Free riding and durable adoption: a test of color television consumption in rural China

Rong, Zhao

15 August 2011

Free Riding and Durable Adoption:
A Test of Color Television Consumption in Rural China

Abstract

Using the consumption of color television sets in rural China, this paper documents the existence of a type of network effect – free riding across neighbors, which reduces the propensity of non-owners to purchase. I construct a model of timing the purchase of a durable good in the presence of free riding, and test its key implications using household survey data in rural China.

JEL Classifications: D12, L68

Keywords: Durables, Free Riding, Network Effects, Rural China

1. Introduction

This paper provides evidence of a type of network effect[1] – the free-riding effect – among consumers of color television sets (CTVs) in rural China. The intuition is straightforward, and it reflects a type of consumption externalities that is perhaps peculiar to developing countries. In rural China, as in other developing countries, the television serves in part as a public good for the neighborhood. When a household purchases one, neighbors gain because they visit frequently to watch television. The nature of social interactions within a village induces the host to share use of his television. There is a network effect involved as well, since the higher the ownership rate, the more convenient it is for a non-owner to free ride.

However, empirically, it is hard to identify this "negative" network effect since it may coexist with some "positive" network effect, such as learning or network externalities, which may stimulate durable adoption.[2] These two types of network effects influence CTV adoption in opposite directions, but are both generally measured by the size of local

[1] Much of the evidence on network effects relates to technology adoption by firms (for a recent example, see Gowrisankaran and Stavins (2004) on the adoption of electronic transfers, or Bandiera and Rasul (2006) on the adoption of new crops in Mozambique), while studies documenting network effects among consumers are few and far between. Among the few exceptions, Gandal (1994) shows that consumers were willing to pay a premium for spreadsheet software compatible with the Lotus platform and with external database programs; Berndt et al. (2003) document how network externalities influence the demand for prescription pharmaceuticals; Goolsbee and Klenow (2002) report that people are more likely to buy their first home computer in areas where a high fraction of households already own computers; and Park (2004) finds that network externalities in video cassette recorders explain much of the dominance of VHS relative to Betamax.

[2] For CTV, a non-owner may learn from owners about its function, quality, price, etc., or benefit from the size of the local CTV "network", if purchased. These two types of network effects influence CTV adoption in opposite directions, but both are generally measured by the size of local users. Other "positive" network effects may include peer pressure. Peer pressure refers to a person changing his behavior in order to conform to a group.

users. This makes it difficult to identify empirically the "negative" network effect from its positive counterpart (Manski, 1993).

The fact that a household may or may not have a close substitute to a CTV – a black and white television set (hereafter BWTV) – provides me with a unique scenario in which to identify the existence of free-riding effects. For a household without either CTV or BWTV (hereafter non-BWTV household), if its neighbor has one, its propensity to buy a CTV should be reduced, due to free-riding effects. Conversely, for a household with only a BWTV but no CTV (hereafter BWTV household), family members can already enjoy TV programs at home. Therefore, their choice to purchase a CTV should not be influenced by free-riding effects. My identification strategy is to examine the effect of BWTV ownership rates[3] on the likelihood of CTV adoption of non-BWTV households, while taking BWTV households as the reference group. Doing so allows me to control for regional variations down to the village level. This eliminates many of the unobservable biases.[4]

This paper is among the first few to study how network effects deter the purchase of a durable good. My major findings are: 1) the estimated coefficient on BWTV ownership rates for non-BWTV households is significantly lower than that for BWTV households; 2) for a non-BWTV household with low income, its likelihood of purchasing a CTV drops more, due to the free-riding effect, compared to a non-BWTV household with high

[3] During my observation period, BWTV ownership rates were much higher than CTV. Therefore, a household is more likely to free ride by watching a BWTV rather than a CTV. More discussions are presented in later sections.

[4] Controlling for unobservable characteristics is also essential to identify the positive network effects. It is difficult to disentangle whether the reason that a household was more likely to adopt a CTV after neighbors did so is due to the positive network effect, or simply to the unobserved regional variations. Manski (1993) calls this inability the "reflection problem".

income; 3) this free-riding effect is weakened with a longer distance between neighbors and becomes less influential on CTV adoption.

This paper is related to the literature on informal risk sharing. Evidence has shown that, while rural households in underdeveloped countries live in poor and high-risk environments, their consumption is remarkably smooth (e.g., Townsend, 1994; Morduch, 1991; Paxson, 1992; Jacoby and Skoufias, 1997). This may be attributed to various risk-sharing arrangements within the community. Rosenzweig (1988), Udry (1994), Lim and Townsend (1998) and Rosenzweig and Wolpin (1993) document different mechanisms through which rural households achieve informal risk sharing, including gifts and transfers from family networks, state-contingent loan arrangements within a village, building up crop inventory, and trading assets. These risk sharing arrangements help because each household can maintain a lower inventory level, and thus consume more. Free riding plays a similar role. But this arrangement is different from risk sharing in that it is unidirectional and only non-TV households, who are generally poor, benefit. By free riding, a poor household benefits not only from holding its savings longer[5] but also from skipping the adoption of BWTV, which turned out to be replaced by CTV in a short period of time. In this aspect, free riding can be viewed as positive externalities that help the poor.

This paper is also related to the literature on public media. It has been shown empirically that public media exert an influence on the traditional norms in an underdeveloped area. For example, Jensen and Oster (2008) examine the introduction of

[5] Financial savings are used to deal with risk, as found by Lim and Townsend (1998) and Behrman et al. (1997).

cable TV at the village level and find it is associated with improvements in women's status. Olken (2006) contends that increasing media access, e.g., more time spent watching TV and listening to radio, is substantially related to lower levels of participation in social organizations. The existence of free-riding effects on CTV adoptions implies that, the influence of media access may not be confined to households with TV. In communities where relationships are close, this influence can easily spread.

The remainder of the paper is organized as follows. In Section 2, I present a dynamic model of a durable purchase. Section 3 describes the data. Section 4 reports empirical results and section 5 concludes the paper.

2. The Model

The model is based on Leahy and Zeira (2005), who discuss the timing and quality choice of durable good purchases in a general equilibrium dynamic model. In their model, both durable and non-durable goods are consumed and the durable good is lumpy. I ignore general equilibrium considerations and the question of quality choice, while introducing financial constraints.

I consider an infinitely-lived agent, who derives utility from consumption of a durable and a non-durable good. The durable good is homogeneous, does not depreciate, and only a single unit of it needs to be purchased. The agent begins life with zero wealth at time $t = 0$, earns income at the rate y, and must pay a price p for the durable good from savings.[6] He discounts at the rate ρ, which I assume equals the interest rate r. Let $u(c)$ denote utility from non-durable good consumption. It is increasing, strictly concave, and satisfies $\lim_{c\to 0} u'(c) = +\infty$. The flow of utility from consumption of the durable good is given by v.

