# ABSTRACT


Title of dissertation: ECONOMICS OF SOCIETY:
ESSAYS ON HEALTH,
MARRIAGE AND CHILD ADOPTION

Anand Murugesan, Doctor of Philosophy, 2015

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The underlying theme of my research has been throwing light on issues of society where individual interest and the larger collective bargain are divergent. Primarily I have used the economic approach to examine social issues such as child adoption, pre-marital and marriage choices, and traditional norms of sanitation. I have chosen issues where my intuition suggested a dissonance between what people are individually motivated to do and what they might like to accomplish together. In my work I have developed simple economic models, and if the context necessitates, I borrow insights from related disciplines, primarily psychology and sociology. In enriching structure, the goal is to illuminate or establish the links between individual motivation and aggregate outcomes. For instance, in my work on child adoption, I show that the increasing trend of international adoptions in the United States has substituted for large number of adoptions from domestic foster care, leading to unintended societal outcomes: prolonged stay in foster care resulting in higher school dropouts, drug use, teen motherhood and juvenile delinquency. In the

second chapter examining the implications of communicable disease testing laws, I posit that uncertainty about future marriage partners' health status may reduce incentives for disease prevention efforts prior to marriage, resulting in higher rates of disease transmission, like HIV. In another paper, ensuing from a model of reciprocal externalities, I show that free riding results in dirty neighborhood drains, aggravating the health externalities due to open defecation in developing countries.

# ECONOMICS OF SOCIETY:
# ESSAYS ON HEALTH, MARRIAGE AND CHILD ADOPTION

by

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# Dedication

to Amma and Appa

# Acknowledgments

Scores of people have helped me bring this dissertation to this juncture, when I am to leave it alone. My thanks must first go to Roberton Williams, my dissertation advisor for seeing the point in letting me pursue research questions I sought to. I benefited greatly from his remarkable grasp of a broad range of ideas and nuanced reasoning. I thank Anna Alberini and Kenneth McConnell for their advice and help over these years. I owe a heavy debt of gratitude to Robert Innes, special member on my dissertation committee for his extraordinary generosity, understanding and guidance throughout my graduate studies in the US. Warm thanks to my colleagues and friends who took time to hear my arguments, read early drafts, and most of all made this journey so much more joyful. Lastly, I set down in writing the immense gratitude I owe to my family, Tiziana, Amma, Appa and Chandru for their hope in my quests and unconditional love.

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# Introduction

My dissertation essays use an economic approach to examine three socio-economic contexts where externalities arise from human behavior. In my work on child adoption, I show that the increasing trend of international adoptions in the United States has substituted for large number of adoptions from domestic foster care, leading to unintended societal outcomes: prolonged stay in foster care resulting in higher school dropouts, drug use, teen motherhood and juvenile delinquency. In the paper on effects of pre-marital testing, I posit that uncertainty about future marriage partners' health status may reduce incentives for disease prevention efforts prior to marriage, resulting in higher rates of disease transmission, like HIV. In the third paper, ensuing from a model of reciprocal externalities, I show that free riding results in dirty neighborhood drains, aggravating the health externalities due to open defecation in developing countries.

I broadly summarize each of my three dissertation essays below.

## "*More than kin and less than kind?* The Economics of Child Adoptions from U.S. Foster Care"

My first dissertation chapter examines the economics of child adoption from foster care. Over 500,000 children in United States are currently in foster care, and in excess of 100,000 children among them are waiting to be adopted out of foster care. Studies have shown that children in foster care tend to have much worse long-run outcomes, including higher rates of unemployment, criminal activity, and incarceration (Doyle, 2007 & 2008). Thus having those children adopted out of foster care reduces these externalities. While the rates of adoption from foster care are low, there has been a spurt in international adoptions and births from Artificial Reproductive Technology (ART). A few recent studies have shown that adoption rates from foster care are highly responsive to adoption subsidies (Buckles, 2011; Doyle and Peters, 2007). Gumus and Lee (2011) analyze the effect of child adoption on the utilization of ART in the US, and find that a 10% increase in adoptions result in a 1.3% - 1.5% decrease in the number of ART cycles performed. Little attention has been paid so far to simultaneous patterns of substitutability among adoptions from different sources (foster, domestic private and international) and ART births. To the best of our knowledge, we are the first paper to empirically evaluate substitution effects among international adoptions, ART births and adoptions from U.S. domestic foster care. To do this, we combine a detailed child-level data on children in U.S. foster care for the period 1998 - 2009 with data on other adoptions and ART births to empirically estimate the margins of displacement. We borrow an instrumental variables strategy developed by Card (2001) and widely used in the immigration and labor literature (Ottaviano et. al. 2013; Hong and Mclaren, 2015). We construct the"supply-push" instrument for the context of immigrant children based on historical patterns of adoption from individual source countries into specific states to identify these substitution effects. We estimate a reduction of about 85,000 adoptions from domestic foster care due to the 230,000 international adoptions, in the last decade. On the other hand, we find no effect of ART births on adoptions from foster care. The large displacement effects casts doubt on the desirability of tax rebates and, calls attention to the consequent externalities on unemployment and criminal activity.

### "*Betrothal Testing, Beliefs and Behavior*: Effect of Testing Rules on HIV Transmission"

In this paper we posit that uncertainty about prospective marriage partners' health reduces the incentives for prevention of diseases from individuals, leading to lowered aggregate efforts and higher disease transmission rates. Individuals in countries with the HIV/AIDS epidemic are exposed to infection if married to an infected spouse (Bongaarts, 2007). Recently several countries (China, India among many others) have instituted premarital testing laws. Such a law mandates disclosure of information about infection status of prospective marital partners to each other. Boozer and Philipson (2000) estimate the behavioral responses to information-intervention of a HIV public testing program and find that although the aggregate effects of the testing program is small, the effects on disaggregated private beliefs are consistent with information elastic behavior for the average individual. My paper analyzes the case of mandated pre-marital testing in contrast to public testing. I use a simple two-period expected utility model to introduce a missing aspect in understanding HIV transmission: the deterrence effect of future information symmetry on current risky sexual behavior, and the motivating effect on safe behaviors. A key insight from the model is that certainty in the infection status of future partners affects current sexual behavior. I examine the effects of compulsory pre-marital HIV testing on rational choice of effort in prevention of STD's prior to and inside marriage and show that under certain conditions voluntary testing will result in lower level of testing compared to mandated testing. I outline effects on social stigma, sorting in marriage, timing of marriage and preference for marriage. Some of the effects predicted in the paper are in line with the empirical evidence shown in related recent papers. Robles (2011) finds a moderate increase in adult syphilis rates and a significant increase in congenital syphilis rates where states repealed their premarital blood testing requirements (BTRs), and argues that cost benefit analysis effect on social welfare suggests that savings from averted premarital blood tests may not have justified the costs of the health consequences from repealing BTRs. Buckles et. al. (2011) find that BTRs are associated with a 6.1 percent decrease in marriage licenses issued by a state.

## "*Neighbors Can Make You Sick*: Health Externalities of Dirty Drains and Open Defecation"

In a co-authored work, we provide evidence that drain quality is a crucial mechanism through which open defecation impacts human health. Economists have recently begun studying the effects of community hygiene and sanitation such as open defecation. Hammers and Spears (2013) use a randomized controlled experiment to estimate the effects of a village-level community sanitation program on child health. They find that the program caused a large average increase in child height. Cameron et. al. (2014) use a randomized experimental design in rural

East Java to evaluate a sanitation intervention consisting of information (to trigger disgust at open defecation) rather than financial assistance. They find that the program significantly increased toilet construction, effected behavioral change amongst households with no private toilets, and had significant impacts on child health. Relevant to the context of our study, they find that toilet construction is however more effective at reducing open defecation than behavioral change but was hindered by the lack of financial assistance. Our paper examines the health externalities of hygiene arising from a complementary network good, drains in the village. We find that the quality of drains have large and significant impact on the incidence of water borne disease. We find that poor quality drains combined with high levels of open defecation, expectedly multiply the health impacts. Incorporating features from models of agricultural household and reciprocal externalities, we present a simple model showing how the choices of one household affects ill-health incidences of other households. We use primary data of 1,530 households in rural Uttarakhand, India, and find strong and systematic evidence that quality of drains affect the frequency of water-borne diseases. We perform falsification tests and robustness checks with a variety of controls, and obtain a consistent effect: clean drains reduce water-borne disease incidence by 60 - 70% compared to the reference group (dirty drains). The result suggests that improving the drainage system in conjunction with improving toilet access is crucial for reducing water-borne diseases in developing countries.

# Chapter 1: More than kin and less than kind? The Economics of Child Adoption from US Foster Care

## 1.1 Introduction

The age-old social institution of child adoption has been an accepted means of family formation across the world and particularly in the United States[1]. With over 130,000 children adopted annually, U.S. leads the list of countries on the number of child adoptions (United Nations 2010). An estimated 87% of cumulative adoptions in the U.S. are children born in the U.S., primarily children from domestic foster care. Such adoptions have been providing permanent homes for children in foster care, improving their long run outcomes. Nevertheless, at any point of time in the last decade about 500,000 children are in the U.S. foster care system[2]. Although foster care is meant to be a temporary arrangement for many children, with roughly

[1]The phenomena of families adopting a biologically related or unrelated child possibly goes far back in human civilization with biblical references to the story of Moses adopted by the Pharoah, and widespread in Indian mythology with Lord Krishna and war-hero Karna being adopted by unrelated parents.

[2]A study by Barth et. al. (2006) using longitudinal adoption subsidy and foster care placement data estimated that the relative fiscal costs of foster care is twice as much as an adoption subsidy for a statistically matched group of children.

60% returning home, the average child stay is over two years (Doyle 2007). More so, in excess of 100,000 children will continue to remain indefinitely[3] in foster care, switching many foster homes every year, unless they are adopted.

Studies have shown that children in foster care tend to have much worse long-run outcomes. For instance, nearly 20 percent of the U.S. prison population under the age of 30 report spending part of their youth in foster care (Burt et al. 1999)[4]. Doyle (2007) identifies causal effects of foster care on long-term outcomes - including higher rates of juvenile delinquency, teen motherhood, and unemployment among children in Illinois. In a related study Doyle (2008) identifies higher rates of adult crime and incarceration later in life for children who spent time in foster care. Other studies across the country supplement these findings by showing higher rate of drug use and sexually transmitted diseases for children who have been in foster care (Jonson-Reid and Barth 2000; Courtney, Terao, and Bost 2004). The negative welfare implications of children waiting to be adopted from foster care therefore is substantive.

In this paper, we focus on the unintended outcomes due to changes in the family formation landscape in the United States that might affect adoptions from foster care [see Fig 1]. We call attention to the remarkable increase in international adoptions and births from fertility treatments over the last two decades. Both these options are alternative means of family formation outside of adoptions from foster care. About 20,000 international children were adopted annually into the U.S. in

[3]Indefinitely, until they age-out of foster care at age 18 in most states in the U.S.

[4]An estimated 28 percent of U.S. homeless population has spent time in foster care as a youth.

the last decade, while the rate of adoptions from domestic foster care continues to be low, with less than a quarter of the waiting children in foster care adopted annually. A natural question then arises: *Do international adoptions reduce adoptions from domestic foster care?*

Figure 1.1: International adoptions, ART Births and adoptions from foster care

Improvement in fertility technology may be driving another trend: a rising number of child births from Artificial Reproductive Technology (ART)[5]. In 2008, as seen in Fig.1, more than 60,000 children (about 5% of total births in some states) were born due to ART. Evidence from other studies suggests that increasing effectiveness and availability of ART may be reversing the fertility problems reported to be affecting millions of women in the United States (Bitler and Schmidt 2007; Schmidt 2006). Descriptive evidence in Moriguchi (2012) suggests a negative correlation between ART births and adoption rates. In the past, infertile couples wanting to have children have sought child adoption, leading to a second question: *Are the increasing ART births reducing the rate of adoption from domestic foster care?*

This paper aims to provide an answer to these two questions. To the best of our knowledge, we are the first to estimate the causal effects of international

[5]According to Center for Disease Control (CDC), ART procedures involve surgically removing eggs from a woman's ovaries, combining them with sperm in the laboratory, and returning them to the woman's body. ART has been used in the United States since 1981, most commonly through the transfer of fertilized human eggs into a woman's uterus.

adoptions and ART births on adoptions from domestic foster care. We develop this argument in three steps. First, we present facts about attributes and costs of adoption from different channels that suggest an hierarchical ordering, in the distribution of attributes and costs across channels. Consistent with these facts, we conceptualize a model of aggregate demand for all types of adoption, in addition to demand for biological children via ART. We argue that the joint investigation of household choices with all available options for child acquisition improves our understanding of the impact of the two simultaneous trends: increase in international adoptions and ART births in the U.S. We bring the theoretical predictions to examine a comprehensive data on adoptions and ART births that we compiled for this study. We use the detailed child-level data on the population of children in foster care between 1998 and 2009, along with an unique dataset on international children adopted from each of the individual source countries during this period. We identify the effects by a novel application of an instrumental variables approach widely used in the labor and immigration literature (Card and DiNardo 2000; Card 2001; Ottaviano et. al. 2013). We exploit the variation of international adoption rates across the states in the U.S. and the historical pattern in adoption enclaves, where adoption of children from specific international countries are concentrated in particular states. We adopt a similar approach for instrumenting ART births, and use alternative instruments for the endogenous regressors as robustness checks. We find that surging international adoptions have displaced a large number of adoptions from domestic foster care, and on the other hand, increasing ART births do not significantly affect adoptions from domestic foster care. These results are in line with our theoretical predictions, and intuitively stem from strength of preference for own child for those choosing ART, and the costs and probability of adoption from different sources.

In the next two sections we provide the background with a discussion of related literature on child adoption and the U.S. foster care. While discussing data in Section II, we present descriptive statistics and facts that is consistent with a story of substitution, that we outline in the theory. Section III presents a short discussion of the theoretical model consistent with those facts, deriving predictions to be brought under econometric scrutiny. Following which we present the empirical framework and econometric evidence on the predictions. Section V concludes.

## 1.2 Background and Related Literature

Adopting a child as an alternative to bearing a child is a widely accepted means of family formation in many societies (Moriguchi, 2012). In the United States, according to the 2000 census about 1.6 million have been adopted, which is about 2.5% of all children in the country. In the last decade the annual average adoptions from other countries were about 20,000 children, and about 50,000 children were adopted from the state managed foster care system per year in the last decade. Despite the importance of adoption the topic has not received much attention in the economics literature until recently[6]. Moriguchi (2012) presents an economic

[6]I exclude the contribution of Schultz and Becker on the topics of human capital and family formation, as it does not relate directly to child adoption. Economists have shied away from the topic for 30 years since Landes and Posner (1978) proposed a "market price for children" that amends the shortage of children relinquished for domestic adoption and the abundance of children

analysis of historical trends in the United States, for the period between 1950 and 2010, outlining the demand-side, supply-side and institutional factors underlying the observed historical patterns. The paper schematically divides child adoption in the U.S. into three categories: domestic private adoption, international adoption and foster care adoption and notes the changing composition with the increase in international adoptions.

As adoption typically entails a permanent change of family for a child, either a transfer across households, or from foster care, it has a long run effect on the lives of the child and families involved on both sides. In addition it has large welfare implications for society at large. Doyle (2008) uses the randomization of families to child protection investigators to estimate causal effects of foster care on adult crime. Children on the margin of placement are found to be two to three times more likely to enter the criminal justice system as adults if they were placed in foster care. In another study, Doyle (2007) uses a similar dataset from Illinois, where rotational assignment process effectively randomizes families to investigators. He exploits the variation in placement tendency of these child protection investigators as an instrumental variable to identify the causal effects of foster care on long-term outcomes - including higher rates of juvenile delinquency, teen motherhood, and employment among children in Illinois. The results suggest that children on the margin of placement tend to have better outcomes when they remain at home, especially older children. These results indicate the adverse effects of being in foster care for children, even while compared to the alternative, being subject to varying

in foster care.

degree of neglect or abuse in their family. Estimates show that the main reasons children enter foster care are physical abuse (18.8%), emotional abuse (7.9%), sexual abuse (6.2%) and caretaker inability (3.2%) (DHS 2007). Other factors for placing children in foster care include, drug or alcohol abusive parents, abandonment and parental incarceration or death. Clearly, all this evidence point that children on the margin of placement have severe impediments for a normal childhood if in foster care.

