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ROAD ACCESSIBILITY AND WEALTH IN RURAL BHUTAN: A DIFFERENCE IN DIFFERENCE APPROACH

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Road accessibility is an important development priority of the government of Bhutan. Since, wealth is assumed to grow with road connectivity, using Bhutan Living Standard Survey data of 2007 and 2012, a Difference in Difference regression based on different wealth quantiles is performed. Wealth index in the study is generated using standard Principal Component Analysis and Polychoric Principal Component Analysis. The findings show that wealth has increased in the lower quantile, whereas road connectivity has no impact on the middle quantiles and wealth decreased in upper quantile. This suggests that the objective of the government is met in increasing wealth of the poor but government still need to be thoughtful about the richer population.

Keywords: Bhutan, Road, Wealth, Principal Component Analysis, Difference in Difference, Quantiles
JEL Classification: C13, C31, D31

1. INTRODUCTION

Bhutan is a low middle-income country (World Bank, 2014) with a total Gross Domestic Product (GDP) of $897.02 million in 2013 (National Statistics Bureau [NSB], 2014a). Due to its small population base of about 720,697 (NSB, 2013), per capita GDP is relatively higher compared to its neighbouring countries. Bhutan's per capita GDP is about $2,420 as compared to $1,913 of India, $840 of Bangladesh and $700 of Nepal in 2012 (World Bank, 2014). During the 10th Five Year Plan (FYP) period, which is from mid 2008 to mid 2013, Bhutan saw huge reduction in poverty from 23 percent in 2007 to 12 percent in 2012 (NSB, 2012) but poverty still remains a major concern for the government. As Bhutan is mostly an agrarian economy, poverty in Bhutan is mostly a rural phenomenon. Increasing rural income was one of the main objectives of the 10th FYP activities. The goal was to enhance mean rural household income to Nu. 35,000 per

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year in local currency unit Ngultrum (Gross National Happiness Commission [GNHC], 2009).

Bhutan is a mountainous country, making road networking a very challenging task. Rural poverty in Bhutan is mostly associated with inadequate access to markets, among many other factors (GNHC, 2009, Road connectivity is essential in a landlocked country like Bhutan for development activities and in promoting domestic and international trade. Realising its importance, government of Bhutan felt the need to upgrade and improve transport infrastructure in the country. Therefore, another important target in the 10th FYP was also to ensure that three fourths of the rural population lives less than half a day's walk from the nearest road-head. The target was aimed to achieve through various activities such as construction of thousands of kilometers of feeder roads, building of national highways and district roads (GNHC, 2009, p.43). As of 2013, total length of roads in Bhutan is 10,578.3 Kilometers (kms) connecting all the 20 districts in the country (NSB, 2014b). Non-black topped roads with a total length of 7,602.9 kms is more than double the length of the tarred or blacktopped roads of 2,975.3 kms (NSB, 2014b)

The importance of road accessibility to promote social and economic development is well recorded in the past literatures. Using a semi parametric procedure in analysing the household level benefits from road projects, Jacoby (2000) finds that providing extensive road access to markets would give substantial benefits on average, much of these going to poor households in Nepal. Similarly, Fan and Chan-Kang (2004) finds that low quality roads which are mostly rural roads has the higher potential to contribute to the Gross Domestic Product (GDP) and alleviate rural and urban poor from poverty in China. However, the size of the market to which the road access is provided is found to be important. Access to small towns is found to have less benefits from road connectivity in Malaysia (Windle and Cramb, 1997). Contrarily, Hettige (2006) sees that rural roads are necessary but not a sufficient condition for graduating poor households from poverty in Indonesia, Philippines and Sri Lanka. It is believed that household asset base determines the use of road.

However, the previous studies are mostly concerned with the impact of road accessibility to social and economic growth at a point in time. The current study proposes to measure the effect of a policy, which is providing increased road accessibility on household wealth in rural Bhutan. In doing so, this study adopts a difference in difference (DiD) approach to see if road connectivity has increased wealth in the country during the 10th FYP development phase. Many of the studies that employ DiD approach is based on panel data. Pooled cross section data are very rarely studied and more so, using national level data is very sparse. To the best knowledge of the author, it is only Kiel and McClain (1995) that used pooled cross section data to study the effect of new garbage incinerator on housing values in North Andover, Massachusetts. However, their study is based on a very small sample ranging between 323 and 711 observations. Therefore, this paper is quite enlightening as it uses two large sample surveys to measure the effect of road connectivity on household wealth.

The current study uses wealth index constructed using household assets from the survey data. Wealth index is chosen over income or expenditure because wealth reflects accumulation of assets over years. Household asset data used in calculating wealth index can be more reliable than income or expenditure data because people usually are reluctant to admit their income or expenditure for fear of income tax (Narayan and Pritchett, 1997). Moreover, household wealth index is found to perform better over expenditure in explaining household characteristic such as education (Filmer and Pritchett, 2001). Further, Wealth indices are considered a very good indicator of long run socio-economic condition and material well being of households (Filmer and Pritcheet, 1999, 2001). Wealth is also thought to help maintain the same standard of living even when income is lost (Hajat, Kaufman, Rose, Siddqi and Thomas, 2010).

More importantly, wealth variable is generated using two separate measures. The wealth index is constructed using the principal component analysis (PCA) technique, where the wealth index is usually proxied by the first principal component as proposed by Filmer and Pritchett (2001). Since, most of the information used in constructing the wealth index is binary variables and as standard PCA is designed for continuous variable, Kolenikov and Angeles (2009) suggest an alternative approach of using polychoric PCA. Therefore, wealth index in the study is obtained using both the approaches, which is named Pchoric wealth and PCA wealth hereafter. However, this paper in no way attempts to provide an extensive clarification of the two different methods but rather tries to measure the sensitivity of the two different processes. A comparison of the results from two different wealth indexes is one of the key contributions of the study.