Denote T as the time of the durable purchase. With the assumption that the interest rate and discount rate are equal, consumption smoothing implies that non-durable good consumption is constant during the interval $[0, T]$ and also during the interval (T, ∞). Thus the agent's problem is

$$\max_{c_1, c_2, T} \int_0^T e^{-rt} u(c_1) dt + \int_T^\infty e^{-rt} \{u(c_2) + v\} dt \,, \tag{1}$$

subject to

$$pe^{-rT} + \int_0^T e^{-rt} c_1 dt + \int_T^\infty c_2 e^{-rt} dt \leq \int_0^\infty ye^{-rt} dt \,, \tag{2}$$

$$pe^{-rT} + \int_0^T e^{-rt} c_1 dt \leq \int_0^T ye^{-rt} dt \,, \tag{3}$$

where inequation (2) is the budget constraint, and inequation (3) is the financial constraint. Local non-satiation implies that both (2) and (3) are binding, and that $c_2 = y$.[7] It then follows that $c_1 = y - s$, where

[6] The absence of consumption loans and the exogeneity of p are assumptions consistent with the situation in rural China during the period of the survey. In the 1990s, the rural market for CTVs was small relative to urban demand, so consumer prices would reflect primarily urban market conditions.

[7] After time T, the only good available for purchase is the non-durable one, so $c_2 \geq y$. The inequality is strict only when the consumer saves in the interval $[0, T]$ more than is necessary to purchase the durable

$$s = \frac{rpe^{-rT}}{1 - e^{-rT}} \tag{4}$$

is the constant saving rate during $[0, T]$. Equation (4) enables me to rewrite the agent's problem as

$$U = \max_{T \geq 0} \quad \frac{\left(1 - e^{-rT}\right)}{r} u\left(y - \frac{rpe^{-rT}}{1 - e^{-rT}}\right) + \frac{e^{-rT}}{r}\left(u(y) + v\right), \tag{5}$$

with necessary condition

$$e^{-rT}\left[\left(v + u(y)\right) - u(c_1)\right] \leq u'\left(c_1\right)s. \tag{6}$$

The left-hand side is the discounted present value of a marginal change in *T*, at which time the flow of utility changes from $u\left(c_1\right)$ to $v + u\left(y\right)$. At an interior optimum, this must equal the cost of a marginal change in *T*, which is given by

$$d\left[\int_0^T u\left(y - s\right)e^{-rt}dt\right] / dT = u'\left(c_1\right)s. \tag{7}$$

If $v < rpu'(y)$, then (6) is a strict inequality and the agent never purchases the durable good. Let $T = T(v, y)$ satisfy (6) when the solution is interior. The following proposition summarizes some useful results.

Proposition 1: *Under the above setting***,**

1. $T(v, y)$ is decreasing in v. $T(v, y)$ is decreasing in y, given that $u(.)$ is quadratic.

2. $\lim_{v \to +\infty} T(v, y) = \frac{1}{r}\ln\left(\frac{rP + y}{y}\right)$.

---

good. The financing constraint imposes the strict inequality $c_1 < y$ for any finite *T*. Hence, $c_1 < c_2$ and there is no incentive to save more than *p* in the interval $[0, T]$ because of consumption smoothing.

3. $\lim_{v \to rPu'(y)} T(v, y) = +\infty$.

4. $\frac{\partial^2 T(v, y)}{\partial v^2} \geq 0$ *and* $\frac{\partial^2 T(v, y)}{\partial v \partial y} \geq 0$*, given that* $u(.)$ *is quadratic.*[8]

With free-riding effects, an agent would behave as if his reservation value from durable consumption becomes lower.[9] Thus, he would postpone his durable purchase according to Proposition 1. The key testable implication is that when free-riding effects are stronger, the propensity to postpone durable adoption would be higher, thus the likelihood of adopting a durable in a fixed time window would be smaller. To adequately test this implication requires controlling for agents' willingness to pay. Proposition 1 indicates that an agent would postpone his durable purchase when either his income is lower, or his reservation value is lower. I am able to control for income. While I cannot directly observe a household's reservation value, I will examine several likely correlates, including the stability of electricity, the quality of the TV signal, and the electricity price, each of which would influence the utility of TV consumption.

---

[8] See the Appendix for proof.

[9] I ignore the endogeneity issue and simply assume that the free-riding effect is exogenous and constant over time. With free-riding effects, the agent's optimal problem becomes

$$\max_{c_1, c_2, T} \int_0^T e^{-rt} \left[u(c_1) + v_1 \right] dt + \int_T^\infty e^{-rt} \left[u(c_2) + v \right] dt ,$$

where v_1 represents the value obtained from free riding. It is easy to verify that the optimal timing for this problem is equivalent to the following:

$$\max_{c_1, c_2, T} \int_0^T e^{-rt} u(c_1) dt + \int_T^\infty e^{-rt} \left[u(c_2) + \left(v - v_1 \right) \right] dt .$$

That is, with free-riding effects, the agent behaves as if his reservation value from durable consumption decreases from v to $\left(v - v_1 \right)$.

Moreover, the income level would influence the free-riding effect. Given that the third-order effect from $u(.)$ is minor,[10] it is proved by Proposition 1 that the absolute value of the derivative $\frac{\partial T}{\partial v}$ would decrease when the income flow y increases. The intuition is as follows. A lower-income agent has a higher marginal saving cost due to his lower consumption level. When the demand for watching a TV program can be partially satisfied, its influence on low-income agents should be stronger because of their higher marginal saving costs. This implies that the timing of a low-income agent should be adversely affected more strongly by the same level of free riding, compared to a high-income agent. In other words, though both types of agents would postpone their durable purchases with the presence of free riding, a lower-income agent would postpone even longer. Therefore, in a fixed observation time window, one should expect that the likelihood of durable adoption by a low-income agent would decrease more due to free-riding effects, compared to a high-income agent.

3. Data

The data used in this paper are mainly from an October 1999 survey of rural durable goods consumption conducted by the Rural Survey Organization (RSO), the National Bureau of Statistics (NBS) of China. I also use data from the RSO's regular annual household survey of 1998. The consumption survey covered over 20,000 households from all the Chinese continental provinces except Tibet. They were drawn by a stratified random sampling method from the RSO regular survey frame of about 68,300

[10] It is sufficient when the utility function takes a quadratic form.

households. I exclude from my sample the 0.7 percent of households with no power. Further eliminating households with invalid data entries leaves me with around 18,800 households.

I treat CTV purchases in rural China during the late 1990s as first purchases rather than replacements. Before 1979, when China's reform began, televisions were scarce, even in urban China. It was even more so for CTV. Most rural households did not purchase CTVs until the 1990s. If the replacement cycle is 10 years or more, it seems reasonable to assume that most rural CTV purchases in the late 1990's were first purchases. Unquestionably, there would be no free-riding effect if the CTV purchase were a replacement.[11]

Table 1 provides some summary statistics. First, households are separated by CTV ownership status before 1998. Second, for households who did not own a CTV before 1998, I further separate them by whether a BWTV was adopted before 1998. Last, for either group, they are further separated by whether the household adopted a CTV from 1998 until the survey time. In either case, with or without a BWTV, new adopters, those who adopted a CTV since 1998, were better educated, earned higher income, and had a slightly smaller household size. As expected, new adopters also enjoyed lower electricity prices and stronger television signals. For non-BWTV households, the adoption rate was 46.5% (903 out of 1940), whereas it was 7.2% (495 out of 6888) for BWTV households. There could be two reasons for this huge difference. First, a BWTV is a substitute for a CTV, thus having a BWTV made a household less likely to adopt a CTV. Second, a

[11] 97% of households with CTV report their purchases within 10 years. The proportion of households with more than two CTVs was tiny. At the time of the survey, this proportion was only 3.2%. They are excluded from my examination since I only have information on the year of their latest CTV purchase.

household may have disposed of its BWTV once it owned a CTV; the survey only reports the current ownership status. If a household had sold its BWTV, its historical ownership would not be reflected in the survey. The failure to detect the disposition of a BWTV may lead to estimation bias. Fortunately, this disposition effect should not dominate. If it were the major reason for the difference in adoption rates, the proportion of households with BWTV should have been extremely low among old adopters who owned their CTV prior to 1998. Actually, this proportion is not that low at 19%, compared to 35% among new adopters. I will revisit this issue in the later sections.