Figure 1.2: Children in U.S. Foster Care

The fact that over 800,000 children enter U.S. foster care every year and on average stay two years in foster care, illustrates the magnitude of the problem [See Fig 2]. Since the passing of a key federal act in 1997, there has been a steady decline in the number of children in foster care due to a bevy of state legislations targeted at reducing the length of foster care stay. As Fig 2 indicates the reduction in the number of children staying in foster care for more than 5 years has been largely outweighed by the increasing proportion of children staying between 1 to 2 years – resulting in the average length hovering around 2 years. About 20% of children in foster care whose parental rights have been terminated, will continue to stay in foster care until they "age out" at eighteen, unless they are adopted[7].

[7]Although there are no causal studies in economics identifying the effects of adoption compared to staying in foster care, a rich literature in psychology evidences benefits of adoption on IQ and

A variety of factors affect adoption rates of children waiting to be adopted out of foster care. Several recent studies show that adoption rates are highly responsive to adoption subsidies (Hansen and Hansen 2006). Since child welfare is largely governed by state statutes, outcomes vary across states in response to their policies. Buckles (2011) exploits state-level variation in the minimum age at which children are eligible for federal subsidy funds and finds over a 11% increase in adoptions with the subsidy eligibility[8]. To put our paper in context, we speak to the question of prolonged stay in foster care by examining variation in relative costs of international adoptions and fertility treatments reducing likelihood of adoption from foster care. We exploit the variation in relative costs of adoption at the state-level arising from heterogeneity in state policies. Additional source of variation in costs are driven by differences in costs and access to international adoptions stemming from historical links. Our assumption about adoption costs dependent on age and other health attributes of children is informed among other evidence, patterns in the data. The assumption is reinforced by Skidmore et. al. (2014), who use a sample survey of Michigan adoptive families that links adoptive parent characteristics, child characteristics, and adoption-related expenses and subsidies. They estimate hedonic-model

other cognitive measures of the adopted child (see meta-analysis by van Ijzendoorn (2005)). On a related note, in the economics literature, Sacerdote (2007) contributes to the nature and nurture argument, by using a dataset on Korean American adoptees who were quasi randomly assigned to adoptive families. He finds large positive effects on adoptees education, income and health advancing the argument in the role for nurture.

[8]Between 2000 to 2006, 86.8 percent of children adopted through child welfare services received a subsidy, with the average amount being $571.95 per month (Buckles 2011).

type regressions to show that most of the variation in adoption costs is explained by child characteristics. Moriguchi (2012) notes that the estimated monetary costs of adopting a healthy infant through domestic private agency can range from $5,000 - $40,000 and that the average waiting time is between 2 to 4 years. The average cost of international adoption ranges between $15,000 - $30,000 and the expected waiting time is comparatively lower, between 10 months to 2 years, depending on the country. The monetary costs of adoption from foster care are lowest, ranging from $0 - $2500 due the adoption subsidies. The waiting time is relatively shorter, given the large number of children waiting to be adopted in foster care. This schema for classifying adoptions and corresponding ordering of costs are relevant to our approach in this paper, which we present in Section II.

A key aspect of adoption is the process of matching, where prospective adoptive parents may be seeking particular attributes in the child they seek to adopt. Baccara et. al. (2012) estimate the preferences of potential adoptive parents over U.S. born and unborn children relinquished for adoption by their birth mothers. They use a micro-level data of an U.S. private adoption agency to identify significant preferences favoring girls and new born children, and against African American children. They also point out that unmatched children in the private adoption "market" usually enter foster care. This suggests that supply of children in domestic foster care is in turn affected by number of unmatched children in the private adoption market. Since a child if matched in the private market will not enter domestic foster care, and only unmatched children would enter foster care, it suggests that private adoptions are unaffected by matching process in foster care.

Pagliero and Tetenov (2012) estimate the effect of various characteristics of Italian couples on their demand for adopted and biological children. They examine the extent of substitution between having a biological child and adopting an unrelated child. Their identification comes from exogeneity of couples fecundity status as they assume that infecund couples have the same distribution of preferences, but face a smaller choice set than fecund couples. Moriguchi (2012) through descriptive evidence in her historical analysis suggests possible substitution effects of ART births on child adoption. Gumus and Lee (2012) analyze the effects of child adoption on the utilization of assisted reproductive technology (ART) in the United States. Using state-level longitudinal data for 1999 - 2006, they estimate that a 10% increase in adoptions leads to a 1.3% - 1.5% decrease in the number of ART cycles performed. The responsiveness is higher for infant adoptions, adoptions by older women, and international adoptions, while there is no substitutability between ART and adoption of related children.

While a spate of the recent studies have contributed to understanding the effectiveness of adoption incentives, the extensive margin of substitution among adoption sources and other options of having a child are still unclear. Our paper contributes to closing this gap by jointly examining adoption alternatives, in addition to ART, and identifying the substitution effects among international adoptions, ART births and adoptions from domestic foster care.

## 1.3 Data and Descriptive Statistics

In this section we begin the discussion with some broad facts on attributes of adopted children. Together with simple statistical evidence, these facts support the story of variation in the average quality of attributes among the adoption sources that informs our empirical predictions. In particular, data show that internationally adopted children on average are younger and healthier than the children adopted from domestic foster care [see Table 1]. The matching between birth mothers and prospective couples on private adoptions happens before child birth and adoptions are finalized immediately or soon after the child is born. Since the match can occur early in the pregnancy, prospective adopters can provide for healthcare of the birthmother and the child in-utero. On the other hand, compared to a new born or yet to be born child adoption, there will be more uncertainty about the health history of older children adopted either from foster care or from international sources. Children adopted through private agencies or independently (through direct contact of prospective adopters with birth mothers) are younger and healthier on average, compared to international adoptions and, domestic adoptions from foster care. Since ART births are all newborns they are naturally younger than any of the adoption possibilities. These facts suggest that the relatively younger age of private or independent adoptions make them a close substitution category to ART births, and that international adoptions may be a close substitution category for adoptions from domestic foster care as the children are often at least a few months old. Correspondingly these facts also indicate that ART births are less likely to substitute away adoptions from domestic foster care in comparison to international adoptions.

Table 1.1: Difference in attributes across adoption sources (% of total)

| Variable | Foster care | International | Private domestic |
|---|---|---|---|
| **Age distribution at adoption** | | | |
| Age less than 1 | 2 | 50 | >90 |
| Age 1 to 4 | 10 | 30 | 0 |
| Age 4 to 8 | 70 | 20 | 0 |
| **Child has special health care needs** | | | |
| Children ages (0-5) | 39 | 10 | 25 |
| Children ages (6-11) | 59 | 33 | 35 |
| Child diagnosed with ADD/ADHD | 38 | 17 | 19 |
| Child behavior problems | 25 | 7 | 11 |

Source: Adoption Factbook V (2012)

As summarized in the table 1 and observed in our data, it is evident that on average annually, the age of children adopted from international sources is lower than the children adopted children from domestic foster care. Almost 50% of the children adopted from international sources are less than one year old compared to only 2% of all adoptions from domestic foster care. Our detailed child level data in foster care lets us construct supply of children for adoptions by each age cohort of children in foster care. The youngest cohort, infants (age less than one) in foster care are smaller in size (about 100,000 on average in our dataset), compared to older cohorts (who roughly range from 200,000 - 250,000 for each cohort up to age eight as seen in Tables 9 and 10). As we do not have individual level data on international adoptions, we only observe proportions of total adoptions that belong to age categories: less than one, age one to four, age five to eight, eight and above.

Also note [Table 1] the lower proportion of special care needs (disability, behavioral problems) children adopted from international sources compared to domestic adoptions, particularly children adopted from domestic foster care. Our child level data on children in foster care includes detailed information about health history, including disability and behavioral problems, some of which are summarized in Table 4 [Summary statistics]. Unfortunately, we do not observe the health attributes of children adopted internationally or from domestic private sources in our data for a more detailed comparison.

We also emphasize that the data on costs of adoption from each of the sources is limited. As evidenced by Skidmore et. al. (2014) and indicated by other reports [see Table 2] adoption costs are correlated with attributes such as age and health of the child. As seen in the distribution of costs in Table 2, adopting a child from foster care costs is considerably lower than adopting internationally or from domestic private agency. Because child welfare in the U.S. is a matter of family law it is largely governed by state legislation. This variation in costs of adoption across the states allows, under certain conditions, to identify whether the relative costs of international adoptions affect the number of adoptions from domestic foster care as we discuss in our empirical framework.

The tables on attributes [Table 2] of children from various sources of adoption indicate a specific pattern in the distribution of attributes in children available for

Table 1.2: **Distribution of adoption costs by type (and major countries)**

| **Description** | **< 1k** | **1-5k** | **5-10k** | **10-20k** | **20-30k** | **30-40k** | **40-50k** | **> 50k** |
|---|---|---|---|---|---|---|---|---|
| Domestic | | | | | | | | |
| U.S. Private agency | 0 | 1 | 1 | 23 | 33 | 25 | 13 | 4 |
| U.S. Independent | 0 | 4 | 13 | 24 | 14 | 25 | 14 | 6 |
| U.S. Foster care | 69 | 18 | 7 | 6 | 0 | 0 | 0 | 0 |
| International (primary) | | | | | | | | |
| China | 0 | 0 | 0 | 1 | 39 | 42 | 16 | 2 |
| S. Korea | 0 | 0 | 0 | 0 | 18 | 68 | 9 | 5 |

Source: *Adoptive Families* magazine, (Sample survey of 1100 adoptive families in 2012-2013)

adoption from the three sources of adoption (foster care, international and domestic private). The literature and simple statistical evidence [Table 2] indicate an approximate ordering on the costs of adoptions, with domestic foster adoption on the lower cost end. We now discuss the data and present some descriptive statistics, which reinforces the previous discussion about variation in the average attributes of adopted children and informs the theoretical model.

### 1.3.1 Children in Foster Care

The core of our data, on the population of children entering the foster care system at the individual child level comes from Adoption and Foster Care Analysis and Reporting System (AFCARS). AFCARS is a federally mandated data collection system recording individual or case level information on all children in foster care. Dramatic improvements in data quality and completeness occurred between 1995 and 1998, since financial penalties were levied for poor quality data (AFCARS, 2000). In our analysis we estimate the results for children under age eight in foster care, even though data are available for all children in foster care, up to a maximum of age eighteen. We do this as the bulk of adoptions (about 90%) from foster care comprise of children under age eight. There is a steep fall in rate of adoptions above the age eight.

Data on child demographics [Table 4 and Fig 3] include gender, race, birth date, health and other information on child attributes for the years 1998 to 2004[9].

Figure 1.3: Demography in Foster Care

### 1.3.2 Immigrant Adoptions

The data on children adopted by citizens of United States from other countries was provided by the Department of Homeland Security for the years 1998 to 2008.

[9]We restricted ourselves to the data until 2004 as AFCARS noted errors in the data compilation from 2005 to 2009. Additionally we prefer to estimate prior to 2004 as there may be changes in the composition of demand for international adoptions from 2005. China accounted for almost 40% of the international adoptions in the U.S. and starting 2005 placed restrictions on prospective adopters, including limiting it only heterosexual couples with minimum two years of marriage, body mass index of less than 40 and not using a list of drugs.

Table 1.3: Summary statistics: State year variables (1998 - 2004)

| Variable | Mean | Std. Dev. | N |
|---|---|---|---|
| International adoptions | 388.73 | 366.94 | 357 |
| Private/Independent adoptions | 1136.54 | 1248.11 | 245 |
| Foster adoptions ($\leq$ age 4) | 319.80 | 473.69 | 336 |
| ART births | 500.01 | 640.38 | 330 |
| International adoption rate + | 0.016 | 0.008 | 357 |
| ART births rate | 0.019 | 0.025 | 330 |
| Private adoption rate | 0.069 | 0.037 | 245 |
| International adopt (male) rate | 0.005 | 0.003 | 357 |
| International adopt(female) rate | 0.011 | 0.005 | 357 |
| College educated % | 25.95 | 5.231 | 350 |
| Per capita personal income | 28848.15 | 4982.70 | 350 |

+ All rates are calculated as numbers divided by the fertile population in the state multiplied by 1000

Table 1.4: Summary statistics: Child level attributes in foster care

(Age less than 2, 1998 - 2004)

| **Variable** | **Mean** | **Min.** | **Max.** | **N** |
|---|---|---|---|---|
| Adopted | 0.055 | 0 | 1 | 267984 |
| Male | 0.508 | 0 | 1 | 267724 |
| White | 0.526 | 0 | 1 | 267984 |
| Asian | 0.014 | 0 | 1 | 267984 |
| Black/African American | 0.368 | 0 | 1 | 267984 |
| Physically abused | 0.166 | 0 | 1 | 250791 |
| Sexually abused | 0.019 | 0 | 1 | 250784 |
| Neglected | 0.588 | 0 | 1 | 250788 |
| Drug abusive parent | 0.262 | 0 | 1 | 250745 |
| Disabled child | 0.036 | 0 | 1 | 246252 |
| Behavioral problem | 0.013 | 0 | 1 | 250755 |
| Parents died | 0.003 | 0 | 1 | 246233 |
| Parents in jail | 0.059 | 0 | 1 | 246233 |
| Abandoned | 0.046 | 0 | 1 | 250665 |

The data contained information on "immigrant orphans" adopted by US citizens in each state by gender and age category [less than age one, 1 - 4, 4 - 8, 8 and above]. A detailed data set for immigrant orphans adopted by state of residence in the United States and the country of origin was used to construct the instrumental variable along with initial distribution of these international adoptions in the U.S.

### 1.3.3 Assisted Reproductive Technology (ART) births data

Data on Assisted Reproductive Technology was obtained from CDC. The aggregate numbers for states on IVF (In Vitro Fertilization) cycles and live births from IVF for each state was compiled from fertility clinic level data for the states. The data used is for the years 1998 to 2008. The data is by type, number, and outcome of ART cycles performed, number of live births and number of infants born in U.S. fertility clinics.

### 1.3.4 Independent/Private adoptions data

We call attention to the measurement errors rife in the data on private adoptions which is recognized widely by experts on adoptions statistics (Flango 2007). The issue stems from the fact that private agencies are not mandated to report their managed adoptions. We have to rely on backing out data on private adoptions from petitions filed in the state courts by adopting parents to validate the adoption process. National Center for State Courts (NCSC) compiles adoption data from data reported annually by these state courts [only 35 state courts have reported these numbers]. These are estimates due to several reasons as most states do not categorize adoptions by type. Courts count all adoption petitions brought to them, and include adoptions through public agency, private agency, individually arranged, and even inter country adoptions. NCSC staff have used the court data in combination with other sources, such as state bureaus of vital records, to develop estimates of the total number of adoptions (Flango 2007; Flango and Shuman 2013).

### 1.3.5 Socioeconomic data

Data on per capita personal income for each state is from Bureau of Economic Analysis, U.S. Department of Commerce. Data on educational attainment - percentage high school graduate and college or more of population 25 years and over, is from the U.S. Census Bureau. Data on marriage and divorce rates were obtained from the National Center for Health Statistics.

## 1.4 Theoretical framework

In this section, we outline a simple model of demand for children in U.S. households that informs our empirical estimation. Our assumption on the distribution of attributes and the cost structure is consistent with descriptive evidence reported in the previous section. With these assumptions we derive empirical predictions on the substitution effects. Explicitly, the two key assumption are on ordering of average "quality" (based on preferred attributes such as age, gender, race) of children and average costs of adopting from each of the sources: foster care, international and private adoption, in addition to ART. With these assumptions, we derive the prediction that adjacent options will have higher elasticity of substitution. Therefore, adoption from foster care can be expected to be more severely affected by lowered costs and/or higher access to international adoption sources, than a change in costs or access to ART.

We tie-up this theoretical prediction on substitution margins in the empirics by exploiting the variation in relative costs and access to adoptions and ART across states. We begin with a discussion of the attribute index ($\delta$), and set up the choice problem.

### 1.4.1 Basic set-up

Households can choose among three sources for adopting an unrelated child:

1) U.S. foster care, or adoption from a public agency

2) Domestic private adoptions, usually private agencies mediating between the birth mother and prospective adoptive parents

3) International adoption, or adopting a child born and living outside the U.S.

In addition to these choices, we incorporate the increasingly viable fertility treatments that couples, or single mothers could opt with varying costs and success rates across the states. In our model, we include Artificial Reproductive Technology that increase the likelihood of having a biological child, or the backstop, not "acquiring" a child.