Further, as the benefit of road is mostly accrued by rich land owners (Jacoby, 2000); difference in difference regression is performed on 5 different quantiles based on Pchoric wealth and PCA wealth. To see the difference in benefit of different kinds of roads such as feeder road and tarred road, separate DiD regressions are performed using these variables as the main interacting factor.

The rest of the paper is organized as follows. In Section 2, data and its source are deliberated, followed by discussion on methodology used in Section 3. Section 4 presents the descriptive statistics and DiD regression results. Finally, Section 5 concludes with some discussion on policy implications.

2. DATA

The data for the study comes from a nationally representative, the Bhutan Living Standard Survey (BLSS) 2007 and BLSS 2012. The survey is based on the Living Standard Measurement Study (LSMS) methodology developed and advocated by the researchers at the World Bank. These surveys provide very rich information collected through an integrated household questionnaire in updating poverty profile, rebasing of Consumer Price Index (CPI) and planning socioeconomic policy. In particular, the BLSS 2012 was conducted to assess the 10th FYP achievements among others.

The BLSS 2007 and BLSS 2012 included a sample of 10,000 and 9,632 households respectively. With a response rate of 97.98 percent in 2007 and 93.1 percent in 2012, the survey covered a total of 9,798 households in 2007 and 8,968 households in 2012. Unfortunately, due to some missing observations in the data on road accessibility, not all the households could be incorporated for the analysis. After accounting for missing values, the final sample is reduced to 8,185 households in 2007 and 7520 households in 2012. Since the present study focuses on rural Bhutan, the study uses 6285 households in 2007 and 3928 households in the 2012.

The information on distance to nearest road is based on a question: "How long does it take to get to the nearest roads such as tarred road, feeder road and farm road? (hours/minutes)". Answers provided in hours are converted into minutes. Instead of measuring the distance of a household by half a day as proposed in the 10th FYP, this study follows the BLSS report where distance is measured in 30 minutes to the nearest road head. Therefore, the final variable, which is distance to nearest road, is a binary variable taking the value of 1 if the distance is less than half an hour, otherwise 0.

Data on distance to nearest road is cautiously derived. Provided that distance to nearest road could be obtained either through distance to nearest tarred road or distance to nearest feeder road, the minimum distance to reach any road head is chosen. In 2012, data on distance to nearest feeder road is scanty. Most probably, it is due to the problem in identification of the roads. The BLSS 2012 has an extra question about farm road, which is excluded in 2007. Upon cross verification of the data, most households have given very similar response about the distance to reach these feeder road and farm road. Therefore, it is found safe to merge these two information under one heading as distance to feeder road. In case of difference in the time taken to reach farm road and feeder road, the shortest distance is used.

Two wealth indices are constructed based on standard PCA and polychoric PCA for the reason already mentioned in section 1. Detailed methodology is outlined in Filmer and Pritchett (2001, p.117) for standard PCA and Kolenikov and Angeles (2009, p.135-137) for polychoric PCA. The 17 variables used in constructing the wealth indexes and its definition is provided in Table 7 in the appendix. The variables are almost identical to that of Filmer and Pritchett (2001). Not all the 21 variables used in Filmer and Pritchett (2001) could be incorporated because some variables could not converge while constructing wealth index through polychoric PCA.

The first principal component has the maximum variance amongst the linear combination of the variables so; the first principal component from the standard PCA and polychoric PCA is used to represent the wealth index. The first principal component from the standard PCA explains 20.54 percent in 2012 and 24.25 percent in 2007. The first principal component from the Polychoric PCA explains about 35.74 percent in 2012 and 41.66 percent in 2007 of the variation in the 17 variables used. The variation of variables in polychoric PCA is almost twice as that of variation in standard PCA, which describes that polychoric PCA is a better indicator of a wealth index.

3. METHODOLOGY

To make the causal inference of road connectivity on household wealth in rural Bhutan, this study adopts the Difference in Difference (DiD) approach. The DiD approach is befitting for this study as it is mostly used to evaluate the impact of policies (Li, Graham and Majumdar, 2012). Basically, DiD approach deals with observations, which are collected for two groups for two periods. One group is the treatment group and the other group is the control group, which receives no treatment during both the periods. The treatment group in this study is the household wealth and the control group, which receives treatment, is the road connectivity. Now the obvious question is, is the road connectivity time invariant? No, but it is reasonable enough to assume that without policy intervention from the government, road infrastructure development would not be as rapid as it does after the policy intervention. Therefore, wealth increase in rural Bhutan over time from 2007 to 2012 is extracted from the increase in road connectivity from 2007 to 2012.

As provided in Wooldrige (2005), the DiD approach can be expressed as follows:

$$W_i = \beta_0 + \delta_0 time + \beta_1 road + \delta_1 interaction + u_t, \quad (1)$$

where W_i is the outcome variable wealth of a household i. The variable $time$ is a dummy variable taking the value of 1 for the year 2012 and 0 for the year 2007. The variable $road$ is also a dummy variable taking the value of 1, if the household i is less than 30 minutes to the nearest road head and 0 otherwise. The variable $interaction$ is interacting variable between $time$ and $road$. The intercept β_0, measure the average wealth of a household that are near the road head. The parameter δ_0 measures the change in wealth from 2007 to 2012. The coefficient β_1 captures the distance effect that is not due to the proximity to the road. δ_1 is the parameter of interest, which measures the increase or decrease in wealth due to increase in road connectivity. Finally, u_t is the random error term assumed normally distributed.

