritis). The estimation results provide no evidence of a strong correlation between instruments and comorbidities, which implies that family diabetes measures do not affect employment apart from the indirect effect through the endogenous variable (i.e., the individual diabetes). Furthermore, the validity of the instrumental variables is tested by the Sargan overidentification test. The test statistics also fail to reject the null hypothesis that the error term in the equation of interest is uncorrelated with the instrumental variables. Finally, the endogeneity of diabetes is tested by a Hausman test. The test statistics show that the hypothesis that diabetes is not an endogenous variable in the employment equation cannot be rejected. It suggests that there is a correlation between the two disturbances and the potential endogeneity problem should be taken into account. The above specification test statistics lead us to conclude that the selected instrumental variables are valid and that it is necessary to use these instruments in the regression analysis performed in this study.

Table 3 presents the parameter estimates of the diabetes probit equation. The results indicate that with an increase in age, the likelihood of being diabetic also increases. Individuals with higher education levels are found to be less likely to have diabetes. Similar results are found for the female sample group. In addition, the estimated coefficient of income is also found to be negative and statistically significantly associated with diabetes. These negative coefficients of education and

income imply that individuals with higher education and higher income may be likely to have more knowledge about or sources of preventive care for diabetes such that the probability of being diabetic decreases. A family history of diabetes which is used as the instrumental variable in this study, as expected, does play an important role in terms of the propensity of being diabetic for the overall sample, and for the male group and female group, respectively. It is shown that, for an individual whose father, mother, or grandparent died of diabetes, the likelihood that the individual has the same disease increases significantly. This result confirms the fact that diabetes has a strong link to a family's health history.

Table 3. Probit regression estimation for diabetes

	All		Men		Women	
Variable	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Constant	−3.98***	0.28	−3.43***	0.39	−4.49***	0.42
Age	0.04***	0.004	0.03***	0.006	0.05***	0.007
Male	0.07	0.05				
Married	0.03	0.07	0.06	0.11	0.02	0.09
Senior high graduated	−0.17**	0.07	−0.08	0.09	−0.29**	0.12
College graduated	−0.22**	0.09	−0.13	0.11	−0.55***	0.19
Mother died of diabetes	0.56***	0.06	0.56***	0.08	0.58***	0.09
Father died of diabetes	0.57***	0.08	0.53***	0.10	0.66***	0.12
Grandparent died of diabetes	0.30**	0.14	0.48***	0.18	0.01	0.24
Income	−0.03*	0.01	−0.01	0.02	−0.06**	0.03
Log likelihood	−4175.86		−1851.39		−2279.03	
N	5297		2668		2629	

* Statistically significant at the 10% level, ** at the 5% level, and *** at the 1% level.

The bivariate probit regression results are presented in Table 4. The most important finding in Table 4 is that diabetes has a significant and negative effect on employment, with a marginal effect of −0.24. In other words, being diabetic is estimated to reduce the probability of being employed in the labor market by 24%, which is much greater than the 11% estimated using the univariate probit regression presented in Table 2. From these results, it is shown that the effect of diabetes on employment tends to be underestimated if one fails to control for the unobserved heterogeneity of the impact of diabetes on employment. Turning to the other explanatory variables, the signs of the parameter estimates are as expected. Table 4 shows that younger males with higher income are significantly more likely to be

employed relative to their counterparts. In addition, the positive sign of the education variable implies that individuals with senior high school levels of education will increase their employment propensity.

Table 4. Bivariate probit regression for employment, full sample

Variable	Coefficient	S.E.	Marginal effect	S.E.
Constant	3.37***	0.21		
Diagnosed with diabetes	−0.72***	0.24	−0.24	0.06
Age	−0.07***	0.004	−0.02	0.004
Male	0.89***	0.03	0.24	0.05
Married	0.03	0.05	0.008	0.01
Senior high graduated	0.09*	0.04	0.03	0.01
College graduated	0.005	0.06	0.01	0.01
Income	0.13***	0.01	0.04	0.009
$\rho(\varepsilon, \mu)$	−0.22*	0.12		
Log likelihood	−4175.86			
N	5297			

Note: The marginal effects are computed at the means of the independent variables. For a dummy variable, the marginal effect is measured by the difference between the conditional probabilities.