#### 1.4.1.1 $\delta$: Index of child attributes

Children differ in their observable and unobservable attributes, such as gender, race, age, health. For simplicity, we model these multi-dimensional attributes as mapped onto an index of quality ($\delta \in [0, 1]$). Descriptive evidence reported in the section (Data and Descriptive Statistics) is consistent with reported estimates suggesting that the average attributes varies across the three adoptions sources. Prospective adopters matched with a birth mother independently or through a private agency (domestic private adoptions) early enough in the pregnancy can influence the health of both the mother and child, in-utero. Usually, they complete the adoption process of the new-born immediately after birth. Evidence suggests that adopters prefer healthy infants. As shown in the descriptive statistics, over 80% of the international adoptions in the period studied were children less than four years, and half of them were infants. On the other hand, as we noted in the previous section, children in foster care predominantly have a history of abuse and neglect, and significant proportion have recorded health problems. Consequently, for prospective adopters looking for young and healthy child for adoption, we note that expected attribute match ($E(\delta)$) from an international source or a domestic private adoption would be on average higher than that from foster care. More on this in the following subsection, where we explicitly state our assumption on relative costs.

Consider a population of potential demanders in state s, time t of size, $N_{st}$[10]. Each member of population obtains a net utility from alternate child acquisition op-

[10] We drop the index s and time dependence for ease of notation.

tions: foster care (f); international child (i); domestic independent adoption through private agency (p); Artificial Reproductive Technology improving the odds of conceiving a biological child (b); no child acquired (o). The utility is a function of attributes of the child $\delta$ and a vector of exogenous demand shifters $X_st$.

The prospective adoptive parent[11] maximizes utility following:

$$Max\{\Pi_f \beta\gamma U_f(\delta, X_{st}) - C_f(\delta),\, \Pi_i \chi U_i(\delta, X_{st}) - C_i(\delta),$$
$$\Pi_p \beta\chi U_p(\delta, X_{st}) - C_p(\delta),\, \Pi_b \alpha U_b - C_b,\, 0\} \tag{1.1}$$

#### 1.4.1.2 Probability and costs

- $\Pi_b$: The probability of conceiving a biological child is determined by an exogenous technology parameter; $C_b$: Cost of ART

- $\Pi_i$: The probability of adopting an international child is determined in the international market, and given that an U.S. adopter is only one among many competing in the international market, so the probability is assumed exogenous; $C_i$: Cost of adopting an international child

- $\Pi_p$: For private domestic adoptions, the probability of success is determined in the national market, and for simplicity we assume this probability is unaffected by state-specific outcome, and every state is 'small' in the nation, so assume exogenous; $C_p$: Cost of adopting a domestic child independently via private agency

[11] If a household, we assume that the utility function for the couple or decision making members of the household as equivalent here.

- $\Pi_f(\delta)$: Probability of adoption from foster care as a function of desired quality;

  $C_f$: Cost of adopting a child from foster care.

The costs are driven by search costs and incurred while seeking adoption, except foster adoption that is borne only if a child is adopted.

#### 1.4.1.3 Dimensions of preference

- $\alpha \in [0, \bar{\alpha}]$: Strength of preference for having a child
- $\beta \in [0, 1]$: Inverse preference for international child (vs. domestic child)
- $\chi \in [0, \bar{\chi}]$: Preference for "quality" or higher $\delta$
- $\eta \in [0, 1]$: Inverse preference for own biological child

The preference parameters are exogenous and drawn from a joint distribution: $\alpha, \beta, \chi, \eta \sim g(\alpha, \beta, \chi, \eta)$

#### 1.4.1.4 Expected Utility

Utility from each option is represented by $U_j(\delta, X_{st})$, where $j \in \{f, i, p, b, n\}$ and $X_{st}$ is a vector of demand shifting variables, such as subsidy and tax rebate available for each option. Without loss, set utility from no child acquisition as $U_n = 0$ for all.

For the moment, we simplify utility[12], and write the utility function as follows:

[12] We simplify by assuming that the quality of child is highest ($\delta = 1$) for all options except foster care.

- $\alpha U_b$: Utility from having an own biological child
- $\alpha U_p$: Utility from adopting a domestic child independently or privately (outside of foster care)
- $\alpha\beta U_i$: Utility of adopting an international child
- $\alpha U_f(\delta, \chi)$: Utility if adopting a child from foster care and,
- $\alpha U_f(\bar{\delta}, \chi) = U_f$, $\forall\, \chi$ where $\delta \in [\underline{\delta}, \bar{\delta}]$
- For any other quality, utility from foster care: $\alpha U_f(\delta, \chi) = U_f + (\delta - \bar{\delta})\chi$

$\frac{\partial U_f}{\partial \delta} > 0$ and $\frac{\partial^2 U_f}{\partial \delta \partial \chi} > 0$ or strong preference for quality.

### 1.4.2 Assumption on marginal search costs

We assume the following order on the quality of attributes, consistent with evidence presented in the previous section about the expected attribute match being highest for an ART birth, followed by private adoption, international adoption and adoption from foster care, respectively.

$$E_f(\delta) \leq E_i(\delta) \leq E_p(\delta) \leq E_b(\delta) \tag{1.2}$$

As described in the data, we find evidence for heterogeneity in relative costs of adoption, stemming from variation in state funded subsidies for foster adoptions and ease of access to international adoptions and private adoptions through local private agencies. In light of this evidence, and in line with ordering of attributes (equation 2), we introduce the following assumption[13] about marginal search costs for adopting a child of certain quality ($\delta$):

$$\frac{\partial C_f(\delta)}{\partial(\delta)} \geq \frac{\partial C_i(\delta)}{\partial(\delta)} \geq \frac{\partial C_p(\delta)}{\partial(\delta)} \geq \frac{\partial C_b(\delta)}{\partial(\delta)} \tag{1.3}$$

Following which we arrive at the number of households choosing each of the options:

$$\begin{aligned} U_j = Argmax_j\{&\Pi_f \beta\gamma U_f(\delta, X_{st}) - C_f(\delta),\, \Pi_i \chi U_i(\delta, X_{st}) - C_i(\delta), \\ &\Pi_p \beta\chi U_p(\delta, X_{st}) - C_p(\delta),\, \Pi_b \alpha U_b - C_b,\, 0\} \end{aligned} \tag{1.4}$$

**Proposition 1** With uniform preferences over $\alpha, \beta, \chi, \eta$ and increasing marginal search costs over quality of child $\chi$ yields an unique marginal foster adoption quality $\dot{\delta} \in (\underline{\delta}, 1)$, such that $C_f(\dot{\delta}) = C_i(\dot{\delta})$, for all $\delta \in (\underline{\delta}, \dot{\delta})$ such that $C_f(\dot{\delta}) \leq C_i(\dot{\delta})$ and, for all $\delta \in (\dot{\delta}, 1)$ such that $C_f(\dot{\delta}) \geq C_i(\dot{\delta})$.

**Proposition 2** With varying preferences, then the assumption (eq. 3) would yield marginal $\delta$ that defines which category to adopt for the different classes are described in the comparative statics.

The aggregate demand for each option will depend on the joint distribution of

[13]This assumption lets us derive predictions on the extent of substitutability among the options but our empirical estimation does not hinge on it. The empirical results are consistent with predictions on margins stemming for this, albeit strong assumption.

parameters and the costs of each option that determine the maximized net utilities.

$$N_f = \int_{U_f \geq U_j} [U_j(\delta, X_{st}) - C_j(\delta)] f(\alpha, \beta, \gamma)\, d\alpha d\beta d\gamma$$

$$\Longrightarrow \Pi_f(\delta) \times N_f = \text{Aggregate demand for foster children} \tag{1.5}$$

### 1.4.3 Comparative statics and model predictions

Essentially our model categorizes three classes of households given their strength of preference for own child: 1) strong preference for biological child, so unlikely to adopt 2) Will adopt or high likelihood of adoption, rather than have biological child (older women with lower probability of ART success or cannot afford ART treatments) 3) all options are imperfect substitutes

- For those with strong preference for biological child, one qualified prediction would be, little or no substitution between ART births (biological children) and adoption from foster care (determining the proportion of people in this class is an empirical question)

- For the two classes where all adoption sources are imperfect substitutes, a second qualified prediction would be strong substitution between adjacent categories (ART and private adoption are stronger substitutes than ART and adoption from domestic foster care); international adoption and adoption from foster care are adjacent categories and predictably have strong substitution effects if costs are lowered or availability or access improves.

- Increase in the probability of international adoption (higher access) or reduction in costs would imply a reduction in adoption from foster care (marginal child in foster care needs a higher $\delta$ to be adopted as the marginal utility from international adoptions in equilibrium is higher)

### Elasticity

Our empirical model calculates the substitution effect of international adoptions and ART births on adoptions from foster care. Since we proxy for costs of adoption and undergoing ART, we can interpret our estimate as an elasticity. The elasticity of substitution of international adoptions on foster adoptions:

$$\epsilon_{fi} = \frac{\Delta N_f / N_f}{\Delta C_i / C_i} \tag{1.6}$$

## 1.5 Empirical Strategy and Econometric Results

We now take the predictions from the previous section to our empirical data. We first focus on the two key predictions 1) direct substitution between international adoptions and domestic foster adoptions, in other words, the proportion of international adoptions displacing adoptions from foster care, and 2) predicted lower substitution effect of ART births on domestic foster adoptions. The two key theoretical predictions intuitively stem from the ordering on costs of adoption and the average attributes of children available among the sources of adoption. As noted in the descriptive statistics [Table 1], children in foster care are qualitatively different since a large proportion have history of neglect or abuse (74% of infants and toddlers in our data) and suffer from physical or mental disability, compared to international adoptions and private adoptions. If households in states where fertility treatments are a viable option are primarily interested in a young and healthy child, they are more likely to hire a private agency and consider a domestic private adoption or an international adoption. Another crucial factor, as outlined in the theory is the cost structure that naturally orders the adoption options, thereby distancing the choices of an average household interested in fertility treatments (comparatively higher income) from an average household choosing to adopt from foster care (the lowest cost option). The similarity of attributes makes international adoptions and adoptions from foster care adjacent options, making the substitution effect sensitive to cost differentials between these two sources of adoption.

### 1.5.1 Variation in costs of adoption and fertility treatments

Our empirical implementation relies on the heterogeneity of adoption costs across states for each type of adoption, and similar variability in the cost of undergoing fertility treatments. As child adoption is legally mandated by policies instituted at the state level economic incentives, such as adoption subsidies vary widely across states (Buckles, 2011; Hansen and Hansen, 2006; Doyle and Peters, 2007). The variation in economic incentives translates into differences in relative costs of adoption from foster care (public agencies) compared to domestic private adoptions or international adoptions (private agencies). Another source of variation in relative costs of adoption is accessibility of international adoptions. Since we do not have actual cost estimates by state, we begin our empirical examination by using direct measures of rates of adoption from international sources and domestic independent sources (private adoption) over time as explanatory variables that affect the adoptions from domestic foster care. The assumption underlying the estimation is that the variation in costs, once we control for state and year effects, are the main source of variation in rates of international and domestic private adoptions. In that case, an OLS regression would identify the effect of levels/rates of other adoptions and ART births on adoptions from foster care. We recognize this indeed is a strong assumption, so in the next section, we instrument the endogenous regressors with variables that proxy their accessibility, both costs and availability.

We present the first specification, that under strong assumptions identifies the substitution effect of international adoption, domestic private adoptions and ART births on adoption from foster care.

$$\begin{aligned} Adopted_{i,s,t} =& \beta_0 + \beta_1 International\ rate_{s,t} + \beta_2 Private\ adopt\ rate_{s,t} + \beta_3 ART_{s,t} + \\ & \beta_4 Child\ attributes_{i,s,t} + \beta_5 Other\ Controls_{s,t} + \tau_s + \tau_t + \epsilon_{i,s,t} \qquad (1.7) \end{aligned}$$

The dependent variable is whether the individual child (i) was adopted from foster care, in state (s) and year (t). In the specification (Eq. 7), we control for individual child level attributes with data on age, gender, race, history of health, abuse and neglect, disability and behavioral problems, and status of parents (whether in jail, and/or have died). Besides child level attributes, we include additional controls. We include the size of the children in the cohort (number of children of the same age) as a control for supply. We control for market level attributes of the available children by including the means of the attributes of children in the cohort (for instance, percentage of each race in the cohort). Both supply of children in the cohort and the average attributes of available children are controlling for the composition of supply, which is key in matching markets. The number of adoptions (or probability of match between adoptive parents and adopted child) depends on the attributes of both the adult population and the population of children waiting to be adopted (Hansen 2007). We partly control for the adoptive parents attributes with socio-economic variables on per capita personal income (pcpi) and percentage college educated in the state.

All specifications include state and year fixed effects and the standard errors are two-way clustered by state and year.

Firstly we would like to draw your attention to the pattern of the coefficients seen both in the point estimates in Table 5 (corresponding marginal effects in Table 6). For both infants (children under age one) and toddlers (children between age one but less than two). Note that the marginal effects [Table 6] reduce when you sequentially drop substitution categories (column 1 to column 3 for infants; column 4 to column 6 for toddlers). This is in line with predictions from econometric theory when relevant variables are omitted from a model. This pattern of diminished negative effect is consistent with our expectation as briefly outlined in the Appendix A.5.

In the Appendix.1 we present the linear probability model as a robustness check, and provides for easier interpretation of coefficients. We note that the linear regression model has qualitatively the same results, but the estimates are consis-

Table 1.5: Effect of Substitutes on Adoptions from Foster Care

| Dependent Variable: Chid Adopted in foster care = 1 | | | | | | |
|---|---|---|---|---|---|---|
| | | Age 0 | | | Age 1 | |
| **Probit** | (1) | (2) | (3) | (4) | (5) | (6) |
| International adopt, rate | -8.543** | -8.344** | -6.734** | -3.008** | -2.176 | -1.903 |
| | (-5.09) | (-3.49) | (-3.09) | (-3.52) | (-1.59) | (-1.48) |
| ART births, rate | -0.874 | -1.220 | | -0.566 | -0.415 | |
| | (-0.94) | (-0.94) | | (-1.09) | (-0.49) | |
| Dom. private adopt, rate | -1.701** | | | -1.262** | | |
| | (-8.05) | | | (-9.71) | | |
| *Additional Controls* | | | | | | |
| Means(Child attributes) | Yes | Yes | Yes | Yes | Yes | Yes |
| Individual child attributes | Yes | Yes | Yes | Yes | Yes | Yes |
| State & year effects | Yes | Yes | Yes | Yes | Yes | Yes |
| No. of Clusters | 160 | 255 | 278 | 160 | 255 | 278 |
| Observations | 43803 | 104591 | 107018 | 94438 | 219325 | 224319 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

The units of observations are at the individual child level in foster care.

Standard errors are clustered by state and year

Other controls are % college educated, PCPI, size of children available for adoption in state

Table 1.6: Effect of Substitutes: Probit Marginal effects

| Dependent Variable: Chid Adopted in foster care = 1 | | | | | | |
|---|---|---|---|---|---|---|
| | Age 0 | | | Age 1 | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| International adopt, rate | -0.3270** | -0.2964** | -0.2435** | -0.3011** | -.2257 | -0.1973 |
| Marg. elasticity | -22.94** | -22.19** | -17.86** | -6.442** | -4.555 | -3.984 |
| ART births, rate | -0.0334 | -0.0433 | | -0.0566 | -0.0431 | |
| Marg. elasticity | -2.34 | -3.2437 | | -1.212 | -0.8694 | |
| Dom. private adopt, rate | -0.0651** | | | -0.1264** | | |
| Marg. elasticity | -4.569 | | | -2.730** | | |
| No. of Clusters | 160 | 255 | 278 | 160 | 255 | 278 |
| Observations | 43803 | 104591 | 107018 | 94438 | 219325 | 224319 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

The units of observations are at the individual child level in foster care.

All regressions include state and year fixed effects and the standard errors are clustered by state and year tently higher than the Probit marginal effects. The marginal effects [Table 6] show similar pattern of sign and significance. We examine possible sources of endogeneity that might bias our estimates and contend with measurement issues in the data on private adoptions.

### 1.5.2 Endogeneity and data issues

In our shares specification above, the state fixed effects absorb any statewide variables that might otherwise influence the level of demand in the local market. Our identification relied on the assumption that variation in costs were the main source of variation in international adoptions and domestic foster adoptions, after controlling for state and year fixed effects.

To the extent that local demand shocks lead to an increase in demand for both international and foster adoptions, the specified shares model will result in biased estimates. The difficulty in establishing a causal effect arises if other unobservable factors are correlated with the error term. For instance, favorable demand conditions in a state may stimulate both international adoptions and domestic adoptions, leading to an upward bias in the partial correlation between international adoptions and foster adoptions. This would mean the negative effect is actually of higher magnitude than we estimate. In other words, we will be underestimating the negative effect of international adoptions on domestic foster adoptions.

A more severe issue would be when the local demand shocks are alternative specific. For example, consider the case where preference in the local population is shifting away from domestic foster adoptions in favor of international adoptions. To illustrate, suppose potential adopters in California favor adopting children from China or Korea rather than from domestic foster care. Our identification assumption fails, if this preference shift occurred between 1998 to 2004 as the state fixed effect would only capture any time-invariant variation in preferences of the states. For e.g., adopters in California always favor international child to domestic child compared to adopters in Nebraska, who favor domestic child relative to international. On the other hand, any time varying, alternative-specific local demand shocks, however, remain in the error terms. This would bias the effect of international adoptions up or down depending on the shifts in the specific local preferences.