The DiD approach heavily relies on parallel time trend. As suggested by Abadie (2005), a vector of covariates is introduced in the model to adjust for factors that might lead to a violation of the parallel trend assumption. Further, the wealth of a household in 2012 might be systematically different than those households in 2007. So, inclusion of covariates can control for such differences. Even if the wealth has remained unchanged but inclusion of covariates can minimize the error variance, which can assist in producing smaller standard error of the parameter estimate δ_1 (Wooldrige, 2005).

After the inclusion of various covariates, the final specification of the DiD model is as follows:

$$W_i = \beta_0 + \delta_0 time + \beta_1 road + \delta_1 interaction + \beta_2 X_i + u_t, \quad (2)$$

where X is the vector of covariates for household i, such as distance to markets and

shop, proportion of working age household members, proportion of dependents in the household, proportion of different education categories and various districts. The base district is the capital city Thimphu. The coefficient β_2 measures the impact of such covariates on household wealth.

The household demographic characteristic such as working age is included to capture the earning capability of a household. The proportion of dependents signify the vulnerability of a household falling into poverty because households with large number of dependents have less potential to earn income and they are characterised by poverty (Mapa, Albis and Lucagbo, 2012). Better education is expected to provide better opportunities like getting jobs and higher salary (Dartanto and Nurkholis, 2013). Therefore, various education categories are included to capture the human capital potential of the households. Access to market is thought to enhance agriculture-based economic growth and increase rural income (International Fund for Agriculture Development [IFAD], 2003). So, access to market is captured by distance to nearest market and shops. Various districts are also included in the model to capture factors such as local culture, different climatic conditions and other varying characteristics between the districts. Variable definition is provided in Table 6 in the appendix.

The specification provided in equation (2) is performed on five different quantiles generated based on Pchoric wealth and PCA wealth. Dividing data into five different quantiles can allow the effects of independent variables to differ over the quantiles (Baum, 2013). This is necessary because road connectivity is supposedly a pro-poor development activity and if the benefit is accrued only by few rich households, it has severe policy implications. The 1st, 2nd, 3rd, 4th and 5th quantile represents the very poor, poor, medium, rich and very rich households. In order to control for heteroscedasticity in the model, results are generated with robust standard errors.

4. RESULTS

The discussion on descriptive statistics is provided before interpreting the final results. Since movement in the variables under various quantiles generated using Pchoric wealth and PCA wealth are similar, the summary explanations are based only on Pchoric wealth quantiles.

4.1. Descriptive Statistics

It is evident from Table 1 that wealth in general is lesser in 2012 compared to 2007 in all the quantiles. Distance to road has reduced across the quantiles. Among the very poor category, around 62 percent of the households are able to reach the nearest road head in less than half an hour in 2012 as compared to 39 percent in 2007. The trend is very similar in case of distance to feeder road. However, the average number of very.

Table 1. Summary statistics by Pchoric Wealth and PCA Wealth

	Pchoric Wealth																	
	Very Poor			Poor			Medium			Rich			Very Rich			TOTAL		
	2007	2012	Pld	2007	2012	Pld	2007	2012	Pld	2007	2012	Pld	2007	2012	Pld	2007	2012	Pld
pchoricwealth	-1.90	-2.39	-2.12	-1.23	-1.21	-1.23	-0.67	-0.64	-0.66	0.04	0.04	0.04	1.41	1.08	1.28	-0.47	-0.65	-0.54
t_road	0.39	0.62	0.49	0.57	0.81	0.64	0.71	0.86	0.76	0.85	0.94	0.89	0.94	0.98	0.96	0.69	0.83	0.75
tfee_road	0.37	0.60	0.48	0.54	0.80	0.62	0.68	0.85	0.74	0.83	0.93	0.87	0.93	0.97	0.95	0.67	0.83	0.73
ttar_road	0.12	0.15	0.13	0.23	0.33	0.27	0.38	0.37	0.38	0.54	0.58	0.56	0.76	0.70	0.73	0.41	0.42	0.41
t_marshop	0.19	0.31	0.24	0.28	0.44	0.33	0.39	0.50	0.43	0.53	0.66	0.58	0.71	0.74	0.72	0.42	0.53	0.46
workingage_r	0.40	0.42	0.41	0.41	0.43	0.42	0.42	0.43	0.42	0.41	0.44	0.42	0.43	0.46	0.44	0.41	0.44	0.42
dependents_r	0.32	0.27	0.30	0.31	0.27	0.30	0.29	0.26	0.28	0.31	0.27	0.29	0.30	0.28	0.29	0.31	0.27	0.29
junioredu_r	0.22	0.27	0.24	0.26	0.28	0.27	0.28	0.29	0.28	0.30	0.30	0.30	0.33	0.30	0.32	0.28	0.29	0.28
highsecedu_r	0.02	0.04	0.03	0.03	0.08	0.04	0.05	0.09	0.07	0.07	0.11	0.08	0.13	0.17	0.15	0.06	0.10	0.07
degreeedu_r	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.02	0.01	0.01	0.04	0.02	0.03	0.07	0.04	0.01	0.03	0.02
	PCA Wealth																	
pcawealth	-2.63	-3.56	-3.07	-1.74	-1.71	-1.73	-0.94	-0.93	-0.93	0.04	0.02	0.04	2.02	1.50	1.81	-0.67	-0.95	-0.78
t_road	0.39	0.62	0.50	0.57	0.81	0.63	0.72	0.85	0.77	0.85	0.93	0.89	0.94	0.98	0.96	0.69	0.83	0.75
tfee_road	0.37	0.61	0.48	0.54	0.81	0.61	0.69	0.85	0.75	0.83	0.93	0.87	0.93	0.97	0.95	0.67	0.83	0.73
ttar_road	0.11	0.15	0.13	0.23	0.33	0.26	0.39	0.38	0.39	0.55	0.56	0.55	0.76	0.69	0.73	0.41	0.42	0.41
t_marshop	0.18	0.31	0.24	0.28	0.44	0.33	0.41	0.50	0.44	0.53	0.65	0.58	0.71	0.73	0.72	0.42	0.53	0.46
workingage_r	0.40	0.43	0.41	0.41	0.43	0.42	0.42	0.43	0.42	0.41	0.44	0.42	0.43	0.46	0.44	0.41	0.44	0.42
dependents_r	0.33	0.27	0.30	0.31	0.27	0.30	0.29	0.26	0.28	0.31	0.27	0.29	0.30	0.28	0.29	0.31	0.27	0.29
junioredu_r	0.21	0.27	0.24	0.26	0.28	0.27	0.28	0.29	0.28	0.30	0.29	0.30	0.33	0.30	0.32	0.28	0.29	0.28
highsecedu_r	0.02	0.05	0.03	0.03	0.08	0.04	0.05	0.09	0.06	0.07	0.11	0.09	0.13	0.17	0.15	0.06	0.10	0.07
degreeedu_r	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.02	0.01	0.00	0.03	0.02	0.03	0.06	0.04	0.01	0.03	0.02