4. Empirical results

4.1. Empirical specification

A household may or may not have a BWTV before its CTV purchase. This provides me with a unique scenario in which to identify the existence of free-riding effects. BWTV households should have a much lower propensity to free ride, for two reasons. First, they could enjoy a TV program simply by turning on their BWTV at home. Second, even though free riding may help save on their electricity bill and *colorful* programs are more enjoyable, taking advantage of neighbors like this was morally unacceptable, thus should rarely happen. Therefore, if free-riding effects did exist, they should most likely exist among non-BWTV households.

I analyze the free-riding effect on CTV purchases using cross-sectional linear probability (LP) regressions for all households. Since owning more than one CTV is rare in my study period, I follow convention in the literature on the demand for durable goods (e.g., Dubin and McFadden, 1984; Farrell, 1954) and treat the demand for CTVs as a binary decision of buying or not buying. I focus on the CTV adoption decision of non-BWTV households, while taking BWTV households as the reference group.[12] The dependent variable is a binary variable that equals one if a household purchased a CTV starting with 1998.

I use BWTV ownership rates in 1997 at the village level to measure the extent of free-riding effects. It is reasonable to believe that this measure is more precise than CTV ownership rates, given that the BWTV ownership rate was on average 54% in 1997, compared to 23% for CTV. It was more likely for a household to free ride by watching BWTV from its neighbor rather than watching CTV. Since the BWTV ownership rates vary only at the village level, the standard errors are corrected to allow for group effects within villages.[13]

I include a group dummy to control for the difference in the propensity to adopt a CTV between BWTV and non-BWTV households, as shown in Table 1. It equals one when the household had no BWTV before 1998, zero otherwise. My major interest is in the interaction of this group dummy with BWTV ownership rates. Assuming other effects related to BWTV ownership rates are similar between BWTV and non-BWTV households, the free-riding hypothesis implies that the coefficient on this interaction should be negative.

My control variables are divided into three groups. The first group includes variables describing household characteristics. They are household size, average age, the fraction

[12] As shown in Table 1, there were 8,829 households without CTV before 1998; among them, 6,888 households had a BWTV before 1998.

[13] When I use uncorrected standard errors, they are smaller. This indicates that there is some correlation within villages.

of male household members, average schooling years of members above sixteen years of age, and net income per capita. Income measures the household's budget constraint. All other variables are intended to control for a household's preference for CTV.

The second group collects variables describing location (town, suburban village, or rural village), and public service conditions enjoyed by a household at the village level.[14] The location variable needs further elaboration. Location favors a rural household close to a town, in two ways. First, living in or close to a town provides a household with easy access to the market and complementary services, thus reducing its cost of buying and using durable goods. Second, a household's consumption style may be more like an urban household if it lives in or close to a town. The public service conditions are binary variables for stability of the power supply (stable=1), access to a TV signal receiving tower (yes=1), and TV signal strength (good=1).[15] The third group includes county dummies to control for common unobserved characteristics across counties, such as local price differences.

I have on average fewer than ten households in each village, and one might be concerned that the sample village ownership rates are imprecise estimates of their population means. To reduce this measurement error, I restrict my sample to villages with at least ten observations.[16]

---

[14] Rong and Yao (2003) used the same data set to study the impact of public service provision on the rural consumption of electric appliances.

[15] Power supply stability and TV signal strength are subjective measures. Since the survey did not provide respondents with clear definitions for these two variables, there may be considerable measurement error in these variables.

[16] I repeat the regressions using the sample of villages with at least five observations. The major results persist.

One might also be concerned that the function of a BWTV is similar to a CTV, thus its purchase should be treated identical to a CTV purchase. However, this treatment seems inappropriate for the late 1990s. First, there is a huge difference in their prices. In my sample, the median purchase price of a BWTV in 1999 was 350 yuan while it was 1620 yuan for a CTV. The latter was close to the rural net income per capita in 1998. Second, after 1997, BWTV sales dropped sharply, indicating BWTV was outdated and was being replaced by CTV. For these two reasons, I ignore the possibility that a household may adopt a BWTV, and pool this situation to no purchase. For a robustness check, I later test how sensitive the estimation results would be without this pooling.

4.2. Main results

In column (1) of Table 2, I report the regression of CTV adoption since 1998. Half of the estimates are significant at the one percent level, with signs consistent with expectations. In the group of family characteristics, higher household population, greater average education, higher income, and the fraction of male household members increase a household's probability of purchasing a CTV. The effect of average age is insignificant. The positive effect of income is as expected. More family members reduce the cost per capita of sharing a CTV, which increases the household's willingness to buy. Higher educational levels have two effects. First, people with more education tend to have a higher desire for a modern life style. Second, more education implies easier adaptation to modern technologies.[17] As expected, BWTV households have a lower propensity to adopt a CTV, compared to non-BWTV households. Geographic location does not matter. As

[17] This is consistent with studies on new technology adoptions, which find that education stimulates new technology adoption.

expected, a stronger TV signal, higher electricity stability, or a lower electricity price makes a household more likely to purchase a CTV. The effect of BWTV ownership rates for BWTV households is significantly positive. This may be due to the local correlated unobservables not being well controlled for.[18]

The estimated coefficient on the interaction of the group dummy with BWTV ownership rates is –0.25, significant at the one percent level, which is consistent with the free-riding hypothesis. This indicates that, compared to a BWTV household, the likelihood for a non-BWTV household to adopt a CTV since 1998 would decrease by 2.5%, when BWTV ownership rates in 1997 were 10% higher. Again, this may be due to the failure to well control for local unobservables.

A better way to control for local unobservables is to use village dummies instead of county dummies. My methodology allows me to do so since my focus is on the interaction term.[19] Including village dummies in the regressions will eliminate most of the unobservable biases since the village size is small enough, with 250 households typically.[20] I rerun the regression with village dummies and report the result in column (2) of Table 2. To do so, I need to drop all the variables valued at the village level. Villages with only non-BWTV or BWTV households are dropped. The estimated coefficient on

[18] However, it is unlikely that BWTV ownership rates capture some positive network effects, which should be delivered by CTV ownership rates. The BWTV ownership rate is negatively correlated with the CTV ownership rate. Their correlation at the village level is –0.30.

[19] Bertrand et al. (2000) adopt a similar approach.

[20] Unlike the empirical literature on neighborhood effects, self-selection is not a concern here since reallocation in China was rare in the later 1990s, with the residence registration policy strictly enforced. This self-selection is also called the sorting problem in the literature, referring to the situation when households with similar characteristics tend to live in the same district.

the interaction term drops in absolute value to –0.17, but remains significant at the one percent level.

4.3. Concern over BWTV as a substitute for CTV

There is an alternative hypothesis consistent with the above findings. It may be the case that when the BWTV ownership rate in a village is higher, the local supply for second-hand BWTV increases. This drags down its local price, which may reduce the local demand for CTV, a close substitute for BWTV. I present three reasons why this should not be the major reason as follows.