Several other such concerns that threaten our internal validity may arise, since our identification with shares regression rests on strong assumptions.

## Data on private adoptions

An issue with our original shares regression is poor data on private adoptions. Mis-measurement on independent variables may lead to biased estimates, in addition to other sources of bias, as sketched in the previous section. Experts on child adoption statistics have widely noted that a major impediment in examining adoption trends is lack of good data on private adoptions (Flango, 2011). Following federal legislation mandating reporting of adoptions from foster care, accurate and comprehensive data have been compiled for adoption from foster care managed by state public agencies. The quality of data on adoptions we use from foster care (maintained by AFCARS), in addition to international adoptions (reported by DHS) has been validated for accuracy. On the other hand, the data on domestic private/independent adoptions (managed by private agencies, outside of foster care) are unreliable. Despite the need for complete information on total adoptions, there are no federal policies (or incentives) that necessitate private agencies to report independent adoptions managed by them. The National Center for Court Statistics estimates total adoptions for most years using petitions by adoptive parents in state courts to finalize the child adoption. Because all adoptions of U.S.-born children and an unknown, but significant number of international adoptions are finalized in U.S. courts, the courts are a key source of adoption data (Shuman and Flango, 2013). The NCSC estimates for each year are approximate as the adoption petition year may not correspond to the actual adoption date. Courts grant most petitions, but not all. Another source of noise is that some states have mandated petitions (6 states in the study period) for all adoptions including international, but the majority have not[14]. But even in the states that have no mandated requirement for

[14] Adoptions by U.S. citizens completed in foreign countries also complicate the adoption count (Flango, 2012). When U.S. citizens adopt a foreign-born child abroad, they must apply to the U.S. Citizenship and Immigration Services of the U.S. Department of Homeland Security for an IR-3 visa – which classifies the child as an immigrant and provides the child with U.S. citizenship upon arrival in the United States. Recognition and validation of adoption is subject to the laws of the states in which the parents reside. Twenty-four states give full effect and recognition to an adoption decree from the country that granted the adoption, which means that the foreign adoption decree is considered as valid and binding as one issued by a state court (Child Welfare Information Gateway, 2008). Twenty-four states offer re-adoption or validation as an option, but

petitioning an international adoption, cautious adoptive parents may petition to be on the safe side. It is evident from the above reasons that private adoptions data are riddled with systematic and random error components.

In our previous estimations we use the total adoption data compiled by NCSC (limited to only 25 states) to arrive at numbers for independent or private adoptions. Econometric theory recognizes that measurement error on independent variables results in biased and inconsistent estimates (Stock and Watson, 2004). Given the gravity of the measurement issues, we conclude that it is a costly trade-off to use the limited and noisy private adoptions data, rather than a balanced panel without private adoptions. We briefly describe our strategy to overcome this data issue below. Firstly, we identified the six states that have mandated that all adoptions finalized in the state need to be petitioned in state courts. In these states, the data on private adoptions can be distinguished from other adoptions. On the cleaned up data in the subset of states, we check if the instruments for international adoptions and ART births are correlated with the private adoptions data. In our case, the "supply-push" instrumental variable on international adoptions were not correlated with the data on private adoptions. On the other hand, the instruments continued to be correlated with the endogenous regressors within the subset of states. We

not a requirement. Validation of the foreign adoption means submitting the foreign adoption decree for state approval, and re-adoption is the process of adopting a child previously adopted in another jurisdiction as a way to legitimize the foreign adoption and obtain a United States birth certificate. Six states require adoptive parents to petition the court to validate or register the foreign adoption, and so presumably in these states the court adoption figures are complete for all adoption - - regardless if finalized in state or abroad.

therefore argue that our instrumental variables specification can exclude private adoption.

Such a supply-push instrument addresses concerns of endogeneity emanating from both unobservable demand shocks as well as error-in-variables.

We report these checks on the instruments in the Appendix. To summarize, we find our proposed instruments to be discussed in detail in the next section are correlated with endogenous regressors and uncorrelated with private adoptions data. This allows us to identify the effect of the key factors, the effect of international adoptions and ART births on adoptions from foster care.

### 1.5.3 Instruments

#### 1.5.3.1 Predicted supply instruments

The instrument we use to proxy cost-driven international adoptions further extends the method proposed by Altonji and Card (1991) and Card (2001). It has been used extensively in the immigration and labor literature since.[15] We exploit the fact that international adoptions from the different source countries, China, Russia, Korea (to name a few, see Fig. 4) have varied in the U.S. according to the changes in the accessibility from these countries and the domestic conditions that are specific

[15]Ottaviano et. al. (2013) in a recent paper analyzing the effect of immigration and offshoring on American jobs use the same methodology to construct their instrument for immigrant labor. They use their instrument to identify whether immigrant labor displaces native employment. In this paper, we construct a similar instrument to identify the displacement effect of "immigrant orphans" on native children in foster care

to the country of origin. High initial presence or historical rates of adoption from these specific source countries into particular states, for eg. South Korea into New Jersey, make those states more susceptible to shifts in origin-specific cost and push factors compared to states with lower initial presence.

Figure 1.4: Changing number of international adoptions, by source

Supported by evidence in the data, we assume that total number of international adoptions from a given source country who enter the United States is independent of country-specific demand conditions in any particular state in the U.S. In other words, no disproportionately large adoptions into a state from a particular source country. The actual inflow of immigrant orphans (to use the US Department of State terminology for internationally adopted children) from a given source country (in the case of China, 3,953 incoming adopted children to U.S. in the year 1997) moving to a destination U.S. state (the case of Florida, 126 children accounted for 3.2% of total incoming U.S. adoptions from China in the same year) can be decomposed into an exogenous supply-push component, based on total inflows from the country and the fraction of earlier immigrants from that country who live in the state, and a residual component reflecting any departures from the historical pattern. Multiplying the total inflow from a given source country based on historical variation in the U.S. states gives an estimate of the supply-push component of recent immigrant inflows that can be used as an instrumental variable in the estimation of equation. Using these two facts we predict the international adoptions from each of the key origin countries to each of the states in the year prior to our regression analysis, and we augment it with aggregate, U.S. level, annual international adoptions from these specific countries. Then, we sum it across all the key source countries for each of the states. This gives us the predicted rate of international adoptions. Note that it varies across states over time, and highly correlated (95%) with our endogenous regressor, actual international adoption rate.

Figure 1.5: Instrumental variables correlated with endogenous regressors

To implement our instrument, we group the source countries for international adoptions. In the last decade alone, one hundred countries have been sources for international adoptions in the U.S. For instance, in the year 1997, there were 102 countries of origin for international adoptions in the U.S, and countries ranged from Afghanistan, Albania, Algeria to Uzbekistan, Venezuela and Vietnam. The largest number of adoptions were from Russia (4,309 children, i.e., 29% of total), China (3,953, 27% of total), followed by Korea (12% of total). There were scores of countries, including Afghanistan, Albania and Uzbekistan that each sent less than 5 children to the U.S. in the year 1997. Therefore using all the source countries to predict our instrumental variable would be erroneous, due to a high proportion of 0 initial proportion from those countries in several states. We retain each country that constitutes more than 5% of the total incoming international adoptions as a separate category and club the rest of the country as the "other" category. For the year 1997, this classification system constructs our instrumental variable with China, Russia, Korea, Guatemala and the "Other" category (22% accounting for the rest of the total international adoptions). We later do a robustness check with two other instruments: (1) a 10% threshold for initial year that identifies countries to arrive at predicted supply (10% predicted supply instrument), and (2) passports issued as a measure of variation in internationalization across the U.S. states.

To formally construct the CARD "supply-push" instrument, we represent the number of immigrants from source country 'c' who entered the US between 1998 - 2004, and let $\frac{P_{c,s,T}}{\sum_s P_{c,s,T}}$ represent the fraction of immigrants from an earlier cohort of immigrants from country 'c' who are observed living in state 's' prior to 1998 ('T'). In our specific example above, of Florida adopting from China, $\frac{P_{c,s,T}}{\sum_s P_{c,s,T}}$ is equal to 0.032. In the absence of demand-pull factors, the number of immigrants from country 'c' who would be expected to move into state 's' between 1998 and 2004:

$$\hat{P}_{s,t}^{CARD5} = \sum_c P_{c,t}^{AGG} \frac{P_{c,s,T}}{\sum_s P_{c,s,T}}$$

$P_{s,t}^{CARD5}$ is independent of demand conditions in state 's' over the 1998 -2004 period, then this estimate is independent of any demand-pull conditions in the city.

We use the same methodology to construct a predicted instrument for ART live births. The initial share of ART births in 1997 for each state were multiplied by the change in levels of ART live births at the U.S. national level. The initial state shares proxy for the ease of access and provide the variation in the costs of

ART live births across the states. We find that the instrument for ART live births are highly correlated with actual numbers on ART live births (see Fig 5). We use two other measures as a robustness check: (1) states that have mandated coverage of fertility insurance (Fertility law[16]), which lowers the cost of fertility treatments in the states, (2) IVF success rate (IVF success), number of IVF cycles resulting in live births, capturing technology variation in fertility treatments across states.

#### 1.5.3.2 Instrument exogeneity

As we noted the immigration and labor literature has resorted to using the predicted supply instrument, since comprehensive data on immigration costs is unavailable. We face a similar challenge in the context of data on costs of adoption. We argue that our instrument on international adoptions is even more defensible, compared to the immigration setting. One objection in the context of labor immigration would be that higher earnings and productivity in certain regions for particular skills drove the original influx, and that region and skill-group-specific relationship may

[16]The first state-level infertility insurance mandate was enacted by West Virginia in 1977. Since that time, 14 other states have passed mandates, and additional states have ongoing legislative advocacy efforts in this area.The mandates vary along several dimensions. A mandate "to cover" requires that health insurance companies provide coverage of infertility treatment as a benefit included in every policy. A mandate "to offer" requires that health insurance companies make available for purchase a policy which offers coverage of infertility treatment. In addition, some mandates exclude coverage of in vitro fertilization (IVF), which is one of the most expensive treatments available for infertility. Finally, some mandates cover all health plans, while others either exclude health maintenance organizations (HMOs) or only cover HMOs. (Schmidt, 2007)

continue to persist over the years. This leads to an endogeneity issue due to omitted variables on measures of inherent productivity complementarities. In the child adoption setting, such concerns are mitigated since incoming immigrant children do not make the choice of emigrating as mostly the case with labor migration. In addition, our instrument for international adoptions does not suffer from concerns of reverse causality, where original immigrants may persuade friends and relatives to emigrate into their region.

Our constructed instrument on international adoptions and ART births in theory traces the supply curve, and therefore mitigates the endogeneity concerns we have raised with the shares regression. We discuss the results in the next section.

### 1.5.4 Key Empirical Results

We present our key results using the method Two Stage Residual Inclusion (2SRI) proposed by Terza et. al. (2008). The 2SRI estimation is similar to more widely used 2SLS when using instrumental variables, except that in the second-stage regression, the endogenous variables are not replaced by first-stage predictors. Instead, first-stage residuals are included as additional regressors (see appendix A.6). We prefer this estimation to conventional 2SLS, as our second stage has a binary outcome (adopted out of foster care) as the dependent variable, rather than a continuous variable. Terza et. al. show that 2SRI is consistent in a generic framework, including non-linear second stage estimation, and 2SLS is not. In the appendix we report the 2SLS estimates as a robustness check on estimation method, and the results are qualitatively similar. The coefficients from the 2SRI estimations also closely resemble the comparable IV probit estimation for the single endogenous regressor model (international adoptions).

In Table 7 and 8 below, we see the first stage estimations on the bottom panel for both infants [Table 7] and toddler [Table 8]. The F statistics on the first stage are over the thumb rule of 10. As reported in the Appendix 14, they exceed the Stock and Yogo critical values for joint instrument relevance (for the conservative 10% maximal IV size).

Turning our attention to the key variables of interest, we find that the effect of international adoptions are negative and statistically significant (1% significance level). On the other hand, ART births, even with instrumenting, continue to be statistically not significant. Note that these effects are in line with the theoretical prediction of a direct displacement (substitution) between international adoptions and adoptions from foster care, and lower degree of substitutability between a biological child (ART birth) and adopting from foster care. The sign and significance are consistent across instruments (5% and 10% predicted supply for international adoptions; and IVF Bartik and Fertility law for ART births). As ART births shows no statistically significant effect on adoptions from foster care, we estimate a single endogenous regressor model without ART births, reported in the last two columns of Table 7 and 8. International adoptions persist with their negative effects on adoptions from foster care. We report the IV estimates for all age cohorts up to age 8 in next section and interpret the marginal effects.

Table 1.7: Effect of International adoptions, ART on Foster Care (Infants)

| | Dependent Variable: Chid Adopted in foster care = 1 | | | | | |
|---|---|---|---|---|---|---|
| | 2 endog. regressor | | | | 1 endog. regressor | |
| International adopt | -48.16** | -38.67** | -49.31** | -36.22** | -50.31** | -50.69** |
| | (-7.13) | (-3.87) | (-6.03) | (-2.65) | (-6.38) | (-5.22) |
| ART births | 2.059 | -2.944 | 2.104 | -2.951 | | |
| | (0.83) | (-0.73) | (0.88) | (-0.66) | | |
| Intl. residuals | 43.95** | 33.49** | 44.14** | 30.29* | 42.80** | 41.96** |
| | (6.22) | (3.18) | (5.29) | (2.14) | (5.65) | (4.62) |
| ART Residuals | -3.152 | 4.540 | -2.969 | 4.465 | | |
| | (-1.03) | (1.00) | (-0.97) | (0.89) | | |
| First Stage | | | | | | |
| *Instrument 1* | 5 pc | 5 pc | 10 pc | 10 pc | 5 pc | 10 pc |
| *Instrument 2* | F. law | Bartik | F. Law | Bartik | | |
| Intl. adopt IV | 180.7** | 164.7** | 136.5** | 129.1** | 158.5** | 119.8** |
| | (3.82) | (3.33) | (3.03) | (2.67) | (3.52) | (2.71) |
| ART IV | 0.0849** | 309.5** | 0.0837** | 290.3** | | |
| | (4.60) | (2.92) | (4.73) | (2.73) | | |
| Clusters | 278 | 278 | 278 | 278 | 278 | 278 |
| Observations | 94263 | 94263 | 94263 | 94263 | 96425 | 96425 |

The units of observations are at the individual child level in foster care.

All regressions include state and year fixed effects and the standard errors are clustered by state and year

Table 1.8: Effect of International adoptions, ART on Foster Care (Toddlers)

| Dependent Variable: Chid Adopted in foster care = 1 | | | | | | |
|---|---|---|---|---|---|---|
| | 2 endogenous regressors | | | | 1 endogenous regressor | |
| International | -27.91** | -16.05+ | -29.95** | -15.73 | -25.57** | -28.39** |
| | (-5.49) | (-1.87) | (-4.96) | (-1.41) | (-4.51) | (-3.95) |
| ART births | 1.002 | -3.824 | 0.798 | -3.854 | | |
| | (0.70) | (-1.44) | (0.55) | (-1.31) | | |
| Intl. residuals | 26.74** | 14.58+ | 28.54** | 14.04 | 24.67** | 26.14** |
| | (5.14) | (1.68) | (4.69) | (1.25) | (4.17) | (3.69) |
| ART residuals | -1.010 | 5.379+ | -0.648 | 5.375+ | | |
| | (-0.65) | (1.94) | (-0.40) | (1.76) | | |
| First Stage | | | | | | |
| *Instruments* | 5pc, FL | 5pc, Bartik | 10pc, FL | 10pc, Bartik | 5 pc | 10 pc |
| Intl. adopt IV | 159.5** | 143.9** | 124.7** | 115.5* | 143.3** | 112.0* |
| | (3.33) | (2.84) | (2.76) | (2.34) | (3.11) | (2.51) |
| ART IV | 0.0810** | 274.2** | 0.0802** | 253.2* | | |
| | (4.34) | (2.67) | (4.51) | (2.46) | | |
| Clusters | 278 | 278 | 278 | 278 | 278 | 278 |
| Observations | 197249 | 197249 | 197249 | 197249 | 201960 | 201960 |

### 1.5.5 Extensions and robustness checks

As we noted earlier, about fifty percent of the total international adoptions are children below age two. Almost eighty percent of the international adoptions are constituted by children less than age 4. The rest of the 20% of international adoptions are mostly children between ages 4 and 8. Therefore, as the model predicts, we expect a substitution effect for cohorts of higher ages, besides the infants and toddlers. We expect ART live births (new-borns) to be further away as substitute for higher cohorts, since the closest substitutes would be the youngest cohorts, infants and toddlers. Since we did not find a significant effect of ART births on infants/toddlers, we estimate the higher cohorts with only international adoptions rate as an endogenous regressor. As reported in Table 9 (cohorts age 2 to 4) and Table 10 (cohorts age 5 to 8), we continue to see a negative and statistically significant effect of international adoptions on domestic foster adoptions in higher cohorts. We present both 2SLS and IV Probit estimates in the appendix.