Note: Pld stands for pooled data.

Poor households living within half an hour distance from tarred road is very less. Though it has improved in 2012 but still the average is only around 15 percent, indicating that access to tarred road in rural villages is less. In total, only around 13 percent of the very poor households are able to reach the nearest tarred road within half an hour as compared to 48 percent in reaching the feeder road.

Along with the improvement in access to roads, distance to markets and shops has also improved in 2012 compared to 2007. Around 31 percent of the poor households are able to access markets and shops within half an hour in 2012 compared to 19 percent in 2007. Similar difference is observed in other wealth categories. However, the change is not drastic in the very rich category. Very rich households being able to reach nearest markets and shops have improved only by 3 percent. Despite the marginal change, the overall average of 72 percent show that very rich households are mostly located in the close proximity of markets and shops. This indicates that access to markets is an important factor in determining wealth of a household.

The average working age members in the households have increased over the years. In the very poor category, the average has increased from 40 percent in 2007 to 42 percent in 2012. The average percentage increase is very similar across the categories with little higher change in rich and very rich category. This shows that rich households have more number of working aged people compared to the poor households. On the other hand, the average numbers of dependents have decreased in 2012 across different categories. The largest drop is seen in the very poor category, where average number of dependents decreased in 2012 to 27 percent as compared to 32 percent in 2007. In other categories, the rate in change is around three to four percent but the lowest change is observed in very rich category. The average number of dependents decreased only by two percent in 2012 from 2007.

In the education categories, some differences are observed in junior high school qualification. In all the wealth quantiles, the average household members in junior high school qualifications have increased except for the very rich category where junior high school qualification has decreased from 33 percent in 2007 to 30 percent in 2012. This shows that richer households have lesser-unqualified members. This is evident from other two-education category as well. Very rich category has 15 percent of their household members with high school qualification and four percent of their household members with degree and above qualification. This is relatively higher compared to the very poor category, where the total average is only around three percent with high school qualification and less than one percent with degree and above qualification.

4.2. Classification Results

Along with the descriptive, it is also important to provide some explanation on the differences in classification produced by different wealth quantiles. As provided in Table 2, 97.9 percent of the households are classified very poor by PCA wealth and Pchoric wealth. However, around 43 households or 2.1 percent of the households are

classified poor by Pchoric wealth as opposed to PCA wealth, which classifies it under very poor category. The commonality between poor categories stands at 93.92 percent because 4.07 percent and 2.01 percent of the households is classified medium and poor by the Pchoric wealth. Similarly, around 4.6 percent of the households are considered poor and 3.82 percent of the households rich by Pchoric wealth, which is classified medium by the PCA wealth. The overall correspondence in the medium category is recorded at 91.58 percent.

Table 2. Classification by PCA Wealth and Pchoric Wealth

	PCA WEALTH				
PCHORIC WEALTH	Very Poor	Poor	Medium	Rich	Very Rich
Very Poor	2,005	41	0	0	0
	(97.9)	(2.01)	0	0	0
Poor	43	1,915	94	0	0
	(2.1)	(93.92)	(4.6)	0	0
Medium	0	83	1,870	77	0
	0	(4.07)	(91.58)	(3.77)	0
Rich	0	0	78	1,930	51
	0	0	(3.82)	(94.52)	(2.5)
Very Rich	0	0	0	35	1,991
	0	0	0	(1.71)	(97.5)

Note: Figures in the parenthesis are percentages.

Among the rich category as well, though the overall similarity is about 94.52 percent, 3.77 percent of the household is classified medium and 1.71 percent of the household is classified very rich by the Pchoric wealth. In the very rich category, 97.5 percent of the households are classified in the same category with only 2.5 percent of the household classified rich by the Pchoric wealth. Overall, the classification results suggest a strong coherence between PCA wealth and Pchoric wealth.

4.3. Difference in Difference Regression Results

The regression results are provided in Table 3. Column 1 to column 5 shows the results obtained using the Pchoric wealth quantiles and column 6 to column 10 shows the results obtained using the PCA wealth quantiles. The major focus of discussion is on the interaction term. The interaction variable elucidates whether wealth over the years have increased or decreased due to change in road connectivity. As the results obtained from Pchoric wealth quantiles and PCA wealth quantiles does not vary much, most of the explanation is based on Pchoric wealth quantiles but opinions are expressed wherever there are differences. For the interest of space, results on the district dummies are not presented in the table.