First, if this substitution effect is significant, one should expect that those who stayed away from CTV would be more likely to adopt a BWTV when the initial BWTV ownership rate was higher. In contrast, the free-riding hypothesis predicts a negative relationship. Free-riding effects would not only deter CTV adoption, but may also deter BWTV adoption.[21] I run the regression on the likelihood of adopting a BWTV since 1998, among non-BWTV households who also reported no CTV at the survey time. The estimation result is reported in Table 3. I also repeat the regression with a different starting year of 1997 and 1999, respectively. For 1997, the estimated coefficient on BWTV ownership rates is significantly negative. This significance disappears when I switch to 1998 or 1999. In all these three cases, the second-hand market hypothesis is rejected. The result for 1997 is consistent with the hypothesis that free-riding effects existed among BWTV adopters, but that is not the case for the years 1998 or 1999. This difference seems to confirm my former statement that BWTV was outdated as of 1998.

[21] The effect may not be so strong since the BWTV price was far cheaper than CTV.

Moreover, if purchasing a BWTV was no longer an option, it makes the assumption that BWTV and non-BWTV households follow similar decision procedures more acceptable.

Second, if the second-hand market hypothesis is the major reason for my finding, one should expect that, if households who adopted a BWTV since 1998 are excluded from the sample, the estimated coefficient on the interaction term should significantly decrease in absolute value since the excluded households are apparently those who were supposed to be influenced most strongly by this substitution effect. For the remaining non-BWTV households, it is unlikely that their delay of purchase is the result of waiting for the optimal time to adopt a BWTV. As the trend has shown, the likelihood of adopting a BWTV after the survey should be minor. In contrast, if the substitution effect is negligible, one should not expect that the estimated coefficient be impacted much because the size of dropped observations is small relative to the size of non-BWTV households. The regression with this subsample is reported in column 3 of Table 2. The estimated coefficient on the interaction term rises slightly in absolute value to –0.18, and persists to be significant at the one percent level. Thus, I confirm that the second-hand market hypothesis is unlikely the major reason for my finding.

Third, even if this substitution effect did exist, the concern should be minor since adopting a BWTV became less and less popular in the late 1990s. In my sample, there were 2081 CTV purchases since 1998, whereas there were only 510 BWTV purchases in the same time span. To better understand how quickly BWTV became less popular, I recalculate these two counts by year. In 1997, there were 1298 CTV purchases, and 690 BWTV purchases. The ratio of these two was 1.9 to 1. In 1998, the numbers were 1283 and 367, respectively, with the ratio of 3.5 to 1. In 1999, they were 798 and 143, with the ratio of 5.9 to 1.

4.4. Robustness check

To address the concern that the details of my specification might potentially distort the estimation results, suppose that the true model is a logit. Using a LP model instead, the interaction term might be a proxy for the non-linear terms, thus generating spurious coefficients. In columns (4) and (5) of Table 2, I estimate probit and logit models, respectively. They include only county dummies, but not village dummies, due to the computational complexity of estimating logits and probits with around a thousand dummy variables. Column (1) indicates that using county fixed effects does not significantly change the results in the LP model, and one might tentatively expect the same to be true for the probit and logit models. The estimated coefficient on the interaction term persists significantly negative.

I also change the time scale and repeat the regression as in column (2) of Table 2. The results are reported in Table 4. Specifically, the 1999 regression has the following merits. First, in a later year, adopting a BWTV became even less popular. Thus the concern about adopting a BWTV as an option to non-BWTV households is further relieved. Second, most of the household characteristic variables are valued at the end of 1998. This makes the 1999 regression logically correct compared with the 1998 regression. Third, it makes the BWTV dummy a more reliable measure since a household should be less likely to have disposed of its BWTV within less than a year of a CTV purchase.

The 1999 estimation result is consistent with that of 1998. In the regression of CTV adoptions since 1997, the estimated coefficient on the interaction term turns insignificant. This change is consistent with the discussion above. Since earlier adopters are more likely to dispose of their BWTV, it makes the identification of free-riding effects more difficult. Another explanation could be that the most effective measure of free-riding effects should be the ownership rate at the time of purchase. When initial ownership rates are used instead, a longer time lag implies a poorer measure of free-riding effects, and thus is less likely to detect the relationship even if it exists.

Notice that the failure to completely account for this disposing effect should lead to underestimation of the interaction effect. As more BWTV households (those who had a BWTV but disposed of it before the survey) are misidentified as non-BWTV households, the inherent difference between these two groups should become less apparent. In extreme cases, when all non-BWTV households are due to misidentification, one should expect no interaction effect at all. Therefore, finding evidence of free-riding effects, in spite of the existence of this disposing effect, only strengthens my case.

If this interaction effect really comes from free riding, one should expect that its magnitude would be weakened when BWTV ownership rates become higher. For a non-BWTV household, the most convenient way to free ride is to turn to its nearest neighbor.[22] Once its nearest neighbor owns one, the further rise in BWTV ownership rates should be irrelevant to this household in terms of free riding. The higher the BWTV ownership rates, the more likely its nearest neighbor already has one, thus it is less likely

[22] It could be its closest relative, but the same logic applies.

a household would be influenced by the further rise in BWTV ownership rates. To test this hypothesis, I separate the sample by BWTV ownership rates. In one group, households were facing BWTV ownership rates less than 70%, and in the other no less than 70%.[23] I rerun the regression with each group, respectively, and report the results in Table 5. For the group of less than 70%, the estimated coefficient is –0.21, significant at the 5% level. In contrast, this significance disappears when switching to those with BWTV ownership rates no less than 70%.

The above finding also helps reject an alternative hypothesis. There may be a sample selection problem when using local ownership rates – the fact that a household has no CTV even after all its neighbors own one may simply indicate that its reservation value of CTV consumption is very low.[24] This sample selection not only explains the negative coefficient among non-BWTV households, but also explains why BWTV households do not follow the same pattern. By owning a BWTV, a household has revealed its preference to watch TV programs. However, this is unlikely the major reason for my results. If so, this interaction effect should be stronger among villages with higher BWTV ownership rates. It is more likely that a household has a very low reservation value if it stays with no TV where other households around it have one. However, Table 5 presents the opposite

[23] It is difficult to divide the sample evenly in size. In most villages, the sample size is exactly 10. So the calculated village ownership rates are clustered among some integer digit, such as 60%, 70%, etc.

[24] This potential problem can be interpreted in another way. Non-BWTV households in villages with low ownership rates may be very different from non-BWTV households in villages with high ownership rates. For instance, suppose there are two types of households, households that sometimes buy a BWTV and households that never buy a BWTV, and there are two types of villages, villages that are conducive to television purchase and those that are not, perhaps because of TV signals or the strength of retail competition. In high ownership villages, only the low value consumers do not purchase. Then one should see no purchase by non-BWTV households in villages with high ownership rates, potentially generating the result.

results – it is among villages with lower BWTV ownership rates where a negative coefficient on the interaction term is detected.

Non-BWTV households probably follow a different decision-making process than BWTV households. For instance, non-BWTV households might exercise the option to adopt a BWTV, but BWTV households do not because they already have one. To test whether my result is due to the estimation bias because of mistakenly pooling these two types of households, I rerun the regressions for each type, respectively. The interaction term is no longer valid. Without the interaction term, the local fixed effects can only be controlled for at the county level. Accordingly, village variables are included to control for local differences at the village level. I reach similar results as shown in Table 6. For BWTV households, the estimated coefficient on BWTV ownership rates is significantly positive. In contrast, for non-BWTV households, this estimated coefficient is significantly negative. Moreover, this difference is statistically significant, consistent with the result of the pooling regression.