#### Gender and age effects

We calculate the cross-elasticity of substitution by breaking down the data by gender and age.

Table 1.9: Cohorts of age 2, 3 and 4

| | Dependent Variable: Chid Adopted in foster care = 1 | | | | | |
|---|---|---|---|---|---|---|
| | Age 2 | Age 2 | Age 3 | Age 3 | Age 4 | Age 4 |
| | 2SLS | IV Probit | 2SLS | IV Probit | 2SLS | IV Probit |
| Adopted | | | | | | |
| International adopt, rate | -2.962** | -20.61** | -2.428* | -14.14* | -3.099* | -18.335* |
| | (-2.75) | (-3.04) | (-2.10) | (-2.05) | (-2.22) | (-2.59) |
| First stage: Intl. rate | | | | | | |
| Intl. IV (5pc) | | 136.4** | | 138.7** | | 135.56** |
| | | (3.30) | | (3.58) | | (3.16) |
| F statistic | | | | | 9.96 | |
| Observations | 242692 | 242692 | 240831 | 240831 | 225411 | 225411 |

The units of observations are at the individual child level in foster care.

All regs. include state and year fixed effects and the s.e. clustered by state and year

Table 1.10: Ages 5, 6, 7, 8

| Dependent Variable: Chid adopted in foster care = 1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Age 5 2SLS | Age 5 IVP | Age 6 2SLS | Age 6 IVP | Age 7 2SLS | Age 7 IVP | Age 8 2SLS | Age 8 IVP |
| Intern. a. rate | -2.76** | -17.59** | -2.96** | -19.41** | -2.79** | -19.75** | -2.42* | -18.49** |
| | (-2.61) | (-3.24) | (-2.64) | (-3.44) | (-2.62) | (-3.55) | (-2.38) | (-3.48) |
| First stage | | | | | | | | |
| Intl. IV (5pc) | | 0.154** | | 0.157** | | 0.158** | | 0.161** |
| | | (2.82) | | (2.89) | | (2.92) | | (3.01) |
| Observations | 249176 | 249176 | 243018 | 243018 | 241777 | 241777 | 242359 | 242359 |

The units of observations are at the individual child level in foster care.

All regs. include state and year fixed effects and the s.e. clustered by state and year

Table 1.11: Breakdown by gender

| | Dependent Variable: Chid adopted in foster care = 1 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Age 0 | | | | Age 1 | | | |
| | Male | | Female | | Male | | Female | |
| Intl. male rate | -9.73* | | -7.38 | | -2.53 | | -4.79+ | |
| | (-2.32) | | (-1.50) | | (-0.95) | | (-1.68) | |
| Intl. female rate | | -11.18** | | -9.57** | | -4.13* | | -3.80* |
| | | (-3.83) | | (-3.19) | | (-2.21) | | (-2.13) |
| Observations | 49,590 | 49,590 | 45,765 | 45,765 | 101,838 | 101,838 | 100,016 | 100,016 |

The units of observations are at the individual child level in foster care.

All regs. include state and year fixed effects and the s.e. clustered by state and year

### 1.5.6 Marginal effects

We estimate a reduction of approximately 10,000 adoptions for a 1 percent increase [see Table 12] in the rate of international adoptions.

In our study period, the total international adoptions increased from 15,583 (in 1998) to peak at 22,991 (in 2004), an increase of about 47.50 percent. Given the steady increase in the interim years this translates to roughly 5 percent annual increase in international adoptions. With the assumption of constant marginal effects on the 5 percent, we estimate a reduction of about 50,000 adoptions in the data period that can be attributed to international adoptions.

In sum, the 135,918 international adoptions between 1998 to 2004 we estimate has displaced about 50,000 domestic foster adoptions in the intervening years.

## 1.6 Potential issues and concerns

In this section we discuss potential issues with the approach in this paper and elucidate our measures to address these concerns.

The principal concern has been about the perspective of examining substitution among adoption options and ART rather than a direct examination of causal factors, such as change in costs leading to a change in the adoption outcomes. Such a direct examination of causal mechanisms would indeed be key to understanding the levers that affect adoption outcomes and lead to specific policy implications. We point that our analysis makes a case for such ensuing studies on mechanisms by showing evidence for strong displacement effect of international adoptions. Al-

Table 1.12: **Marginal effect of international adoptions**

| | Foster Care | | | M. eff. | Int. r. | Δ | | Est. red. | |
|---|---|---|---|---|---|---|---|---|---|
| **Age** | **No.** | **Adp.** | **Adp. %** | | | **Prob.** | **Mean pr.** | **1pc** | **5pc** |
| 0 | 129405 | 1993 | 0.02 | -2.33 | 0.16 | -0.0038 | -24.43 | -487 | -2434 |
| 1 | 267984 | 14696 | 0.05 | -2.53 | 0.16 | -0.0041 | -7.46 | -1096 | -5481 |
| 2 | 289039 | 32280 | 0.11 | -2.96 | 0.16 | -0.0048 | -4.27 | -1379 | -6897 |
| 3 | 284620 | 37409 | 0.13 | -2.43 | 0.16 | -0.0039 | -2.98 | -1113 | -5567 |
| 4 | 265458 | 35644 | 0.13 | -3.10 | 0.16 | -0.0050 | -3.72 | -1325 | -6627 |
| 5 | 251879 | 28647 | 0.11 | -2.76 | 0.16 | -0.0044 | -3.91 | -1120 | -5600 |
| 6 | 245795 | 25928 | 0.11 | -2.97 | 0.16 | -0.0048 | -4.54 | -1176 | -5881 |
| 7 | 244682 | 23693 | 0.10 | -2.98 | 0.16 | -0.0048 | -4.96 | -1174 | -5872 |
| 8 | 245187 | 22382 | 0.09 | -2.42 | 0.16 | -0.0039 | -4.27 | -956 | -4780 |
| Total | 2,224,049 | 222,672 | | | | | | -9,828 | -49,139 |

though our work does not directly link between cost changes and demand, we exploit key aspects of "immigrant orphan" inflows[17], particularly variation in attributes and inflow rates across states that proxy for the underlying cost differential. In doing that we argue that our instrument is uncorrelated with omitted variables. On the other hand examining policy changes directly is often vexed with endogeneity issues due to selection bias. In our approach, we sidestep these identification concerns by using an exogenous supply side instrument and take a first cut at the issue of domestic adoption from foster care displaced by international adoption. A second concern is about use of the term "margins of substitution" among child acquisition

[17]We borrow the phrase "immigrant orphans" from the classification of a foreign born child adopted by US citizens by the US Department of Homeland Security.

options. We prefer the concept of displacement akin to the immigration literature, where labor economists examine the effect of immigrants on native employment. The displacement effect we estimate, i.e., every three international adoptions displacing one domestic adoption from foster care are analogous to diversion ratio for discrete goods in the regulatory literature, that capture cross-elasticity of demand. The diversion ratio can be interpreted as measuring how much of the demand diverts from good 'F' to good 'I' due to a relative price change, and can be calculated as the product of the ratio of the cross-elasticity to the own-elasticity and the ratio of the demand for product 'I' to the demand for product 'F'.

We would like to point out that duration analysis may be appropriate for the child adoption setting. Duration models are designed to estimate the length of time before an event occurs – job lost, war breaks, individual is afflicted by a disease episode, or as in the case of adoption, how long before the child gets adopted out of foster care conditional on a variety of factors. In order to implement such duration models we need to track the unit of observation over time. Since the individual child-level data is encrypted for confidentiality and our own strategy to identify these children[18] was error-prone, we were unable to use duration models. Rather we resorted to a conceptually similar model that estimates the conditional probability of adoption with our cohort-level regressions (based on age). Our estimation method allows us to estimate the effects more precisely as we are able to comprehensively

[18] We used time-invariant child-level attributes such as date of birth, race and date of first entry in foster care to construct child level identifiers. Unfortunately we were only able to get a fuzzy match with a significant percentage of children unable to be tracked

use the data on the population of children in foster care.

## 1.7 Concluding remarks

With the large population of children waiting to be adopted at risk of experiencing negative life outcomes due to prolonged stay in foster care, it is imperative to examine some of the causal factors adversely affecting their adoption outcomes. In the analysis here, we outline a simple model of household choice to examine the underlying substitution effects among child adoption options, in addition to births from choice of fertility treatments. We take the prediction to data and estimate a strong negative substitution effect of international adoptions on domestic adoptions from U.S. foster care system. We borrow an instrumental variables approach widely used in the labor literature to identify the effect of international adoptions and ART births. Births due to fertility treatments do not have a statistically significant effect on adoptions from foster care. Both these effects are consistent with prediction from the model, arising from an ordering of preference among options. We estimate a reduction (or delayed adoption) of approximately 10,000 adoptions for a 1 percent increase in the rate of international adoptions. Between 1998 and 2004, international adoptions increased steadily at about 5% annually. Our estimates suggest that the 5 percent increase in international adoptions has resulted in a reduction of about 50,000 adoptions from U.S. domestic foster care.

In sum, the 136,000 international adoptions has displaced about 50,000 domestic foster adoptions in the intervening years of rising international adoptions. Studies on psychological and other measures of well-being strongly suggest that adoption is a favorable outcome for children in foster care. We note the identified effects of prolonged stay in foster care on individual outcomes, but also highlight the large welfare implications on society due to increased rates of teen motherhood, unemployment, criminal activity and incarceration[19].

While interpreting these results, two main caveats should be kept in mind. First, we estimate annual reduction in adoptions at the cohort level which amounts to delay in adoption for at least one year. Since we are unable to track children over time, we would be unable to identify if these children are adopted in later years. Second, even though the instrumental variable estimations should ameliorate bias from omitted variables, the exclusion of private adoptions may bias the estimates downwards (as illustrated in the appendix and indicated in the shares estimation). Therefore the IV estimates can be seen as a lower bound on the substitution effect.

Still, the large displacement effects of international adoptions indicate that both the federal and state governments need to evaluate the policies that affect adoption of children in foster care. Other studies find that adoption subsidies incentivize adoptions from foster care. The federal government needs to re-examine its uniform tax rebate of up to 13,000$ for all types of adoptions which reduce the relative cost of international adoptions. We emphasize that our paper is an attempt to bring attention to the unintended consequences on foster outcomes and does not indicate that international adoptions are unfavorable.

[19]A recent study calculates that the average annual cost on correctional facilities and incarceration alone associated with the 29,000 youth who aged out of foster care in 2007 is about $36,150 per person(Kelley 2012).

## 1.8 Appendix

### Appendix A: Comparative table with numbers and rates of adoptions

**Table A: Adoptions: Foster care (< age 4) and international**

| Year | Adoption rate from foster care | Number of children in foster care | Adopted children from foster care | Number of International adopt. |
|---|---|---|---|---|
| 1998 | 0.0651 | 152811 | 9949 | 15583 |
| 1999 | 0.0926 | 170007 | 15745 | 15719 |
| 2000 | 0.0847 | 173905 | 14743 | 18857 |
| 2001 | 0.0856 | 175933 | 15068 | 19647 |
| 2002 | 0.0917 | 179374 | 16450 | 21467 |
| 2003 | 0.0920 | 181819 | 16745 | 21654 |
| 2004 | 0.1003 | 186967 | 18754 | 22991 |
| 2005 | 0.1048 | 197347 | 20688 | 22734 |
| 2006 | 0.0981 | 207524 | 20373 | 20680 |
| 2007 | 0.0989 | 209852 | 20762 | 19608 |
| 2008 | 0.1081 | 204408 | 22106 | 17456 |
| 2009 | 0.1150 | 195022 | 22434 | 12744 |

## A.1: Shares specification with linear models

Table A.1 presents the linear regression corresponding to the specification estimated in Table 13. Linear model estimates a slightly larger magnitude of substitution effects compared to the probit estimation, but the qualitative results do not change. The estimated coefficient on international adoption rate is negative (-0.551) at the 1% level of significance (t statistic is -3.66) with inclusion of all substitutes for infants. The effect is numbed down (-0.328), without the inclusion of other substitutes, and statistical significance is reduced to 10% level. A similar pattern holds for toddlers, but now without the substitutes, international adoptions are no longer significant predictors of adoptions from foster care. The pattern is consistent with econometric theory when a relevant variable is omitted, in this case, a substitute (See Appendix A.5).

Table A.1: No endogenous reg. model: OLS estimation

| Dependent Variable: Chid Adopted in foster care = 1 | | | | | | |
|---|---|---|---|---|---|---|
| | Age 0 | Age 0 | Age 0 | Age 1 | Age 1 | Age 1 |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| International adoption, rate | -0.551** | -0.380* | -0.328* | -0.411** | -0.279+ | -0.248 |
| | (-3.66) | (-2.50) | (-2.32) | (-3.15) | (-1.72) | (-1.63) |
| ART births, rate | -0.0597 | -0.0448 | | -0.0779 | -0.0379 | |
| | (-1.10) | (-0.76) | | (-1.27) | (-0.40) | |
| Dom. private adopt, rate | -0.0921** | | | -0.127** | | |
| | (-4.18) | | | (-4.27) | | |
| Observations | 44033 | 104821 | 107248 | 94438 | 219325 | 224319 |

The units of observations are at the individual child level in foster care.

All regs. include state and year fixed effects and the s.e. clustered by state and year

Table A.2.1: 2SLS regression for Infants in Foster Care

| Dependent Variable: Chid Adopted in foster care = 1 | | | | | | |
|---|---|---|---|---|---|---|
| | Intl. adopt endog. | | Intl. adopt and ART births endog. | | | |
| | 5 pc | 10 pc | 5 pc<br>F. law | 5 pc<br>ART | 10 pc<br>F. Law | 10 pc<br>ART |
| International adopt, rate | -2.371** | -2.289* | -2.347** | -2.214* | -2.335** | -2.144+ |
| | (-3.11) | (-2.49) | (-3.59) | (-2.19) | (-3.01) | (-1.72) |
| ART births, rate | | | 0.0424 | -0.0227 | 0.0434 | -0.0289 |
| | | | (0.28) | (-0.06) | (0.30) | (-0.07) |
| First Stage | | | | | | |
| International adopt IV | 158.5** | 119.8** | 192.82** | 175.08** | 147.27** | 138.59** |
| | (3.52) | (2.71) | (4.06) | (3.51) | (3.24) | (2.83) |
| Fertility Law | | | -0.0849** | | 0.0837** | |
| | | | (4.60) | | (4.73) | |
| ART bartik | | | | 309.48** | | 290.32** |
| | | | | (2.92) | | (2.73) |
| F statistic | | | | | | |
| Kleibergen-Paap F stat. | 12.39 | 7.34 | 9.00 | 1.62 | 6.25 | 1.26 |
| Observations | 107248 | 107248 | 104821 | 104821 | 104821 | 104821 |

Stock Yogo CV: 10% IV size, 7.03; 15%, 4.58; 20%, 3.95; 25%, 3.63

Table A.2.2: 2SLS regression for Toddlers in Foster Care

| Dependent Variable: Chid Adopted in foster care = 1 | | | | | | |
|---|---|---|---|---|---|---|
| | Intl. adopt endog. | | Intl. adopt and ART births endog. | | | |
| | 5 pc | 10 pc | 5 pc<br>F. law | 5 pc<br>ART | 10 pc<br>F. Law | 10 pc<br>ART |
| International adopt, rate | -1.983** | -1.985* | -2.359** | -1.535* | -2.539** | -1.427+ |
| | (-2.69) | (-2.29) | (-3.13) | (-2.12) | (-2.72) | (-1.70) |
| ART births, rate | | | 0.266 | -0.290 | 0.257 | -0.301 |
| | | | (1.63) | (-0.93) | (1.50) | (-0.95) |
| First Stage | | | | | | |
| International adopt IV | 143.3** | 112.0* | 171.34** | 154.69** | 134.742** | 124.540* |
| | (3.11) | (2.51) | (3.58) | (3.03) | (2.96) | (2.49) |
| Fertility Law | | | 0.081** | | 0.080** | |
| | | | (4.34) | | (4.51) | |
| ART bartik | | | | 274.195** | | 253.169 |
| | | | | (2.67) | | (2.46) |
| F statistic | | | | | | |
| Kleibergen-Paap F stat. | 9.67 | 6.30 | 7.20 | 1.01 | 5.43 | 0.77 |
| Observations | 224319 | 224319 | 219325 | 219325 | 219325 | 219325 |