The point estimate of the impacts of various variables on wealth is not really of interest but their association and significance is the main motivation behind the present study as they have policy implications. Therefore, the association between road connectivity and household wealth is explained instead of probing on the coefficient changes. Wealth is lesser in very poor, rich and very rich category in 2012 compared to 2007 as depicted by the variable time. However, the association is significant only in the case of very poor category. Whereas, wealth is more in poor and medium category with significant association only in case of medium category. The distance to road has positive association with wealth, indicating that road connectivity actually increases household wealth. The association is significant in poor, medium and very rich categories.

The interacting term provides a very interesting find. It shows that wealth has increased in the very poor category and decreased in the very rich category. Both the associations are statistically significant at 1 percent level of significance. This implies that road connectivity, as pro-poor development objective in Bhutan has been successful. However, the decrease in wealth in the very rich category is little obscure but possible. In 2012, Bhutan was badly hit by a balance of payment crisis mainly brought about the huge imports from India (Cabinet Secretariat of Bhutan, 2012). The central bank immediately checked on private credit growth by freezing most of the commercial loans. Such move by the central bank hugely affected the richer households. However, this benefited the local farmers, as they were encouraged to produce vegetables, livestock's and other domestic products. With more access to roads, their products could easily reach markets on time. This could most probably explain why there is increase in wealth in the very poor category and decrease in very rich category. So, decrease in wealth in the very rich category may not necessarily be due to road connectivity but mostly be due to economic recession. Though there is some indication that wealth has reduced in poor and medium category and increased in rich category but their associations are statistically insignificant.

Among the covariates, more number of household members in working age category has no significant effect in all the wealth quantiles. This could most probably explain the subsistent living condition of the rural households. They mostly work on daily basis not to accumulate wealth but for daily sustenance. Distance to markets and shops have significant impact only on very poor and very rich category though the association is positive in all the wealth quantiles. The significant association in the two extreme ends of wealth quantiles could most probably be because the very poor households are mostly suppliers and very reach categories are mostly sellers. So, access to market is of huge importance to generate wealth.

More numbers of dependents have adverse impact on wealth in the very poor and poor wealth quantiles while it has positive effect on the very rich category. This shows that dependents in the poor households are extra mouths to feed, plummeting the household wealth whereas, in the very rich category, they most probably assist their category. High school education is also significant at 10 percent level of significance in

Table 3. Quantile Difference in Difference Regression by Distance to Road

Variables	PCHORIC WEALTH				
	Very Poor	Poor	Medium	Rich	Very Rich
	(1)	(2)	(3)	(4)	(5)
time	-0.642***	0.0137	0.0423**	-0.0534	-0.136
	(0.035)	(0.018)	(0.018)	(0.033)	(0.099)
t_road	0.0278	0.0251**	0.0244**	0.0284	0.289***
	(0.018)	(0.010)	(0.012)	(0.018)	(0.063)
interaction	0.204***	-0.0034	-0.0233	0.0479	-0.270***
	(0.043)	(0.021)	(0.020)	(0.035)	(0.103)
t_marshop	0.0675***	0.00233	0.00373	0.0125	0.0632**
	(0.024)	(0.009)	(0.008)	(0.011)	(0.032)
workingage_r	0.0231	-0.0049	0.0184	-0.00979	0.0501
	(0.045)	(0.018)	(0.017)	(0.026)	(0.072)
dependents_r	-0.0859*	-0.0367*	0.00364	-0.00792	0.221***
	(0.049)	(0.021)	(0.021)	(0.031)	(0.075)
junioredu_r	0.105**	0.0436**	0.00715	0.0312	0.133**
	(0.048)	(0.019)	(0.018)	(0.027)	(0.065)
highsecedu_r	0.204*	-0.00681	0.0391	0.103***	0.538***
	(0.121)	(0.030)	(0.025)	(0.034)	(0.078)
degreeedu_r	0.339	0.0451	-0.0624	0.0542	0.866***
	(0.212)	(0.045)	(0.039)	(0.054)	(0.121)
constant	-1.949***	-1.223***	-0.703***	0.0392	0.981***
	(0.124)	(0.043)	(0.036)	(0.042)	(0.101)
N	2046	2052	2030	2059	2026
	PCA WEALTH				
	Very Poor	Poor	Medium	Rich	Very Rich
	(6)	(7)	(8)	(9)	(10)
time	-1.213***	0.0246	0.0312	-0.0799*	-0.179
	(0.054)	(0.026)	(0.027)	(0.046)	(0.142)
t_road	0.0155	0.0436***	0.0367**	0.0421*	0.445***
	(0.025)	(0.014)	(0.016)	(0.025)	(0.093)
interaction	0.396***	-0.0172	-0.0382	0.0531	-0.462***
	(0.067)	(0.029)	(0.030)	(0.049)	(0.147)
t_marshop	0.0935**	-0.00755	0.0142	0.0329**	0.0858*
	(0.039)	(0.012)	(0.012)	(0.015)	(0.045)
workingage_r	0.0609	-0.00364	0.0194	0.0106	0.0970
	(0.071)	(0.026)	(0.024)	(0.037)	(0.102)
dependents_r	-0.151**	-0.0414	0.0266	0.0467	0.369***
	(0.077)	(0.029)	(0.030)	(0.043)	(0.107)
junioredu_r	0.173**	0.0704***	0.0243	0.0291	0.177*
	(0.076)	(0.026)	(0.026)	(0.038)	(0.094)
highsecedu_r	0.411**	0.0301	0.0665*	0.0917*	0.768***
	(0.195)	(0.044)	(0.036)	(0.048)	(0.108)
degreeedu_r	0.413	0.0993	0.0458	0.208***	1.259***
	(0.342)	(0.089)	(0.059)	(0.078)	(0.173)
constant	-2.679***	-1.692***	-0.955***	0.0351	1.408***
	(0.200)	(0.061)	(0.052)	(0.057)	(0.146)
N	2048	2039	2042	2042	2042