My estimation setting is essentially a differences-in-differences estimation, comparing purchase decisions of non-BWTV households in villages with high and low ownership rates, controlling for the difference in purchase decisions by BWTV households in villages with high and low ownership rates. One may still be concerned that the estimation results come from differential selection. This effect includes, but is not limited to, the sample selection. Generally speaking, different types of households are sorted into different villages, which may lead to the estimation result. To further eliminate this possibility, the following study will mostly restrict to non-BWTV households. If the estimation results are still consistent with the free-riding hypothesis, then it is unlikely that differential selection is the major reason.

4.5. Distance effect

I now test another implication of the free-riding hypothesis. Greater distance between neighbors may be negatively correlated with the magnitude of free-riding effects. As distance raises visiting costs between neighbors, the free-riding effect should be weakened. Thus, longer distance, on average, should promote CTV adoption. To test this implication, I use another independent variable, open living space per capita, as a proxy for the average distance between neighbors.[25] One limitation of this proxy is that it is valued at the provincial level. Again, my interest is in its interaction with the "not having a BWTV" dummy. Free riding should not influence BWTV households, thus distance between neighbors would not influence the likelihood of their CTV adoptions. In comparison, the rise in distance should lead to an increase in the likelihood of CTV adoption for non-BWTV households. This implies that the coefficient on this interaction should be positive. I rerun the regression including this interaction term and report the result in column (1) of Table 7. As expected, the estimated coefficient on this interaction term is significantly positive.

If this difference in distance effects between non-BWTV and BWTV households really stems from the fact that greater distance weakens the free-riding effect, one should also expect that for villages with greater distance between neighbors, the free-riding effect should be less influential even among non-BWTV households. As neighbors reside farther away, the effect of BWTV ownership rates should decrease in absolute value. I

[25] Its mean is 2.05 (100m^2 per capita). The standard deviation is 0.97.

rerun the regression including the interaction of a distance dummy and BWTV ownership rates, with samples restricted to only non-BWTV households. The distance dummy equals one if the distance proxy is among the top 10%. Doing so requires that I drop the village dummies. County dummies are included instead, as are variables at the village level. The result is reported in column (2). Though the sign of its estimated coefficient is positive, it is only significant at the 20% level. This may be due to the fact that the distance proxy is at the province level, and may not fully capture variations in distance at the county or village level.[26]

There is an alternative hypothesis consistent with the average effect. Distance makes watching TV programs more valuable since social interaction between neighbors becomes less convenient. For those who already owned a BWTV, this is not an issue because having BWTV is sufficient to enjoy TV programs at home. In this sense, distance only influences those without BWTV, but has no effect on those with BWTV. Due to data limitations, it is impossible to distinguish these two hypotheses by examining the interaction effect.

4.6. Income effect

[26] There is another testable implication. The distance effect should not be detected when including this distance proxy in the regression of the likelihood of household adoption of either refrigerators or washing machines. While rural Chinese commonly watch their neighbor's television, they do not generally keep food in their refrigerators or use their washing machines. For these two appliances, there should be no free-riding effect, thus no distance effect should be expected. Since I do not have a control group for these appliances, as I have for CTVs, I can only detect the average distance effect. Neither village nor county dummies are included in the regressions since the distance proxy is valued at the provincial level. For either appliance, the estimated coefficient on the distance proxy is insignificant. For comparison, I also run a similar regression of CTV adoption likelihood for non-BWTV households. The distance effect is significantly positive, as shown in column (3) of Table 8. In contrast, the estimated coefficient is significantly negative when regressing for BWTV households, as shown in column (4). Though the above results are consistent with the free-riding hypothesis, I do not give them much credit since local unobservables are not well controlled for.

Another testable implication from the free-riding hypothesis is related to income level. Based on the discussion in Section 2, the propensity for low-income households to purchase CTV should drop more due to the free-riding effect. Therefore, in a fixed observation time window, one should expect that the likelihood of CTV adoption for a lower-income household should decrease more due to free-riding effects, compared to a higher-income household. In addition to the reasoning presented earlier, there is another mechanism at play, that is, the reputation concern. Free riding by a high-income household may be looked upon as taking advantage of others, and may ruin the host's reputation. In contrast, free riding by a low-income household is more understood. A household with TV is more willing to help its poorer neighbors by sharing watching TV programs with them.

To test this implication, I construct an income dummy indicating whether a household's average net income is among the lowest 50%. I include its interaction with BWTV ownership rates into the regression. The village-level fixed effect is well controlled for with village dummies included. It is well known that the non-linearity of the income effect may lead to spurious results. I thus include a quadratic term of average net income. I also include the interaction between the income dummy and average net income. I rerun the regression for non-BWTV households and BWTV households, respectively, and report the results in columns (1) and (3) of Table 8. For non-BWTV households, the estimated coefficient on the interaction is negative, significant at the 10% level, indicating that free-riding effects influence lower-income households more adversely. In contrast, one should expect no free-riding effect for BWTV households, thus this pattern should not be found. My estimation result is as expected. As shown in column (3), the estimated coefficient on the interaction is insignificant.

Furthermore, one should expect the lowest-income households to be influenced the most strongly by free-riding effects. I rerun the regressions by redefining the income dummy to indicate if a household's average net income is among the lowest 25%, and report the results in columns (2) and (4). The previous results persist. Moreover, for non-BWTV households, the estimated coefficient on the interaction is larger in absolute value, which is consistent with the above statement that the lowest-income households were impacted the most strongly.

With the above estimation results, let us reconsider the sample selection hypothesis. If the sample selection were the major reason for my findings, one should expect that a non-BWTV household with high income, in a village of high ownership rates, should be more likely to have a very low reservation value compared to a non-BWTV household with low income, in the same situation. Tight budget constraints may be the reason that a low-income household does not purchase a BWTV. In contrast, this is less likely an issue for a high-income household. Therefore, one should expect that detecting a negative coefficient on BWTV ownership rates among high-income households is more likely. However, my estimation yields the opposite results, therefore further confirming that my findings are unlikely due to the sample selection.

5. Conclusions

Motivated by the observation that TV owners in rural China typically welcome their non-owner neighbors to watch television with them, I set out to test whether this free riding would influence non-owners' CTV adoption. I constructed a model of the timing of purchasing a durable good, and showed that, with free-riding effects, a non-owner would postpone purchase.

Using micro-level data on nearly 19,000 rural China households surveyed in 1999, I provide evidence that this free-riding effect has significant influence on a household's CTV adoption. I find that, compared to BWTV households, non-BWTV households are less likely to adopt a CTV in a village where a large share of households already own a BWTV. My method allows me to control for the local fixed effect at the village level.

I also find that the free-riding effect influences lower-income households more strongly. This is consistent with the hypothesis that a low-income household has a stronger incentive to take advantage of free riding in order to smooth its consumption. Moreover, I further test another implication of free-riding effects. Greater distances between rural households are likely negatively correlated with the magnitude of the free-riding effect. The distance effect on CTV adoption is significantly positive for non-BWTV households, compared to BWTV households.