* Statistically significant at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 5 presents the results of the bivariate probit model for males and females, respectively. The marginal effects are compared for the same type of men and women. In males, the effect of diabetes on employment is statistically significant and negative. The marginal effect for the male diabetes dummy is −0.19; that is, for men with diabetes the probability of employment is 19 percentage points lower than for men without diabetes. For females, the estimated coefficient of the diabetes dummy is negative but statistically insignificant. It is worth noting that the negative impact of diabetes on the labor market is found to be more substantial for men than for women. The analysis also demonstrates that the predicted conditional probability decreases significantly as individuals become older, for both males and females. It can contribute to the fact that the average productivity decreases with age and, as a consequence, the probability of employment decreases. Meanwhile, it is interesting to note that marriage has a significant and positive effect on employment for men, but a significant and negative effect for women. This result can be supported by the notion that, based on the traditional gender norms in Taiwan, men are the primary providers

of family income and they therefore have a responsibility to work in order to support their family, while women are the main child care providers in their family, and thus some of the women may be forced to exit the labor market once they get married.

Table 5. Bivariate probit regression for employment, by gender

	Men		Women	
Variable	Coefficient	M.E.	Coefficient	M.E.
Constant	4.8***		3.11***	
	(0.32)		(0.29)	
Diagnosed with	−0.87**	−0.19	−0.39	−0.15
diabetes	(0.38)	(0.05)	(0.39)	(0.15)
Age	−0.08***	−0.01	−0.06***	−0.02
	(0.006)	(0.007)	(0.005)	(0.003)
Married	0.41***	0.06	−0.15**	−0.06
	(0.08)	(0.04)	(0.06)	(0.02)
Senior high	0.04	0.008	0.14**	0.06
graduated	(0.07)	(0.01)	(0.06)	(0.03)
College	−0.25***	−0.03	0.26***	0.11
graduated	(0.08)	(0.02)	(0.09)	(0.04)
Income	0.20***	0.02	0.09***	0.03
	(0.02)	(0.01)	(0.01)	(0.007)
Log likelihood	−1851.39		−2279.03	
N	2668		2629	

Note: M.E. stands for marginal effect. The marginal effects are computed at the means of the independent variables. For a dummy variable, the marginal effect is measured by the difference between the conditional probabilities. Standard errors are in parentheses.

* Statistically significant at the 10% level, ** at the 5% level, and *** at the 1% level.

5. Discussion and Conclusion

The main objective of this paper has been to investigate the impact of diabetes on the individual's employment propensity using the 2005 National Health Interview Survey in Taiwan within the context of a bivariate probit model. The major finding of this research is that diabetes has a significant negative effect on employment, and the negative effect is more pronounced for men than for women in Taiwan. This result can be attributed to the fact that diabetes is a chronic disease that imposes an economic burden in the form of lost productivity and therefore affects employment.

The estimation results are in accordance with those of studies based on data from western countries such as Latif (2009) for Canada, Bastida and Pagán (2002) and Minor (2011) for the U.S.

Moreover, the analysis presented in this study shows that there is a correlation between the error terms of the diabetes and employment equations, and therefore the null hypothesis of the exogeneity of diabetes in relation to employment is strongly rejected. The instrumental variable estimation results provide evidence that, after controlling for unobserved heterogeneity, the effect of diabetes on employment is more severe than with the univariate probit model. It shows that neglecting the endogeneity of diabetes will result in the negative impact of diabetes on employment being underestimated, a result which is similar to the findings of Brown et al. (2005) and Minor (2011). The findings of this study support previous studies, such as Brown et al. (2005), Latif (2009) and Minor (2011), which suggest that, in order to assess the impact of diabetes on the employment outcome more correctly, policy-makers should take the issue of endogeneity into account.

Diabetes results in excess medical expenses and places a heavy economic burden on the healthcare systems and society. However, diabetes is not just a health issue. It can also generate an impact on the labor market through reduced productivity. The implication of this study is that, apart from raising awareness of the risk of diabetes and promoting preventive care in relation to diabetes among the public, policy-makers should also advocate setting up diabetes-at-work programs and provide a comfortable working environment that can accommodate individuals with diabetes. Taken together, the results of this empirical analysis not only contribute to shedding light on the topic regarding the impact of diabetes on the labor market outcome, but also provide further evidence as to the extent of this chronic disease in an Asian country setting.

Acknowledgements

Financial support from the Sapintia Culture and Education Foundation is gratefully acknowledged. This study is based in part on data from the National Health Interview Survey Original Database provided by the Bureau of Health Promotion, Department of Health, Executive Yuan, National Health Research Institutes and Food and Drug Administration, Department of Health, Executive Yuan of Taiwan. The interpretation and conclusions contained herein do not represent those of Bureau of Health Promotion, the Department of Health, Executive Yuan, National Health Research Institutes and Food and Drug Administration, Department of Health, Executive Yuan of Taiwan.

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