Note: Robust standard error in the parenthesis. *, **, *** denotes significance level at 10 percent, 5 percent and 1 percent respectively.

parent in fostering wealth accumulation. Among the education categories, junior education qualification is relatively important in explaining wealth in very poor and poor the very poor category. Contrarily, all the education categories are statistically significant in very rich wealth quantile. High school education is significant in rich wealth quantiles as well. This finding in a way shows that education is very important determinant in explaining household wealth but as poor households are mostly constrained by resources, they are only able to provide lower level of education. Whereas, very rich households are able to provide for education and they reap the benefit of further enhancing their wealth.

The results in column 6 through column 10 generated using PCA wealth also provide very similar findings. The interacting term, which is the main variable of concern, provides identical association and significance to that of Pchoric wealth quantiles. This finding also serves as the robustness check on the earlier results and explanation. Some minor discrepancies in the significance are also observed. The association between rich quantile and variables such as distance to road, distance to market and shops, and degree qualification is found insignificant in the regression results produced when using the Pchoric wealth but the association is significant while using the PCA wealth. The discrepancies could most probably be due to the differences in classification that is provided in Table 2. The degree of agreement between the quantiles is lowest in the medium category at 91.58 percent. About 3.82 percent of household that is classified medium by Pchoric wealth is considered rich by the PCA wealth. Since, PCA wealth slightly overestimates households classified under rich category, this could have overall implication on the significance as well. In general, the differences in the results produced by Polychoric PCA and standard PCA are not really huge.

In order to understand the importance of different road structure in aiding household wealth, distance to road is bifurcated into distance by feeder road and distance by tarred road. Table 3 and Table 4 presents the DiD regression results when using distance to reach the feeder road and distance to reach tarred road respectively. The results produced, when using feeder road, as the interacting variable is identical to that of the overall regression results. However, the results differ in their significance while using the tarred road as the interacting variable. The association and significance remain the same in the other wealth quantiles to that of earlier two regressions except for poor and medium wealth quantiles. The negative association is statistically significant at 10 percent level of significance. This could mostly be due to the economic recession in 2012 as already mentioned. Despite their close proximity to the tarred roads, which are mostly national highways, these categories of households also suffered the same fate as that of very rich category.

Table 4. Quantile Difference in Difference Regression by Distance to Feeder Road

Variables	PCHORIC WEALTH				
	Very Poor	Poor	Medium	Rich	Very Rich
	(1)	(2)	(3)	(4)	(5)
Time	-0.643***	0.0180	0.0352*	-0.0464	-0.0790
	(0.034)	(0.018)	(0.018)	(0.032)	(0.094)
Tfee_road	0.0281	0.0238**	0.0168	0.0269	0.287***
	(0.018)	(0.010)	(0.011)	(0.018)	(0.058)
Interaction_1	0.208***	-0.00903	-0.0144	0.0405	-0.332***
	(0.043)	(0.020)	(0.020)	(0.034)	(0.098)
T_marshop	0.0675***	0.00300	0.00516	0.0127	0.0633**
	(0.024)	(0.009)	(0.008)	(0.011)	(0.032)
Workingage_r	0.0256	-0.00508	0.0184	-0.00996	0.0457
	(0.045)	(0.018)	(0.017)	(0.026)	(0.072)
Dependents_r	-0.0839*	-0.0373*	0.00264	-0.00800	0.224***
	(0.049)	(0.021)	(0.021)	(0.031)	(0.075)
Iunioredu_r	0.104**	0.0436**	0.00791	0.0309	0.129**
	(0.048)	(0.019)	(0.018)	(0.027)	(0.065)
Highsecedu_r	0.204*	-0.00710	0.0381	0.104***	0.537***
	(0.121)	(0.029)	(0.025)	(0.034)	(0.077)
Degreeedu_r	0.336	0.0430	-0.0625	0.0534	0.866***
	(0.212)	(0.046)	(0.039)	(0.054)	(0.121)
_cons	-1.951***	-1.220***	-0.698***	0.0407	0.987***
	(0.124)	(0.043)	(0.036)	(0.041)	(0.098)
N	2046	2052	2030	2059	2026
Variables	PCA WEALTH				
	Very Poor	Poor	Medium	Rich	Very Rich
	(6)	(7)	(8)	(9)	(10)
Time	-1.213***	0.0284	0.00932	-0.0838*	-0.122
	(0.053)	(0.025)	(0.026)	(0.044)	(0.133)
Tfee_road	0.0146	0.0406***	0.0219	0.0399*	0.450***
	(0.025)	(0.014)	(0.016)	(0.024)	(0.085)
Interaction_1	0.403***	-0.0224	-0.0110	0.0573	-0.525***
	(0.067)	(0.029)	(0.030)	(0.047)	(0.139)
T_marshop	0.0936**	-0.00652	0.0164	0.0330**	0.0846*
	(0.039)	(0.012)	(0.012)	(0.015)	(0.045)
Workingage_r	0.0649	-0.00349	0.0195	0.0102	0.0899
	(0.071)	(0.026)	(0.024)	(0.037)	(0.102)
Dependents_r	-0.147*	-0.0424	0.0258	0.0459	0.373***
	(0.077)	(0.029)	(0.030)	(0.043)	(0.107)
Iunioredu_r	0.170**	0.0703***	0.0253	0.0292	0.170*
	(0.076)	(0.026)	(0.026)	(0.038)	(0.094)
Highsecedu_r	0.412**	0.0292	0.0641*	0.0915*	0.766***
	(0.195)	(0.044)	(0.036)	(0.048)	(0.108)
Degreeedu_r	0.407	0.0971	0.0463	0.206***	1.258***
	(0.342)	(0.090)	(0.059)	(0.078)	(0.173)
_cons	-2.682***	-1.687***	-0.946***	0.0376	1.413***
	(0.200)	(0.060)	(0.052)	(0.057)	(0.141)
N	2048	2039	2042	2042	2042