If neighbors don't know each other, there should be no free-riding effects. Therefore, the existence of free-riding effects indicates that households in a village somehow have a close relationship with each other. Though it is not tested due to data limitations, it seems reasonable to further expect that the intimacy of neighbors should influence the free-riding tendency. Similar patterns have been found in the literature on risk sharing. For instance, Fafchamps and Lund (2003) show that, in the Philippines, gifts and informal loans circulate within networks made primarily of relatives. Similar evidence is also found in Tanzania by De Weerdt and Dercon (2006).

Although this free-riding effect is not evident in my data for washing machine and refrigerator adoptions in rural China, it is likely not unique to rural CTV adoption. Other durable goods with the characteristic of a public good should lead to similar results. Notable examples may be that of local phone service.

Even though this free-riding effect is minor in the developed countries, it may exist, especially among intelligence-related products, like DVDs, CDs, and etc. A current example is the policy instituted by amazon.com that e-books are available for rent. More specifically, as mentioned in its website, "Eligible Kindle books can be loaned once for a period of 14 days. The borrower does not need to own a Kindle -- Kindle books can also be read using our free Kindle reading applications for PC, Mac, iPad, iPhone, BlackBerry, and Android devices." In light of this dramatic reduction in the cost of sharing an e-book, it would be interesting to examine how free riding (such as borrowing a book from a friend rather than buying one) would influence an individual's purchasing behavior.

The finding of a network effect that discourages purchases has implications both for manufacturers and for policy makers. To the extent that the externality is limited to a setting in which social ties are relatively intimate, its existence suggests that demand for such goods will be lower in rural areas of developing countries, even after controlling for observable indicators of demand, such as income. On the policy side, it implies that demand is socially inadequate, and welfare might be enhanced through the judicious use of subsidies.

Appendix: Proof of Proposition 1

Let

$$B = e^{-rT}. \tag{A1}$$

Problem (6) is equivalent to the following maximizing problem:

$$\max_{B} \quad U = \frac{(1-B)}{r} u\left(y - \frac{rpB}{1-B} \right) + \frac{B}{r}\left(u(y)+v\right) \tag{A2}$$

$$s.t.\ \ B \in (0,1].$$

The constraint arises from the fact that T is nonnegative. The first-order condition (FOC), when the solution is interior, is

$$-\frac{1}{r} u\left(y - \frac{rpB}{1-B} \right) - \frac{P}{1-B} u'\left(y - \frac{rpB}{1-B} \right) + \frac{1}{r}\left(u(y)+v\right) = 0. \tag{A3}$$

I then check the second-order condition (SOC). The second derivative of U with respect to B is

$$\frac{\partial^2 U}{\partial B^2} = \frac{rP^2}{(1-B)^3} u''\left(c_1\right). \tag{A4}$$

It is always negative when $B \in (0,1]$. Therefore, if there is an internal solution for (A2), this solution would lead to the global optimal.

When $v \le rPu'(y)$, we have $\frac{\partial U}{\partial B}|_{B=0^+} = -u'(y)P + \frac{v}{r} \le 0$. Notice that when B approaches zero, T goes to infinite. Since the second derivative is negative, we should have $\frac{\partial U}{\partial B} < 0$ for $B \in (0,1]$. Thus, when $v \le rPu'(y)$, the agent's best choice is to never purchase the durable, and his non-durable consumption is equal to y.

When $v > rPu'(y)$, the agent would purchase the durable at time T when the FOC is satisfied.

Total differentiation of (A3) with respect to v and B leads to

$$\frac{dB}{dv} = -\frac{(1-B)^3}{r^2P^2u''(c_1)} > 0 . \quad \text{(A5)}$$

Thus,

$$\frac{dT}{dv} = \frac{dT}{dB}\frac{dB}{dv} < 0 . \quad \text{(A6)}$$

That is, the agent would purchase the durable earlier if the flow of utility v were larger.

Similarly, total differentiation of (A3) with respect to y and B leads to

$$\frac{dB}{dy} = \frac{-\frac{1}{r}\left[u'(c_1) - u'(y)\right] - \frac{P}{1-B}u''(c_1)}{-\frac{rp^2}{(1-B)^3}u''(c_1)} . \quad \text{(A7)}$$

It is positive given $u(.)$ is quadratic. Thus,

$$\frac{dT}{dy} = \frac{dT}{dB}\frac{dB}{dy} < 0 . \quad \text{(A8)}$$

That is, the agent would purchase the durable earlier if his income flow y were higher.

Now let us consider the second derivative. Assume that the influence of the third derivative of $u(.)$ is minor. Specifically, assume that $u(.)$ is quadratic, so its second derivative is a negative constant. Differentiating (A5) with respect to v, we get

$$\frac{d^2B}{dv^2} = \frac{3(1-B)^2}{r^2P^2u''(c_1)} . \frac{dB}{dv} < 0 . \quad \text{(A9)}$$

Since

$$\frac{d^2T}{dv^2} = \frac{d^2T}{dB^2}\left(\frac{dB}{dv}\right)^2 + \frac{dT}{dB}\frac{d^2B}{dv^2} , \quad \text{(A10)}$$

where, $\frac{dT}{dB} = -\frac{1}{rB} < 0$ and $\frac{d^2T}{dB^2} = \frac{1}{rB^2} > 0$, we have $\frac{d^2T}{dv^2} > 0$.

Similarly, given $u(.)$ is quadratic, differentiating (A5) with respect to *y* leads to

$$\frac{d^2B}{dvdy} = \frac{3(1-B)^2}{r^2P^2u''(c_1)}.\frac{dB}{dy} < 0. \qquad \text{(A11)}$$

Since

$$\frac{d^2T}{dvdy} = \frac{d^2T}{dB^2}\frac{dB}{dv}\frac{dB}{dy} + \frac{dT}{dB}\frac{d^2B}{dvdy}, \qquad \text{(A12)}$$

where, $\frac{dT}{dB} = -\frac{1}{rB} < 0$ and $\frac{d^2T}{dB^2} = \frac{1}{rB^2} > 0$, we have $\frac{d^2T}{dvdy} > 0$.

References

Bandiera, O., Rasul, I., 2006. Social Networks and Technology Adoption in Northern Mozambique. Econ. J. 116, 869–902.

Behrman, J. R., Foster, A., Rosenzweig, M. R., 1997. Dynamic Savings Decisions in Agricultural Environments with Incomplete Markets. J. Econ. Busi. Stat. 15, 282-292.

Berndt, E. R., Pindyck, R. S., Azoulay, P., 2003. Consumption Externalities and Diffusion in Pharmaceutical Markets: Antiulcer Drugs. J. Indu. Econ. 51, 243-270.

Bertrand, M., Luttmer, E., Mullainathan, S., 2000. Network Effects and Welfare Cultures. Qtr. J. Econ. 115, 1019-1055.

De Weerdt, J., Dercon, S., 2006. Risk-Sharing Networks and Insurance Against Illness. J. Dev. Econ. 81, 337-356.

Dubin, J. A., McFadden, D., 1984. An Econometric Analysis of Residential Electric Appliance Holdings and Consumption. Econometrica 52, 345-362.

Fafchamps, M., Lund, S., 2003. Risk Sharing Networks in Rural Philippines. J. Dev. Econ. 71, 261-287.

Farrell, M. J., 1954. The Demand for Motor Cars in the United States. J. Royal Stat. Society 117, 171-201.

Gandal, N., 1994. Hedonic Price Indexes for Spreadsheets and an Empirical Test for Network Externalities. RAND J. Econ. 25, 160-170.

Goolsbee, A., Klenow, P.J., 2002. Evidence on Learning and Network Externalities in the Diffusion of Home Computers. J. Law Econ. 45, 317-343.