Table A.3.1: Instruments orthogonal to data on private adoptions

| Dependent Variable: Private adoptions in states with mandated petition for adoption | | | | | | |
|---|---|---|---|---|---|---|
| **OLS** | | 5 pc IV | | | 10 pc IV | |
| Intl. IV (5 pc pred.) | 0.247 | 0.386 | -1.145 | | | |
| | (0.34) | (0.46) | (-0.75) | | | |
| Intl. IV (10 pc pred.) | | | | -6.53e-09 | -3.04e-08 | -1.0e-07 |
| | | | | (-0.04) | (-0.11) | (-0.50) |
| ART instrument (F. Law) | | | -0.0001 | | | -0.0001 |
| | | | (-1.43) | | | (-1.16) |
| ART instrument (Bartik) | | -0.303 | | | 0.335 | |
| | | (-0.22) | | | (0.18) | |
| Constant | -0.0162** | -0.0160** | -0.0163** | -0.0159* | -0.0157+ | -0.0136+ |
| | (-5.70) | (-5.28) | (-5.23) | (-2.89) | (-2.68) | (-2.16) |
| Number of Clusters | 28 | 28 | 28 | 28 | 28 | 28 |
| Observations | 25039 | 25039 | 25039 | 25039 | 25039 | 25039 |

Table A.3.2: Instruments correlated with international adoptions in the mandated petition states only

| Dependent Variable: International adoptions in states with mandated petition for adoption | | | | | | |
|---|---|---|---|---|---|---|
| **OLS** | | 5 pc IV | | | 10 pc IV | |
| Intl. IV (5 pc pred.) | 356.3* | 632.2* | 328.9 | | | |
| | (3.24) | (3.92) | (1.51) | | | |
| Intl. IV (10 pc pred.) | | | | 0.00009** | 0.0001** | 0.00009** |
| | | | | (7.06) | (7.47) | (4.06) |
| ART instrument (F. Law) | | 0.0291+ | | | 0.00859+ | |
| | | (2.37) | | | (2.28) | |
| ART instrument (Bartik) | | | 62.35 | | | -44.20 |
| | | | (0.22) | | | (-0.22) |
| Number of Clusters | 33 | 33 | 33 | 33 | 33 | 33 |
| Observations | 28430 | 28430 | 28430 | 28430 | 28430 | 28430 |

Table A.4: Two endogenous reg: 2SRI estimation (Instruments: Intl. 5pc, IVF success rate)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Intl.r. | ART r. | Age 0 | Intl. r. | ART r. | Age 1 |
| International adoption, rate | | | -49.65** | | | -28.60** |
| | | | (-6.31) | | | (-4.79) |
| ART births, rate | | | -4.607 | | | -0.128 |
| | | | (-1.09) | | | (-0.06) |
| Residuals (Intl.) | | | 45.02** | | | 27.08** |
| | | | (5.41) | | | (4.47) |
| Residuals (ART) | | | 6.163 | | | 1.098 |
| | | | (1.30) | | | (0.45) |
| First stage | | | | | | |
| Intl. IV (5pc pred. supply) | 158.5** | | | 143.3** | | |
| | (3.52) | | | (3.11) | | |
| ART IV (IVF success rate) | | 0.184** | | | 0.192** | |
| | | (3.48) | | | (3.86) | |
| Observations | 96655 | 94493 | 94263 | 201960 | 197249 | 197249 |

The units of observations are at the individual child level in foster care.

Include state and year fixed effects; standard errors are clustered by state and year

## A.5: Omitted Variable Bias

We present a short note here on the issue of direction of bias with omitted substitution categories. Following our simple model, we model all adoption categories (foster care, domestic private and international adoption) are imperfect substitutes[20].

$$Adopt\ in\ Foster\ Care = \beta_1\, Const. + \beta_2\, International\ adopt + \beta_3\, Dom.\ Priv.\ adopt + \epsilon$$

If our identification assumptions hold, the estimates of the above specification will yield the substitution effects of the various categories on adoption from foster care. What are the consequences if we estimate this specification omitting the scarce and noisy domestic private adoption data? In that case, we are left with the reduced model below:

$$Adopt\ from\ Foster\ Care = \beta_{1a}\, Constant + \beta_{2a}\, International\ adopt + \epsilon$$

[20] For simplifying this discussion, we leave the other substitute in our paper, ART births

We know that

$$\beta_{2a} = \frac{\textit{Cov(Intl. adopt, Adopt from FC)}}{\textit{Var(Intl. Adopt)}} \tag{1.8}$$

$$= \frac{\textit{Cov(Intl. adopt, } \beta_1 \textit{Constant} + \beta_2 \textit{ Intl. adopt} + \beta_3 \textit{ D. Priv. adopt} + \epsilon\textit{)}}{\textit{Var(Intl. Adopt)}} \tag{1.9}$$

$$= \beta_1 \frac{\textit{Cov(Intl. adopt, Constant)}}{Var(Intl.Adopt)} + \beta_2 \frac{\textit{Cov(Intl. adopt, Intl. adopt)}}{Var(Intl.Adopt)}$$

$$\beta_3 \frac{\textit{Cov(Intl. adopt, D. Priv. adopt)}}{Var(Intl.Adopt)} + \frac{\textit{Cov(Intl. adopt,}\epsilon\textit{)}}{Var(Intl.Adopt)} \tag{1.10}$$

$$= \beta_2 + \beta_3 \frac{\textit{Cov(Intl. adopt, D. Priv. adopt)}}{Var(Intl.Adopt)} \text{ (as other terms amount to zero)} \tag{1.11}$$

We know that $\beta_3 < 0$, since domestic private adoptions negatively affect adoptions from foster care. Since international adoption and domestic private adoption are substitutues, we expect their covariance to be negative. Since variance is always non-negative (denominator), we can sign the bias from omitting international adoptions as positive.

Essentially, our reduced equation underestimates ($\beta_{2a}$) the effect of international adoptions on domestic foster adoptions. This can be interpreted as lower bound estimates. Our instrumental variables estimation we argue[21] mitigates some of this bias despite omission of the private adoptions category.

[21] As we showed in Section A.3 that our instruments are orthogonal to private adoptions in the subset data, restricted to states with clean classification of private adoptions

## A.6: Two Stage Residual Inclusion

The first stage begins with the two population regressions (equation 6 and 7) linking the endogenous regressors, (1) international adoptions, (2) ART live births, and their respective instruments.

$$International\ rate_{i,s,t} = \alpha_0 + \alpha_1 Predicted\ supply\ (5pc)_{s,t} + \alpha_2 Controls_{s,t} + \quad (1.12)$$

$$ART\ birth\ rate_{i,s,t} = \alpha_0 + \alpha_1 Predicted\ supply\ (IVF)_{s,t} + \alpha_2 Controls_{s,t} + \quad (1.13)$$

The second stage we plug in the residuals.

$$\begin{aligned} Adopted_{i,s,t} = &\beta_0 + \beta_1 International\ rate_{s,t} + \beta_2 ART_{s,t} \\ &+ \beta_{res1} Residual\ 1_{s,t} + \beta_{res2} Residual\ 1_{s,t} \\ &\beta_4 Child\ attributes_{i,s,t} + \beta_5 Other\ Controls_{s,t} + \tau_s + \tau_t + \epsilon_{i,s,t} \quad (1.14) \end{aligned}$$

# Chapter 2: Betrothal Testing, Beliefs and Behavior: Effect of testing rules on HIV transmission

> Two neighbors may agree to drain a meadow, which they possess in common; because 'tis easy for them to know each others mind; and each must perceive, that the immediate consequence of his failing in his part, is the abandoning of the whole project. But 'tis very difficult and indeed impossible, that a thousand persons shou'd agree in any such action; it being difficult for them to concert so complicated a design, and still more difficult for them to execute it; while each seeks a pretext to free himself of the trouble and expense, and wou'd lay the whole burden on others.
>
> - David Hume, *A Treatise of Human Nature, Vol II* (1739)[1]

## 2.1 Introduction

Marriages are widespread in the recorded history of human societies (Westermarck 1922). They can last a life-time[2] and key to pscyhological, sexual and

[1]The epigraph is in the hope that David Hume will eloquently convey in a few lines that the author attempts in the next few pages.

[2]Or atleast meant to be. Traditional marriage vows in most cultures signify this lasting nature of marriage with phrases like 'till death do us apart' in Christian weddings or circumambulating

overall well-being in adult life (Gove 1983, Oppenheimer1988). Given the centrality of marriage in people's lives, considerable efforts are exerted in choice of partners by individuals. The laws and customs that regulate the marital institution varies across countries and cultures. Like any institution, the social and legal institution of marriage regulates the activity of its individual members within its purview. Economists have noted that uncertainties in health and other attributes of future partners significantly affect the outcomes in the marriage market (Becker 1973). In the last two decades, the risk of HIV/AIDS [3] infection from a partner inside marriage has appended to a host of other risks. For instance in India, a country with the second largest number of HIV infected individuals, an estimated 90% of women living with HIV acquired the virus from their husbands or long-term partner[4] (Silverman 2008). Recently, several governments across the world have stipulated mandatory testing as a prerequisite for marriage[5]. A not-so-apparent consequence of such laws, if it

the fire according to Saptapadi rites in a Hindu marriage.

[3]Acquired Immunodeficiency Syndrome (AIDS) is a disease caused by the Human Immunodeficiency Virus (HIV)

[4]It must be noted at the onset that empirical examination of people's "private lives" is extremely challenging and riddled with reporting and measurement errors. The source of errors in prevalence statistics include: the 'window period' when testing does not detect infection (Corbitt 1999), non-comparability between regions with low testing rates with regions with higher testing, selection bias in voluntary testing and absence of testing. Bias in estimation of responses is to be expected due to underreporting by people indulging in risky sexual behavior.

[5] Local governments in India, China, Ethiopia; countries of Bahrain, Guinea, United Arab Emirates, Saudi Arabia among many other have enacted laws and policies mandating premarital testing

increases testing is the reduced uncertainty in infection status of prospective marital partners. In this paper, I examine the incentives at work in three different institutional regimes that affect pre-marital sexual behavior, which consequently affects aggregate social welfare through preference for marriage, marriage timing, sorting, HIV stigma and transmission of HIV. I bring attention to the effect of information acquisition and transmission and the ensuing incentives in the three regimes which characterizes systems across countries 1) no HIV testing 2) voluntary pre-marital HIV testing of a prospective partner and 3) mandated pre-marital HIV testing of a partner. I highlight the efforts chosen at prevention of disease during the pre-marital period of sexual activity, sorting in marriage and its effect on incidence or new infections under different regimes. In addition to showing that efforts at prevention are higher in a mandated regime compared to "no testing regime", the paper brings attention to the interaction of cultural norms with fear of learning in the voluntary testing regime that may lead to an socially inferior outcome. The paper briefly traces the trade-offs for the individual and for the social-planner within each regime. The paper in part is about recognizing psychological costs (of resolving uncertainty) and the prevailing structure of social interaction for optimal institutional design.

In the next section I outline the history of pre-marital testing legislation, followed by a brief section on relevant literature. A simple expected utility model to determine the equilibrium efforts at prevention and the resulting outcomes under varying regimes follows. The discussion section introduces the idea, why voluntary testing may result in sub-optimal welfare compared to mandatory testing? I conclude with a section on the trade-offs confronting the social planner.

## 2.2 Background

### 2.2.1 Mandated testing: legal history

The judicial standpoint on mandatory testing across countries and within is neither uniform nor clear-cut. In the United States, the state of Illinois introduced mandatory HIV testing for acquiring marriage licenses in the late eighties. The law stipulated that both parties to a proposed marriage inform each other of their test results with effect from January 1, 1988. Marriages in the state plummeted from 95,613 in 1987 to 78,302 in 1988. The Monthly Vital Statistics Report (1991) records that, "the number of Illinois brides who married in other states, particularly neighboring states, increased substantially, doubling and even more than tripling in some states". The state registered a drop of 22.5% in marriages in that period, 8 of 70,846 applicants for marriage licenses were found to be HIV positive and the total cost of the testing program for 6 months was estimated at $2.5 million or $312,000 (in 1989 dollars) per HIV positive individual identified (Turnock 1989). Another study estimated that mandatory premarital screening, if adopted nationally, would cost $167,230,000 (Petersen 1990a). In neighboring Mexico, seven out of thirty two states had pre-marital HIV testing mandated as early as 1994. A prevalence of 0.03% was found in the regions and according to a study, "... premarital HIV testing is not only violative of human rights but an expensive public health measure useless in the control of the spread of HIV" (Del 1994). Although the monetary costs of testing has fallen drastically, the drop in marriage rates in Illinois raises the issue of preference for mandated testing.

In the recent past, several state governments in India have passed mandatory HIV testing laws before marriage and the national government is evaluating adopting it countrywide (Malhotra 2008). Malaysia mandated a HIV screening test nationally starting January 1, 2009; several Christian churches in Nigeria have required their members to test before marriage since 2007; Roman Catholic churches in Burundi require HIV testing to precede the wedding ceremonies from 2006. Several local governments in countries including China have mandated compulsory testing laws for prospective marital partners. Nevertheless legal opinion is highly divided, bringing to fore concerns about human rights violation in the implementation of such laws. It is evident that stipulating a mandatory testing is highly controversial and requires scrutiny by social scientists besides legal scholars and human rights activists.

## 2.3 Related literature

The HIV epidemic has become the most feared and analyzed disease of the last two decades with an over 34 million estimated infected in 2007UNAIDS2007. New infections of HIV occur primarily through sexual activity between individuals with different infection status (Dow 1996). Approximately ten percent of adults in Sub-Saharan Africa are infected with HIV and the primary mode of transmission in the region is heterosexual sex. Currently, the absence of cure for AIDS and the high costs of treatment has led policy makers to focus on interventions preventing further spread[6] (Hogan 2005).

Increasingly, voluntary counseling and testing (VCT) has been widely advocated intervention and used to increase awareness of HIV status and reduce risky behavior in affected countries (Sweat 2000). Evaluation studies in many countries have reported that reduction in risky behavior and transmission due to VCT intervention is unclear (Glick 2005). A recent paper finds that minor monetary incentives could increase testing rates by 50%, and that individuals on learning their HIV positive status are three times more likely to purchase condoms (Thornton 2008). Self selection in opting for voluntary counseling and testing admittedly is a serious limitation in evaluating its effects (Thornton 2008). Universal mandatory testing does not suffer from such selection. Although a pre-marital testing law may have other implications such as change in preference for marriage itself, which may reintroduce bias.

The emphasis on HIV testing for prevention has underlying assumptions: first, the positive effects of learning HIV will prevent the spread of the disease. In particular, it is implicitly assumed that those diagnosed negative will protect themselves from infection and those diagnosed positive will take precautions to protect others. Second, many believe that it is difficult to get people to learn their HIV status (due to psychological or social barriers like stigmatization), thus justifying expenditures on de-stigmatization and advertising campaigns (Thornton 2008).

[6] (Canning 2006) has written a comprehensive literature review of the recent literature on the macroeconomic issues of HIV/AIDS. I restrict myself to studies examining behavioral responses to incentives.

As we mentioned in the previous section, several countries have attempted to introduce, considering implementation or have already mandated testing. Besides a couple of case studies in the public health literature on the Illinois experience (Cleary 1987,Turnock 1989) and cost-benefit analysis of mandatory syphilis testing in the US (Haskell 1984), a careful examination of the economic implications of mandatory testing is required. A related study by economists has been analyzing the impact of public testing on HIV (Boozer 2000). Their paper estimates the behavioral responses to the type of information-intervention a public HIV testing program would typify using a demand for information model. Given the centrality of marriage, and the high costs of HIV, there is a need to examine the implications of mandated pre-marital testing. This paper examines the outcomes of mandatory testing laws, focussing on HIV transmission, and compares it to the case of "voluntary testing" and the base case "no testing". Additionally, the paper underscores the differences in institutional and psychic costs under the different regimes. The economic trade-offs are recognized in the different regimes of testing which vary with culture and structure of social interaction.

## 2.4 Theory

As outlined in the earlier section, legal institutions governing pre-marital testing rules differ across countries. In this section, I use a simple model to capture the incentive structure for individuals to prevent disease that are inherent in the different regimes of testing. The model presented here ignores several complexities in the real-world in the hope of elucidating the key insights. Another idea which I attempt to show is the interdependence between individual psychic costs of testing and the institutional environment, which exacerbates the costs of testing. Here again, the model allows us to easily recognize the interaction and thereby illuminates the (possibly surprising) outcome of the regimes that hinge on the institutional environment.