Note: Robust standard error in the parenthesis. *, **, *** denotes significance level at 10 percent, 5 percent and 1 percent.

Table 5. Quantile Difference in Difference Regression by Distance to Tarred Road

Variables	PCHORIC WEALTH				
	Very Poor	Poor	Medium	Rich	Very Rich
	(1)	(2)	(3)	(4)	(5)
time	-0.541***	0.0246**	0.0371***	-0.0142	-0.171***
	(0.023)	(0.011)	(0.010)	(0.017)	(0.046)
ttar_road	0.0317	0.0347***	0.0220**	-0.00055	0.253***
	(0.027)	(0.011)	(0.011)	(0.014)	(0.048)
interaction_2	0.188***	-0.0330*	-0.0305*	0.0124	-0.289***
	(0.056)	(0.018)	(0.016)	(0.022)	(0.056)
t_marshop	0.0836***	0.000546	0.00454	0.0174	0.0428
	(0.025)	(0.009)	(0.008)	(0.012)	(0.033)
workingage_r	0.0219	-0.00428	0.0174	-0.0086	0.0652
	(0.046)	(0.018)	(0.017)	(0.026)	(0.071)
dependents_r	-0.0749	-0.0381*	0.00331	-0.0077	0.240***
	(0.049)	(0.021)	(0.021)	(0.031)	(0.074)
junioredu_r	0.109**	0.0404**	0.00629	0.0304	0.122*
	(0.049)	(0.019)	(0.018)	(0.027)	(0.066)
highsecedu_r	0.218*	-0.00656	0.0390	0.102***	0.537***
	(0.118)	(0.029)	(0.025)	(0.034)	(0.077)
degreeedu_r	0.286	0.0363	-0.0637	0.0577	0.857***
	(0.201)	(0.046)	(0.039)	(0.054)	(0.122)
_cons	-2.018***	-1.215***	-0.690***	0.0618	1.055***
	(0.120)	(0.042)	(0.035)	(0.039)	(0.092)
N	2046	2052	2030	2059	2026
Variables	PCA WEALTH				
	Very Poor	Poor	Medium	Rich	Very Rich
	(6)	(7)	(8)	(9)	(10)
time	-1.033***	0.0326**	0.0116	-0.063***	-0.298***
	(0.037)	(0.015)	(0.015)	(0.023)	(0.067)
ttar_road	0.0308	0.0494***	0.0168	-0.00923	0.358***
	(0.039)	(0.016)	(0.015)	(0.020)	(0.071)
interaction_2	0.408***	-0.0487*	-0.0220	0.0629**	-0.417***
	(0.086)	(0.026)	(0.024)	(0.031)	(0.081)
t_marshop	0.120***	-0.00921	0.0180	0.0371**	0.0604
	(0.041)	(0.013)	(0.012)	(0.016)	(0.048)
workingage_r	0.0518	-0.00219	0.0186	0.0127	0.117
	(0.072)	(0.026)	(0.024)	(0.037)	(0.101)
dependents_r	-0.127*	-0.0431	0.0256	0.0463	0.395***
	(0.077)	(0.029)	(0.030)	(0.043)	(0.106)
junioredu_r	0.178**	0.0658**	0.0246	0.0267	0.164*
	(0.077)	(0.026)	(0.026)	(0.037)	(0.095)
highsecedu_r	0.446**	0.0304	0.0644*	0.0881*	0.768***
	(0.193)	(0.044)	(0.036)	(0.048)	(0.107)
degreeedu_r	0.328	0.0897	0.0462	0.215***	1.249***
	(0.322)	(0.092)	(0.060)	(0.077)	(0.175)
_cons	-2.816***	-1.678***	-0.933***	0.0709	1.546***
	(0.195)	(0.059)	(0.051)	(0.054)	(0.132)
N	2048	2039	2042	2042	2042

Note: Robust standard error in the parenthesis. *, **, *** denotes significance level at 10 percent, 5 percent and 1 percent respectively.

5. CONCLUSION

This study adopts DiD regression technique to measure the impact of policy initiatives such as improving road connectivity in rural Bhutan. The regression technique is quite befitting for the present study, as such methods are mostly used to assess the impact of policy initiatives.

The control variable in study, which is also the variable that is altered due to the policy change, is the distance to nearest road head. To see the impact of access to different road, further analysis is performed using tarred road and feeder road as the interacting variable. The treatment variable is the wealth index generated using the principal component analysis technique. Two sets of wealth index are produced, one using the standard principal component analysis and another using the Polychoric principal component analysis to measure the sensitivity of the two wealth index. Further, as the benefit of policy initiatives differ between rich and poor households, data on the rural households are divided into five different quantiles using both the wealth indexes. The lowest quantiles is classified as the very poor category and the highest quantile being the very rich category. Other covariates like demographic characteristics and district dummies are also used to control for parallel trend assumption.