Gowrisankaran, G., Stavins, J., 2004. Network Externalities and Technology Adoption: Lessons from Electronic Payments. RAND J. Econ. 35, 260-276.

Jacoby, H., Skoufias, E., 1997. Risk, Financial Markets, and Human Capital in a Developing Country. Rev. Econ. Studies 64, 311-335.

Jensen, R., Oster, E., 2008. The Power of TV: Cable Television and Women's Status in India. Mimeo, University of Chicago.

Leahy, J. V., Zeira, J., 2005. The Timing of Purchases and Aggregate Fluctuations. Rev. Econ. Studies 72, 1127-1151.

Lim, Y., Townsend, R., 1998. General Equilibrium Models of Financial Systems: Theory and Measurement in Village Economies. Rev. Econ. Dyn. 1, 59-118.

Manski, C. F., 1993. Identification of Endogenous Social Effects: The Reflection Problem. Rev. Econ. Studies 60, 531-542.

Morduch, J., 1991. Consumption Smoothing Across Space: Tests for Village-Level Responses to Risk. Mimeo, Harvard University.

Olken, B., 2006. Do Television and Radio Destroy Social Capital? Evidence from Indonesian Villages. NBER Working Paper No. 12561.

Park, S., 2004. Quantitative Analysis of Network Externalities in Competing Technologies: The VCR Case. Rev. Econ. Stat. 86, 937-945.

Paxson, C. H., 1992. Using Weather Variability to Estimate the Response of Savings to Transitory Income in Thailand. Am. Econ. Rev. 82, 15-33.

Rong, Z., Yao, Y., 2003. Public Service Provision and the Demand for Electric Appliances in Rural China. China Econ. Rev. 14, 131-141.

Rosenzweig, M., 1988. Risk, Implicit Contracts and the Family in Rural Areas of Low-Income Countries. Econ. J. 98, 1148-1170.

Rosenzweig, M., Wolpin, K., 1993. Credit Market Constraints, Consumption Smoothing and the Accumulation of Durable Production Assets in Low-Income Countries: Investment in Bullocks in India. J. Political Econ. 101, 223-244.

Townsend, R., 1994. Risk and Insurance in Village India. Econometrica, 62, 539-592.

Udry, C., 1994. Risk and Insurance in a Rural Credit Market: An Empirical Investigation in Northern Nigeria. Rev. Econ. Studies 61, 495-526.

Table 1

Demographics of Non-Owners Versus Owners

Variable	CTV Household		BWTV Household Y		BWTV Household N		Non-BWTV Household Y		Non-BWTV Household N	
Ownership rate in 1997	0.53	(0.26)	0.24	(0.22)	0.17	(0.18)	0.26	(0.23)	0.11	(0.17)
Average net income (1,000 yuan)	2.79	(1.96)	3.00	(1.99)	2.01	(1.31)	2.45	(1.67)	1.50	(0.99)
Average years of education	6.12	(1.86)	6.10	(1.89)	5.60	(1.85)	5.94	(1.79)	4.85	(1.99)
Average age (100 years)	0.32	(0.10)	0.34	(0.09)	0.32	(0.10)	0.32	(0.10)	0.32	(0.12)
Household size	4.27	(1.27)	4.15	(1.20)	4.23	(1.22)	4.14	(1.18)	4.44	(1.26)
Fraction male	0.52	(0.21)	0.57	(0.23)	0.53	(0.22)	0.53	(0.21)	0.51	(0.22)
Fraction in town	0.05	(0.21)	0.01	(0.11)	0.02	(0.13)	0.03	(0.18)	0.02	(0.12)
Fraction in rural village	0.86	(0.34)	0.92	(0.27)	0.93	(0.25)	0.90	(0.30)	0.94	(0.23)
Fraction with stable electricity	0.94	(0.24)	0.96	(0.19)	0.93	(0.26)	0.94	(0.25)	0.87	(0.34)
Electricity price (yuan/kW.h)	0.71	(0.28)	0.75	(0.23)	0.80	(0.28)	0.72	(0.26)	0.80	(0.30)
Fraction with strong TV signal	0.92	(0.27)	0.91	(0.29)	0.87	(0.33)	0.90	(0.30)	0.77	(0.42)
Fraction with TV tower	0.12	(0.32)	0.09	(0.29)	0.09	(0.29)	0.11	(0.31)	0.16	(0.37)
Observations	4133		495		6393		903		1037	

Note: For each sub-sample, the first column reports the mean and the second column reports the standard deviation. Y represents households who adopted CTV since 1998. N represents those who did not.

Table 2

LP Estimation Results on CTV Adoption

Variable	(1)	(2)	(3)	(4)	(5)
BWTV ownership rate	-0.248***	-0.171***	-0.181***	-2.123***	-1.166***
***Not having BWTV**	(0.052)	(0.062)	(0.064)	(0.351)	(0.186)
BWTV ownership rate	0.104***	-	-	1.091***	0.629***
	(0.028)			(0.300)	(0.154)
Not having BWTV	0.514***	0.452***	0.516***	4.320***	2.373***
	(0.036)	(0.044)	(0.044)	(0.253)	(0.130)
Average age	-0.037	-0.028	-0.038	-0.077	0.013
	(0.034)	(0.037)	(0.038)	(0.373)	(0.202)
Average years of education	0.013***	0.013***	0.014***	0.143***	0.079***
	(0.002)	(0.002)	(0.002)	(0.021)	(0.011)
Population	0.021***	0.021***	0.023***	0.218***	0.121***
	(0.003)	(0.004)	(0.004)	(0.039)	(0.021)
Fraction male	0.045**	0.039*	0.044**	0.577***	0.334***
	(0.018)	(0.020)	(0.020)	(0.197)	(0.107)
Average net income	0.043***	0.045***	0.044***	0.365***	0.204***
	(0.004)	(0.004)	(0.004)	(0.030)	(0.016)
Town dummy	-0.007			-0.150	-0.103
	(0.038)			(0.334)	(0.183)
Rural village dummy	-0.007			-0.081	-0.052
	(0.019)			(0.177)	(0.095)
Electricity stability	0.029**			0.216	0.138
	(0.014)			(0.168)	(0.089)
Electricity price	-0.046			-0.568**	-0.297**
	(0.028)			(0.261)	(0.140)
Strength of TV signal	0.046***			0.450***	0.256***
	(0.013)			(0.132)	(0.070)
Having TV tower or not	0.011			0.075	0.039
	(0.015)			(0.157)	(0.083)
County dummies	Y			Y	Y
Village dummies		Y	Y		
Observations	9309	9038	8711	8909	8909
Adjusted R^2/ Log Likelihood	0.279	0.296	0.329	-2648	-2659

Note: *, **, *** indicate the coefficient is different from zero at the 10%, 5%, and 1% significance levels, respectively. Standard errors are in parentheses.