### 2.4.1 The expected utility model

Set up and assumptions:

Individuals live in two periods: One prior to marriage (period 1) and one inside marriage (period 2).

Information/Beliefs[7]: Common priors with homogenous beliefs or ex-ante heterogenous priors [two types: previously careful (PC), previously not careful/reckless (PR)] in period 0 (or before the start of period 1).

Efforts (e) are exerted to prevent infection in period 1 based on information in period 0.

$e \in [0, 1]$

Personal probability of infection $p(e)$ depends on own efforts (e), conditional on the population infection rate, $\Pi(\dot{e}|\lambda, \beta) = \Pi(\dot{e})$. $p'(e) < 0$ ; $p''(e) = 0$ ($p(e)$ is linear and decreasing in efforts).

[7]Beliefs, personal probability of infection and transition probabilities all belong to the subjective-expected-utility world of Savage (1954). In addition, I assume that the subjective probabilities overlap with objective probabilites in the aggregate.

The population infection rate is a function of aggregate population efforts ($\widehat{e}$) determined by equilibrium individual efforts ($e$) and conditional on the infection rate in period 0 ($\lambda$), and the virulence of disease ($\beta$), a biological parameter. For simplicity, we assume $\beta = 1$. Efforts are costly (C(e))

$C'(e) > 0$ ; $C''(e) > 0$

Utility measure representation[8]:

$U^{hh}$: Utility of of being uninfected oneself and marrying an uninfected partner or a healthy-healthy match in marriage;

$U^{ii}$: Utility of an infected-infected match in marriage;

$U^{hi}$: Utility of being healthy oneself and marrying an infected partner or a healthy-infected match in marriage;

$U^{ih}$: Utility of an infected-healthy match in marriage.

I assume that a discordant marriage (one infected, one healthy) is equal in utility to an infected-infected marriage[9].

$U^{ih} = U^{hi} = U^{ii} = U^{I}$

and $U^{hh} = U^{H}$

I assume that a healthy marriage is preferred to an infected marriage.

$U^{H} > U^{I}$

If an individual chooses to stay single, I assume being a healthy-single is pre-

[8]The assumptions have also been informed by previous studies. A 2007 Johns Hopkins study in Ethiopia reports that 96% of the respondents would cancel the marriage if pre-marital test was discordant and they tested healthy.

[9]This assumption can find some validity if infection is difficult to prevent inside marriage. So both partners are infected eventually in a discordant marriage.

ferred to infected-single $\left[U^h > U^i\right]$. Note that the health status in superscripts are in capitals for married individuals.

An expected-utility maximizer with a pre-determined utility measure in period 0 $\left(\bar{U}\right)$, will choose efforts $(e)$ to maximize his returns from period 2 (expected marital health), given the prevailing infection rate $(\lambda)$, costs of effort $C(e)$. Higher efforts $(e)$ will lower his personal probability of infection[10] in period 1, if he were uninfected in period 0 but will be increasingly costly ($C(e)$ is convex). The trade-off is increased (expected) benefits from healthy marriage in period 2 (due to lowered probability of infection in period 1), and cost of preventing disease in period 1. The institutional environment (allowing, or in this case hindering information acquisition that affords choice of partner and thereby health inside marriage) is reflected with expected health in marriage determined by population infection transition probability $(\Pi)$.

$$\underset{e}{Max} \quad \bar{U} - C(e) + \delta(1-\lambda)\left\{(1-p(e))\left[U^{hh}\left(1-\Pi(\widehat{e})\right) + U^{hi}\Pi(\widehat{e})\right] + p(e)\left[U^{ih}\left(1-\Pi(\widehat{e})\right) + U^{ih}\Pi(\widehat{e})\right]\right\}$$
$$+\delta\lambda\left\{U^{ih}\left(1-\Pi(\widehat{e})\right) + U^{hi}\Pi(\widehat{e})\right\}$$

### 2.4.2 No Testing regime

#### 2.4.2.1 Common priors

Pre-determined utility at period 0, $\bar{U}$.

[10]High efforts in period 1 or the period of pre-marital sexual activity, for instance could be complete abstinence which would translate into efforts close to maximum $(e \to 1)$ in the model.

$$\underset{e}{Max} \quad \bar{U} - C(e) + \delta(1-\lambda)\left\{(1-p(e))\left[U^{hh}\left(1-\Pi(\dot{e})\right) + U^{hi}\Pi(\dot{e})\right] + p(e)\left[U^{ih}\left(1-\Pi(\dot{e})\right) + U^{ih}\Pi(\dot{e})\right]\right\}$$
$$+\delta\lambda\left\{U^{ih}\left(1-\Pi(\dot{e})\right) + U^{hi}\Pi(\dot{e})\right\}$$

First order condition:

$$-C'(e) + \delta(1-\lambda)\left\{-p'(e)\left[U^{hh}\left(1-\Pi(\dot{e})\right) + U^{hi}\Pi(\dot{e})\right] + p'(e)\left[U^{ih}\left(1-\Pi(\dot{e})\right) + U^{ih}\Pi(\dot{e})\right]\right\} = 0$$

which can be reduced to [See Appendix for details of derivation],

$$\Longrightarrow C'(e) = -\delta(1-\lambda)\left(1-\Pi(\dot{e})\right)p'(e)\left(U^H - U^I\right) \tag{2.1}$$

the familiar Marginal cost = Marginal benefit equation. The optimal efforts $(\bar{e})$ will be determined by equation 1[11].

$\frac{-C'(e)}{p'(e)} = \delta(1-\lambda)\left(1-\Pi(\dot{e})\right)\left(U^H - U^I\right)$

Since we know that $\left(U^H - U^I\right) > 0$ ; $1 > \left(1-\Pi(\dot{e})\right) > 0$ ; $(1-\lambda) > 0$ and $\delta > 0$, we have a positive term on the right side in the above equation.

$\frac{-C'(e)}{p'(e)} \geq 0$, as $C(e)$ is convex and $p(e)$ linear and decreasing in $e$. We arrive at $\bar{e} \geq 0$.

#### 2.4.2.2 Ex-ante heterogenous priors

In the real-world, even with no testing availability it is likely people possess varying levels of information about their previous efforts and hold subjective beliefs of their infection status. Although continuity would generate a richer set of results, for simplicity I assume two types of individuals (1) previously careful (PC), with subjective probability[12] (belief) of infection $\lambda_{pc}$ (2) previously not careful/reckless

[11] The (Kakutani) fixed point theorem gives us the proof of existence of an equilibrium.

[12] I assume that subjective probability overlap with actual probabilities

(PR) with subjective probability of infection $\lambda_{pr}$.

$\lambda_{pr} > \lambda_{pc}$

The maximization problem for previously careful and previously not careful involve identical expected utility models in their prior beliefs about infection [See details in appendix]. We derive $e^*_{pc} > e^*_{pr}$. As expected those previously careful will have higher level of efforts compared to previously reckless in the period before marriage (period 1).

#### 2.4.2.3 A note on signalling equilibrium

If efforts were observable, under certain conditions (including single crossing property of the utility functions of the two types), a signalling equilibrium can result with previously careful, exerting a level of effort to distinguish themselves, a level that would not be optimal to the previously reckless if they were to choose it. This will result in previously careful matching in marriage with previously careful.

### 2.4.3 Mandatory testing regime

#### 2.4.3.1 Common priors

Testing is assumed available in this regime. As pointed out in the literature review, studies in several countries find that people do not test for HIV/AIDS, even if free and easily accesible. It may be rational to not resolve uncertainty about one's infection status, for instance if there is no cure or the treatment is unavailable or prohibitively costly. Currently, there is no cure for HIV/AIDS and issues of lack of access to treatment and limited availability of free treatment is beginning to resurface in several countries in Africa. It may be crucial to therefore recognize the psychic costs of learning one's status by testing. Let $\overline{P}$ capture such psychic costs of testing which has to be overcome if one chooses to learn own infection status.

Under mandatory testing, partners are required by law to test, and each has to learn own and the other's status at the time of marriage. Since utility from marrying a healthy partner is higher than marrying an infected partner, if one is healthy, they would prefer to marry a healthy partner (I allow for rematching partner's at some cost). These rematching costs can be subsumed in the psychic costs of testing $\overline{P}$ . An individual if healthy in a mandatory testing regime with low psychic costs will choose to test and marry a healthy partner. The other option is to test and remain single or not to test and remain single. For sufficiently large $P(.) > 0$, the test and remain single option may be dominated by 'do not test and remain single' (and 'if test, marry'). The maximization problem is to choose between 'do not test and remain single' and 'test and marry' a partner of equal or infected status.

'Test and marry' will be preferred to 'do not test, stay single' if the following condition holds:

$$\underset{e}{Max} \quad \bar{U} - C(e_s) + \delta(1-\lambda)\left\{(1-p(e_s))\,U^{hh} + p(e_s)U^{ii}\right\} + \delta\lambda U^{ii} - P(.) \quad >$$

$$\underset{e}{Max} \qquad \bar{U} - C(e_m) + \delta(1-\lambda)\left\{(1-p(e_m))\,U^{h} + p(e_m)U^{i}\right\} + \delta\lambda U^{i}$$

Comparing the first order conditions, we derive the conditions to 'test and marry' under mandatory testing regime.

$$\frac{C'(e_s)}{\delta(1-\lambda)p'(e_s)\left(U^h - U^i\right)} = \frac{C'(e_m)}{\delta(1-\lambda)p'(e_m)\left(U^{hh} - U^{ii}\right)} \tag{2.2}$$

If we assume[13] that utility differential between having a healthy marriage and staying healthy but single is greater than being in an infected marriage and staying single and infected $[U^{hh} - U^{h} > U^{ii} - U^{i}]$, we arrive at $\overset{**}{e}_m > \overset{**}{e}_s$ from equation () . Efforts at prevention in period 1 are higher for those who choose to 'test and marry' compared to those who prefer to remain 'untested and single'.

#### 2.4.3.2 Ex-ante heterogenous priors

The psychic costs of testing may be higher for the previously not careful $\left(\overline{P}_{pr} > \overline{P}_{pc}\right)$ since they expect a higher probability of being infected $(\lambda_{pr} > \lambda_{pc})$. As a consequence the likelihood of the previously not careful not testing and remaining single in the mandatory testing regime is higher than the previously careful. Another result if both groups choose to test and marry is that the equilibrium efforts of the previously careful will be higher than the other group, derived below from the first order conditions (FOC).

c

As $\lambda_{pr} > \lambda_{pc} \Longrightarrow (1 - \lambda_{pc}) > (1 - \lambda_{pr}) \Longrightarrow \frac{C'(e_{pc})}{p'(e_{pc})} > \frac{C'(e_{pr})}{p'(e_{pr})}$. Since $p'(e_{pr}) = p'(e_{pc})$, we have $C'(e_{pc}) > C'(e_{pr}) \Longrightarrow \overset{**}{e}_{pc} > \overset{**}{e}_{pr}$.

[13] In several countries there is an increasing number of HIV positive marriage bureaus as infected people report that their lives would be much better with a partner. Therefore if we were to make an argument for the reverse inequality $U^{ii} - U^{i} > U^{hh} - U^{h}$, the interesting outcome $\overset{**}{e}_m < \overset{**}{e}_s$ results – i.e., those who choose to be single exert more effort than those choosing to marry.

### 2.4.4 "Mandatory testing" vs. "no testing"

A key outcome from mandatory testing is no cross-infections in marriage if healthy marry healthy. A less obvious result is that equilibrium efforts in period 1 are higher in mandatory testing compared to the no testing regime. Let us illustrate this result by comparing the FOC's in the two regimes with identical initial conditions and for all choosing to marry (since we assumed a strong preference for marriage, $[U^{hh} > U^h, U^{ii} > U^i]$). The "no testing regime" is on the left hand side of the equality and the "mandatory testing regime" on the right hand side.

$$\frac{C'(e)}{-\delta(1-\lambda)\,(1-\Pi(\dot{e}))\,p'(e)\,(U^H - U^I)} = \frac{C'(e)}{\delta(1-\lambda)p'(e)\,(U^H - U^I)} \tag{2.3}$$

Since $1 > (1-\Pi(\dot{e})) > 0$, we get $\overset{**}{e}_m > \bar{e}_m$ i.e., the efforts at prevention under mandatory regime ($\overset{**}{e}_m$) are higher than the efforts with no testing regime ($\bar{e}_m$). This is because of incentives under mandatory regime, which motivates people to stay healthy with high effort levels in period 1, by rewarding them healthy partners in marriage. A mandatory pre-marital testing law is akin to an insurance for healthy people who pay a higher premium in period 1 through efforts and are guaranteed a healthy marriage in period 2, with information about prospective partner's health. This is consequent of the possibility of knowing the infection status and choosing a healthy partner in mandatory testing.

### 2.4.5 Voluntary testing regime

Under this regime, testing is available but not enforced as is the case in most countries. People can voluntarily choose to learn own status and if cultural norms permit ask partner to test and share information. Norms vary across cultures and countries, and in some countries it is relatively costless to mutually exchange information on infection status. In some parts of the world it is taboo (very costly to learn partner's infection status), while in most countries there is at least some discomfort in bringing up the issue of exchanging test results. An analogy would be considering a pre-nuptial where issues about mistrust surfaces between couples before getting married. Prevalent marital customs and norms therefore affect costs of learning prospective marital partner's infection status. Therefore, such institutional/cultural norms are modeled as the cost of getting partner to test $\left(\overline{N}\right)$ have to be considered in addition to psychic costs of own testing $\left(\overline{P}\right)$ in voluntary testing regimes.

The options for an individual in a such a regime are (1) learn own status and stay single (2) learn own status and marry without mutally learning each other's status (3) marry with mutual learning of own and other's status (4) do not learn own status and stay single (5) marry without learning each and other's status.

With our earlier assumptions of preference for marriage, we can rule out option (1) and (2), if $\overline{P}$ is sufficiently high. One would choose to test only if the benefits or the expected utility from marriage outweigh the psychic and institutional costs of testing $\left[\overline{P}+\overline{N}\right]$ which is option (3) or to stay untested and single (4). Option (5) can be recognized as marrying without testing, akin to the "no testing regime". The level of efforts (e) at prevention in period 1, in the voluntary regime are similar to the no testing regime, if $\left[\overline{P}+\overline{N}\right]$ are sufficiently large, where people choose to marry without testing or remain single. If $\left[\overline{P}+\overline{N}\right]$ are small, the efforts will be similar to the mandatory testing regime. The mandatory regime removes the cultural norms as the impediment to testing [zero institutional (cultural) costs, ($\overline{N} = 0$)], more people will choose to test and marry compared to voluntary regime. In the voluntary regime where people with preference for marriage will choose "no testing" and marry without testing option due to the absence of cultural norms of exchanging test status (or high institutional costs). An outcome of allowing individuals the choice of testing, as I shall argue in the next section, could result in a sub-optimal equilibrium with lower social welfare.

## 2.5 Results and discussion

A mandatory pre-marital testing law is an institution which sets specific rules for marriage. It specifies that all those who choose to marry (1) will be required to learn own status 2) will be guaranteed to learn prospective marriage partner's health status (3) and the marriage partner is in turn guaranteed information about an individual's health status. The regime negates the gamble of possibly marrying an infected partner as in the "no-testing regime" if one has incurred the costs of staying healthy. It imposes the psychic costs of learning own status on everybody choosing to marry. It motivates safe behavior by ensuring choice of healthy partner. The fear of having to learn that one is infected if one chooses to marry, may additionally motivate people to exert higher efforts at preventing disease in the period prior to marriage. This behavioral outcome is absent in voluntary testing regime, where individual members will still have a positive probability of finding another individual who similarly chooses not to test. The psychic costs of learning $\overline{P}$ are aggravated by the institutional costs $\overline{N}$, which further hinders mutual testing. The structure of social interactions may not evolve quickly to respond to prevalence of disease and the disease dynamics. Governments which may recognize any possibility of explosion of asymptomatic diseases like HIV have to contend with trade-offs. The benefits from higher effort levels at prevention are the resulting lowered incidence, lowered cross-infections in marriages due to higher likelihood of assortive matching. Such benefits may outweigh the imposed psychic costs on the population under a mandatory testing regime and increased marginal cost at prevention in the pre-marital period. If early treatment has benefits, this in turn will lead to higher welfare for the tested. I briefly make a case for a possible interesting fallout of mandatory testing – an increase in early testing, which improves the health of the already infected due to early treatment.

In this context, let us go back to the individual maximization problem and arrive at possible equilibria in the different regimes by introducing the benefits of early treatment.