Findings from the analysis suggest that due to the policy initiative of providing rapid access to road, very poor section of the rural societies have benefited. The impact is found insignificant in poor, medium and rich categories. On the other hand, road connectivity is found to have detrimental effect on wealth in the very rich category. The impact is very consistent when road is branched into tarred road and feeder road and when the results are generated using standard PCA wealth as well. Increase of wealth in the very poor category is also consistent with government's poverty report. Poverty got reduced from 23 percent in 2007 to 12 percent in 2012 (NSB, 2012) indicating that lots of very poor people in 2007 graduated out of poverty in 2012.

Findings also indicate that in order for poor households in rural areas to alleviate from poverty, it is important for the government to provide road connectivity. This could provide the rural poor households with higher employment opportunities and better terms of trade. Although road connectivity aided very poor section, it did not have equal benefit across the society. The insignificant impact on poor, medium, rich societies and the unfavourable effect on very rich category is an indication that if road connectivity is not complemented by vibrant market structure, road connectivity alone cannot increase wealth. Therefore, it is equally important for the government to have thriving economy to reap the benefit of road networks.

The discrepancies in the results produced using Polychoric PCA and standard PCA are not that severe. However, as the Polychoric PCA is by design developed for binary variables and as the first principal component explains almost twice the size in maximum variance amongst the linear combination of the variables, it is advisable to use Polychoric PCA in the future studies that use wealth index to proxy income or expenditure.

Finally, it is also important to mention some of the shortcomings of the present study. The study is purely based on cross sectional data in two periods, so tracking of wealth in a particular household is not possible. In addition, the results generated here should be cautiously read with possible endogeneity in the estimates. Wealth could also lead to increase in road connectivity but without plausible instruments available for road connectivity, instrument variable regressions could not be performed.

APPENDIX

Table A1. Variable Definition

Variable	Definition
Pchoric wealth	Wealth Index generated using the polychoric Principal Component Analysis
PCA wealth	Wealth Index generated using the standard Principal Component Analysis
Time	Binary dummy variable taking the value of 1 if the year is 2012 and 0 for 2007.
t_road	Binary dummy variable taking the value of 1 if the total time taken to reach the nearest either feeder road or tarred road is less than 30 minutes.
tfee_road	Binary dummy variable taking the value of 1 if the total time taken to reach the nearest feeder road is less than 30 minutes. Feeder roads usually connects village centres to the district capitals.
ttar_raod	Binary dummy variable taking the value of 1 if the total time taken to reach the nearest tarred road is less than 30 minutes. Tarred roads are blacktopped roads, which usually connects different districts.
interaction	Interacting term between roads and time (t_road*time).
interaction_1	Interacting term between feeder roads and time (tfee_road*time).
interaction_2	Interacting term between roads and time (ttar_road*time).
t_marshop	Binary dummy variable taking the value of 1 if the total time taken to reach the nearest market place or shops is less than 30 minutes.
workingage_r	Proportion of people between 25-60 years old in a household.
dependents_r	Proportion of children below the age of 15 in a household.
junioredu_r	Proportion of household member who has a qualification of junior high school (grade 1-8)
highsecedu_r	Proportion of household member who has a qualification of higher secondary school (grade 9-12)
degreeedu_r	Proportion of household member who has a qualification of bachelor's degree and above, diplomas and vocational certificates.

Note: Proportion is $\frac{X_i}{HS_i}$, where X_i is the explanatory variables of household i and HS_i is the household size of household i.

Table A2. Wealth Variable Definition

Variables	Definition
Car	Binary dummy variable taking the value of 1 if the household owns a car, otherwise 0.
sewing_machine	Binary dummy variable taking the value of 1 if the household owns a sewing machine, otherwise 0.
television	Binary dummy variable taking the value of 1 if the household owns a television, otherwise 0.
bicycle	Binary dummy variable taking the value of 1 if the household owns a bicycle, otherwise 0.
Radio	Binary dummy variable taking the value of 1 if the household owns a radio, otherwise 0.
Watch	Binary dummy variable taking the value of 1 if the household owns a watch, otherwise 0.
motorbike_scooter	Binary dummy variable taking the value of 1 if the household owns a motorbike/scooter, otherwise 0.
refrigerator	Binary dummy variable taking the value of 1 if the household owns a refrigerator, otherwise 0.
landholdings	Binary dummy variable taking the value of 1 if the household has land 5 acres or more, otherwise 0.
qualitywall	Binary dummy variable taking the value of 1 if the material used in constructing external wall of the house is either mud-bonded bricks/stones, cement-bonded bricks/stone or concrete, otherwise 0.
qualityroof	Binary dummy variable taking the value of 1 if the main construction material of the roof is either metal sheets, concrete/cement or tiles/slate, otherwise 0.
qualityfloor	Binary dummy variable taking the value of 1 if the main material of the floor is either wood, cement/tiles or concrete, otherwise 0.
Rooms	Total number of rooms in the household including bedrooms, living rooms and rooms used for family enterprise, but excluding toilets, kitchens and balconies.
pipedsource	Binary dummy variable taking the value of 1 if the main source of drinking water is either from pipe in dwelling/compound, neighbours' pipe or public outdoor tap, otherwise 0.
flushtoilet	Binary dummy variable taking the value of 1 if the type of toilet in the household has a flush system of any type, otherwise 0.
lightsource_electric	Binary dummy variable taking the value of 1 if the main source of lighting is electricity, otherwise 0.
cookingfuel	Binary dummy variable taking the value of 1 if the fuel used of cooking is either wood, coal or dung cake, otherwise 0.

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