Table 3

Effects of BWTV Ownership Rates on BWTV Adoption

Variable	Adoption 1997 (1)	Adoption 1998 (2)	Adoption 1999 (3)
BWTV ownership rate	-0.206***	-0.069	0.010
	(0.071)	(0.063)	(0.037)
Average age	-0.362***	-0.294***	-0.099*
	(0.105)	(0.105)	(0.054)
Average years of education	0.027***	0.021***	-0.000
	(0.007)	(0.006)	(0.004)
Population	0.025**	0.024**	0.006
	(0.011)	(0.012)	(0.008)
Fraction male	0.099*	0.002	0.015
	(0.053)	(0.057)	(0.038)
Average net income	0.039***	0.018	0.000
	(0.015)	(0.015)	(0.009)
Town dummy	0.167	0.101	0.083
	(0.138)	(0.157)	(0.104)
Rural village dummy	0.033	0.002	-0.038
	(0.072)	(0.063)	(0.035)
Electricity stability	0.054	0.024	-0.012
	(0.050)	(0.056)	(0.023)
Electricity price	0.162**	0.120	-0.014
	(0.077)	(0.086)	(0.035)
Strength of TV signal	0.089**	0.086**	0.039*
	(0.040)	(0.041)	(0.022)
Having TV tower or not	-0.053	-0.043	-0.022
	(0.049)	(0.052)	(0.027)
Observations	2004	1483	1223
Adjusted R^2	0.190	0.138	0.092

Note: *, **, *** indicate the coefficient is different from zero at the 10%, 5%, and 1% significance levels, respectively. Standard errors are in parentheses. County dummies are included.

Table 4

Effects of BWTV Ownership Rates on CTV Adoption

Variable	Adoption 1997 (1)	Adoption 1998 (2)	Adoption 1999 (3)
BWTV ownership rate* Not having BWTV	-0.068	-0.171***	-0.187***
	(0.057)	(0.062)	(0.054)
Not having BWTV	0.424***	0.452***	0.314***
	(0.036)	(0.044)	(0.040)
Average age	-0.034	-0.028	-0.025
	(0.040)	(0.037)	(0.026)
Average years of education	0.015***	0.013***	0.006***
	(0.002)	(0.002)	(0.002)
Population	0.031***	0.021***	0.013***
	(0.004)	(0.004)	(0.003)
Fraction male	0.041*	0.039*	0.005
	(0.021)	(0.020)	(0.015)
Average net income	0.051***	0.045***	0.030***
	(0.004)	(0.004)	(0.004)
Observations	9903	9038	8165
Adjusted R^2	0.335	0.296	0.202

Note: *, **, *** indicate the coefficient is different from zero at the 10%, 5%, and 1% significance levels, respectively. Standard errors are in parentheses. Each column regresses the decision to buy a CTV since 1997-1999, respectively. Village dummies are included.

Table 5

Regressions by the Level of BWTV Ownership Rates

Variable	Less than 70%	No less than 70%
BWTV ownership rate	-0.201**	-0.228
***Not having BWTV**	(0.093)	(0.251)
Not having BWTV	0.501***	0.457**
	(0.052)	(0.215)
Average age	-0.084	0.071
	(0.052)	(0.050)
Average years of education	0.015***	0.007**
	(0.003)	(0.003)
Population	0.022***	0.020***
	(0.005)	(0.005)
Fraction male	0.055**	0.031
	(0.028)	(0.028)
Average net income	0.047***	0.042***
	(0.006)	(0.006)
Observations	4827	4211
Adjusted R^2	0.357	0.168

Note: *, **, *** indicate the coefficient is different from zero at the 10%, 5%, and 1% significance levels, respectively. Standard errors are in parentheses. Village dummies are included.

Table 6

Effects of BWTV Ownership Rates on CTV Adoption

Variable	Non-BWTV	BWTV
BWTV ownership rate	-0.164***	0.079***
	(0.049)	(0.022)
Average age	-0.250***	0.108***
	(0.084)	(0.030)
Average years of education	0.027***	0.005**
	(0.005)	(0.002)
Population	0.022***	0.020***
	(0.008)	(0.003)
Fraction male	-0.011	0.057***
	(0.046)	(0.019)
Average net income	0.065***	0.034***
	(0.009)	(0.004)
Town dummy	-0.008	-0.045
	(0.103)	(0.032)
Rural village dummy	0.017	-0.023
	(0.056)	(0.016)
Electricity stability	-0.005	0.017
	(0.027)	(0.011)
Electricity price	-0.111*	-0.033*
	(0.064)	(0.020)
Strength of TV signal	0.105***	0.000
	(0.028)	(0.010)
Having TV tower or not	-0.028	0.015
	(0.031)	(0.013)
Observations	2421	6888
Adjusted R^2	0.359	0.085

Note: *, **, *** indicate the coefficient is different from zero at the 10%, 5%, and 1% significance levels, respectively. Standard errors are in parentheses. County dummies are included.

Table 7

Distance Effects on CTV Adoption

Variable	(1)	(2)	(3)	(4)
Distance*Not having BWTV	0.097**			
	(0.044)			
Distance dummy *BWTV ownership rate		0.256		
		(0.215)		
Distance			0.066**	-0.014**
			(0.027)	(0.005)
BWTV ownership rate * Not having BWTV	-0.149*			
	(0.083)			
Not having BWTV	0.257*			
	(0.126)			
BWTV ownership rate		-0.178***	-0.091	-0.004
		(0.051)	(0.063)	(0.017)
Average age	-0.025	-0.251***	-0.188**	0.134***
	(0.038)	(0.084)	(0.079)	(0.033)
Average years of education	0.013***	0.027***	0.052***	0.005**
	(0.002)	(0.005)	(0.005)	(0.002)
Population	0.021***	0.022***	0.006	0.021***
	(0.004)	(0.008)	(0.009)	(0.005)
Fraction male	0.041**	-0.010	-0.103*	0.039
	(0.019)	(0.046)	(0.051)	(0.028)
Average net income	0.044***	0.065***	0.095***	0.038***
	(0.004)	(0.009)	(0.008)	(0.007)
Village variables			Y	Y
County dummies		Y		
Village dummies	Y			
Observations	8695	2421	2339	6627
Adjusted R^2	0.307	0.360	0.234	0.048

Note: *, **, *** indicate the coefficient is different from zero at the 10%, 5%, and 1% significance levels, respectively. Standard errors are in parentheses. In columns (1), (3) and (4), standard errors are clustered at the province level.

Table 8

Interaction Effects with Income

Variable	(1) Non-BWTV 50%	(2) Non-BWTV 25%	(3) BWTV 50%	(4) BWTV 25%
BWTV ownership rate	-0.114*	-0.162**	0.019	0.025
*** Income dummy**	(0.070)	(0.074)	(0.024)	(0.024)
Average age	-0.200**	-0.178**	0.116***	0.116***
	(0.091)	(0.087)	(0.034)	(0.034)
Average years of education	0.020***	0.018***	0.004*	0.004*
	(0.005)	(0.005)	(0.002)	(0.002)
Population	0.039***	0.040***	0.020***	0.021***
	(0.009)	(0.009)	(0.004)	(0.004)
Fraction male	0.013	0.013	0.048**	0.048**
	(0.045)	(0.043)	(0.021)	(0.021)
Average net income	0.136***	0.122***	0.051***	0.047***
	(0.028)	(0.025)	(0.012)	(0.010)
Average net income	-0.011***	-0.009***	-0.002	-0.001
* Average net income	(0.003)	(0.003)	(0.001)	(0.001)
Average net income	0.020	0.011	-0.005	-0.019
* Income dummy	(0.030)	(0.049)	(0.011)	(0.017)
Observations	2756	2881	6888	6888
Adjusted R^2	0.464	0.481	0.121	0.121

Note: *, **, *** indicate the coefficient is different from zero at the 10%, 5%, and 1% significance levels, respectively. Standard errors are in parentheses. Village dummies are included.