Table 1, summarizes the trade-offs faced by an individual in the different regimes. In addition to the results from the earlier maximization problem, we include the benefits of testing. If tested before period 2, the early treatment increases the utility of the infected individuals from $U^I$ to $U^{I+}$ (if infected and tested at the end of period 1) or $U^{I++}$(if infected and tested before period 1). In the mandatory testing regime [Case 15 to 20 in Table 1], the expected utility maximizers choosing marriage over single will (stipulated testing) have to incur the psychic costs ($-\overline{P}_1$) at end of period 1. They also recognize the benefits of early testing (in period 0) which will yield them a higher utility if infected. As they prefer marriage they will necessarily have to submit to testing (prior to period 1), it may be beneficial to get tested even earlier (in period 0) if the benefits outweigh the costs (Case 17 to 20). The trade-off[14] is the possibility of being infected in period 0 and exerting a higher marginal efforts at prevention rather than reaping the benefits of early treatment. With heterogenous priors, we can expect an increased likelihood of the previously reckless choosing early testing if the net treatment benefits are high.

The voluntary testing regime harbors the likelihood of being married without undergoing the psychological and institutional costs of testing. The fear of learning interacts with the cultural norms to result in an outcome of increased uncertainty in the marital institution. Individuals not mandated to test in the future, may choose not to recognize the benefits of early testing as well. Although the possibility of the outcome with high social welfare as in mandatory testing is possible [case 11 to 14], a choice in testing may result in the "tragedy of the commons" of lowered efforts in period 1 and lower expected returns in marriage, identical to the "no testing regime" outcome [case 7 or 8].

## 2.6 Conclusion

A social planner is confronted with trade-offs in mandatory and voluntary regimes. The parameters he must consider are the infection rate (prevalence $\lambda$), the disease dynamics ($\Pi$), the treatment availability, access and its costs ($-T$) (and

[14]Note that the psychic costs also subsumes the costs of stigma if infected

benefits). Although he may not be able to influence the psychic costs immediately [15]if an aysmptomatic disease is expected to register an explosive growth, and the prevalent customs have been unable to evolve rapidly to respond with high levels of voluntary testing, a mandated law could undo some of the institutional costs of getting a partner to test [Table 2 provides a brief schema of social welfare]. As discussed a mandated law may encourage early testing and thereby segregate the infected and the healthy early. The planner will have to consider the possible discriminatory outcomes (and likely social sanction of the infected[16]) and compare it with the increased efficiency of efforts[17]at prevention by those testing healthy in period 0 and the lowered incidence, lowered likelihood of cross-infections in marriage (period 1) and benefits of early treatment for the infected. It is possible that there may be cases where the psychic costs are prohibitively high and the population collectively choose not to resolve such uncertainty. A case may be where the incidence of HIV is extremely high, but people would be better-off without learning their status [Case

[15]Over time, stigma could be reduced by creating awareness. Besides, a mandated testing law removes the taboo from testing, which may considerably lower the psychic costs of going to test.

[16]Luginaah et al (2005) examine the impact of church mandated testing in Ghana. Their results reveal how broader social impacts of HIV testing for those planning to marry may extend beyond individuals or couples in different cultural contexts. The findings also support the view that programs for Ghana cannot be neutral to cultural values and need to be tailored for particular (ethnic) populations.

[17]The early testing will result in a reallocation ofthe efforts are higher for those testing healthy. The infected will choose early treatment. The early testing results will further reallocate efforts of period 1 for healthy-healthy and infected-infected (low or no effort), and high efforts if healthy are in a relationship with infected.

5 in Table 2].

The mandatory pre-marital testing law is controversial and human rights activists oppose it on grounds of privacy violation due to poor implementation. This paper brings an economic insight about the gains from reduced uncertainty due to mandatory testing. Governments have to carefully consider the trade-offs inherent in the legal institutions governing marriage. In developing a rough schema of trade-offs under different regimes and prevailing conditions, this paper informs the debate on mandated HIV testing.

## 2.7 References

## 2.8 Appendix

### 2.8.1 No testing regime

#### 2.8.1.1 Common priors

$$\underset{e}{Max} \quad \bar{U} - C(e) + \delta(1-\lambda)\left\{(1-p(e))\left[U^{hh}\left(1-\Pi(\dot{e})\right) + U^{hi}\Pi(\dot{e})\right] + p(e)\left[U^{ih}\left(1-\Pi(\dot{e})\right) + U^{ih}\Pi(\dot{e})\right]\right\}$$
$$+\delta\lambda\left\{U^{ih}\left(1-\Pi(\dot{e})\right) + U^{hi}\Pi(\dot{e})\right\}$$

First order condition:

$-C'(e)+\delta(1-\lambda)\left\{-p'(e)\left[U^{hh}\left(1-\Pi(\dot{e})\right) + U^{hi}\Pi(\dot{e})\right] + p'(e)\left[U^{ih}\left(1-\Pi(\dot{e})\right) + U^{ih}\Pi(\dot{e})\right]\right\} =$
0

$$-C'(e)+\delta(1-\lambda)\left\{-p'(e)\left[U^{H}\left(1-\Pi(\dot{e})\right) + U^{I}\Pi(\dot{e})\right] + p'(e)\left[U^{I}\left(1-\Pi(\dot{e})\right) + U^{I}\Pi(\dot{e})\right]\right\} = 0$$

$$\Longrightarrow -C'(e)+\delta(1-\lambda)\left\{-p'(e)\left[U^{H}\left(1-\Pi(\dot{e})\right) + U^{I}\Pi(\dot{e})\right] + p'(e)\left[U^{I}\right]\right\} = 0$$

$$\Longrightarrow -C'(e)+\delta(1-\lambda)\left\{-p'(e)U^{H}\left(1-\Pi(\dot{e})\right) - p'(e)U^{I}\Pi(\dot{e}) + p'(e)U^{I}\right\} = 0$$

$$\implies -C'(e) - \delta(1-\lambda)p'(e)\left\{U^H\left(1-\Pi(\dot{e})\right) - U^I\left(1-\Pi(\dot{e})\right)\right\} = 0$$

$$\implies -C'(e) - \delta(1-\lambda)\left(1-\Pi(\dot{e})\right)p'(e)\left(U^H - U^I\right) = 0$$

$$\implies C'(e) = -\delta(1-\lambda)\left(1-\Pi(\dot{e})\right)p'(e)\left(U^H - U^I\right)$$

#### 2.8.1.2 Ex-ante heterogenous priors

The maximization problem for previously careful,

$$\underset{e}{Max} \quad \bar{U}_{pc} - C(e) + \delta(1-\lambda_{pc})\left\{(1-p(e))\left[U^{hh}\left(1-\Pi(\dot{e})\right) + U^{hi}\Pi(\dot{e})\right] + p(e)\left[U^{ih}\left(1-\Pi(\dot{e})\right) + U^{ih}\Pi(\dot{e})\right]\right\}$$
$$+\delta\lambda_{pc}\left\{U^{ih}\left(1-\Pi(\dot{e})\right) + U^{hi}\Pi(\dot{e})\right\}$$

The maximization problem for previously not careful,

$$\underset{e}{Max} \quad \bar{U}_{pr} - C(e) + \delta(1-\lambda_{pr})\left\{(1-p(e))\left[U^{hh}\left(1-\Pi(\dot{e})\right) + U^{hi}\Pi(\dot{e})\right] + p(e)\left[U^{ih}\left(1-\Pi(\dot{e})\right) + U^{ih}\Pi(\dot{e})\right]\right\}$$
$$+\delta\lambda_{pr}\left\{U^{ih}\left(1-\Pi(\dot{e})\right) + U^{hi}\Pi(\dot{e})\right\}$$

FOC for previously careful:

$$\implies C'(e) = -\delta(1-\lambda_{pc})\left(1-\Pi(\dot{e})\right)p'(e)\left(U^H - U^I\right) \tag{2.4}$$

FOC for previously not careful:

$$\implies C'(e) = -\delta(1-\lambda_{pr})\left(1-\Pi(\dot{e})\right)p'(e)\left(U^H - U^I\right) \tag{2.5}$$

The transition probability will be a function of the aggregate efforts of both the groups $\Pi(\dot{e}_{pc}, \dot{e}_{pr})$. Let us compare the effort levels for the two groups.

$$\frac{-C'(e_{pc})}{p'(e_{pc})\delta(1-\lambda_{pc})(1-\Pi(\dot{e}_{pc},\dot{e}_{pr}))(U^H-U^I)} = \frac{-C'(e_{pr})}{p'(e_{pr})\delta(1-\lambda_{pr})(1-\Pi(\dot{e}_{pc},\dot{e}_{pr}))(U^H-U^I)}$$

$$\implies \frac{-C'(e_{pc})}{p'(e_{pc})(1-\lambda_{pc})} = \frac{-C'(e_{pr})}{p'(e_{pr})(1-\lambda_{pr})}$$

$\implies \frac{C'(e_{pc})(1-\lambda_{pr})}{p'(e_{pc})} = \frac{C'(e_{pr})(1-\lambda_{pc})}{p'(e_{pr})}$

We know that $(1 - \lambda_{pc}) > (1 - \lambda_{pr})$, therefore

$\frac{C'(e_{pc})}{p'(e_{pc})} > \frac{C'(e_{pr})}{p'(e_{pr})}$

We know that $p(e)$ is linear. Therefore $p'(e)$ is a constant for all $e$, $p'(e_{pc}) = p'(e_{pr})$

$\implies C'(e_{pc}) > C'(e_{pr})$

Since $C'() > 0$ and $C''() > 0$ we derive $e^*_{pc} > e^*_{pr}$

# Chapter 3: Neighbors Can Make You Sick: Health Externalities of Dirty Drains and Open Defecation

## 3.1 Introduction

Over a billion people lack access to clean drinking water and over twice as many do not have access to hygienic sanitation facilities (UNDP 2013). Despite a steady decline in open defecation rates over the past two decades in South Asia, India continues to have the largest number of people defecating in the open: 597 million people, about half the population, according to recent estimates (WHO 2014). 1.9 million deaths from diarrheal disease in 2004 are attributable to unsafe water and sanitation, including lack of hygiene (WHO, 2004). In India 80% of diseases are water related: over 4 hundred thousand children die every year due to unsafe drinking water, unsafe water makes 1 in 5 babies ill every fortnight (Sharma, 2006). It is clear that much work needs to be done to meet the Millennium Developmental Goals.

The first order effects of access to clean water, and of personal hygiene and sanitation on health have been well documented (Merrick, 1985; Behrman and Wolfe 1987; Esrey et al. 1991; Lavy et al. 1996; Lee, Rosenweig and Pitt 1997; Jalan and

Ravallion 2003; and Gamper-Rabindran, Khan and Timmins, 2010). Economists have recently begun studying the effects of community hygiene and sanitation such as open defecation (Shah et al 2014; Hammer and Spears 2013; Spears 2012; Christensen et al 2014). Hammers and Spears (2013) use a randomized controlled experiment to estimate the effects of a village-level community sanitation program on child health. They find that the program caused a large average increase in child height. In a related work, Spears (2012) estimates an average effect of Total Sanitation Campaign (TSC)[1] on rural Indian children's health. Matching survey and census data on health outcomes to administrative records and program rules, and by exploiting exogenous variation in the timing of program implementation, Spears finds that the TSC reduced infant mortality and increased children's height. In a follow-up study, Spears and Lamba (2012) find that early life exposure to improved rural sanitation due to the TSC additionally caused an increase in cognitive achievement at age six, using a similar approach to identification.

Another recent work uses a randomized experimental design in rural East Java to evaluate a sanitation intervention consisting of information (to trigger disgust at open defecation) rather than financial assistance (Shah et al 2013). They find that the program significantly increased toilet construction, effected behavioral change amongst households with no private toilets, and had significant impacts on child

[1]This program offered a partial construction subsidy for building household latrines, and most importantly provided for village-level community sanitation mobilization. This was especially encouraged by the Clean Village Prize, a cash incentive to the leaders of villages that eliminate open defecation.

health. Relevant to the context of our study, they find that toilet construction is however more effective at reducing open defecation than behavioral change but was hindered by the lack of financial assistance.

Our paper examines the health externalities of hygiene arising from a complementary network good, drains in the village. We find that the quality of drains have large and significant impact on the incidence of water borne disease. We find that poor quality drains combined with high levels of open defecation, expectedly multiply the health impacts. Importantly, we find evidence that improved drains can lower the exposure and thereby mitigate the impact of fecal contamination from open defecation. Our paper uses a household level dataset and controls for a wide range of correlated variables to evidence for this mechanism linking open defecation with poor health and human capital accumulation. A causal interpretation of the relationship between water-borne disease incidence and neighborhood drain quality depends importantly on the estimated correlation between these two measures being quantitatively robust to conditioning on additional correlates of unobserved factors including information (awareness of water borne disease vectors), beliefs (such as open defecation construed as healthy) and other channels (social capital such as community networks). Our assessment of robustness when we control for battery of observed correlates is in line with Altonji, Elder, and Taber (2005), as we examine whether the estimated correlation is much affected by the inclusion of additional controls that, a priori, should be correlated with neighborhood drain quality through their correlation with unobserved or misspecified variables. If these unobservables are indeed important sources of the observed correlation between health outcomes and neighborhood drain quality, then adding the controls should have a substantial effect on the estimated correlation coefficients. The magnitude and statistical significance of our estimated effect of drain quality on health persists despite the addition of these controls.

Our finding that drains play a key role in determining the water borne disease impact on households is robust to inclusion of several other factors, including reported awareness of water borne disease transmission, oral - fecal route and the importance of safe toilets. Although, further experimental work would be required to unpack the role of the each of the factors in the fecal oral route, this paper provides strong evidence to examine the role of drains in this vector of transmission.

To make a case for the role of improving quality of drains alongside higher access to toilets, we present a simple model of health externalities of households' hygiene and sanitation, showing how the choices of one household affects ill-health incidences of other households. The model incorporates the features from agricultural household models (Bardhan and Udry, 1999) and models of reciprocal externalities (Dasgupta, 1993). Then using micro level survey data of 1,530 households in rural Uttarakhand, India, we show that both household and community hygiene and sanitation are significant inputs in the determination of households' ill-health incidences (i.e. diarrhea, cholera, typhoid, dysentery, worm infestation and jaundice), with the latter having a greater impact than the former, over and above effects attributable to households' socioeconomic status. Our key result is that there is a large health externality of community level sanitation, specifically, quality of drains. Additionally, we explore the determinants of households' hygiene and sanitation, and of water availability inside the house. We document that while households' hygiene and sanitation choices are strongly correlated with their economic status, access to water inside the house, and awareness about the causes of diarrhea, and a household's education, occupation and social status. Access to water is correlated with a household's economic status and the geographical characteristics of the villages. Finally, we discuss the policy implications.

The remainder of this paper is organized as follows. Section 2 presents a simple model of health externalities of households' hygiene and sanitation. Section 3 discusses the context and data including measurements of ill-health of household. In Section 4, we discuss empirical framework and estimation strategy. The results are presented in Section 5. Section 6 explores the factors of households' hygiene and sanitation, and of the availability of water supply. We conclude in Section 7.

## 3.2 Theory

Our theoretical model incorporates features from two kinds of widely used models: agricultural household models (Bardhan and Udry, 1999) and models of reciprocal externalities (Dasgupta, 1993). We assume that there are two identical villagers, A and B. A and B subscripts are used to denote these two villagers. We concentrate on A's choices, and point the resulting externalities these choices by A imply for B. Since villagers are identical, by symmetry the reverse holds for A when B makes choices.

We assume that the villagers enjoy utility arising from consumption of cooked food ($C_F$), consumption of other goods ($C_{Other}$), sickness (S) and leisure time ($t_L$).

$$U = U(C_F, C_{Other}, S, t_L) \tag{3.1}$$

Sickness is assumed to be a function of bacterial exposer (E), consumption of cooked food, and individual characteristics ($Z^i$).

$$S = S(E, C_F, Z^i) \tag{3.2}$$

Bacterial contamination is a complex phenomenon. For simplicity, we assume that bacterial exposure experienced by A is an additively separable function of a baseline level of exposure ($E_0$), water supply inside the house of A ($W_A$), latrine not dependent on water inside A's house ($L_A^{NW}$), and latrine dependent on water inside A's house ($L_A^W$). In addition, bacterial exposure depends on the total level of cleaning of drains in the village, given by $D_A + D_B$, where A pays for $D_A$ and B for $D_B$. Finally, bacterial exposure experienced by A also depends on whether B uses a latrine inside his/her house, whether with water or not. Thus,

$$E_A = E_0 - g1(W_A) - g2(L_A^{NW}) - g3(L_A^W(W_A)) - g4(L_B^{NW}) - g5(L_B^W(W_B)) - g6(D_A + D_B), \tag{3.3}$$

where the g's denote functions. We expect g2 and g3 to have stronger effects than g4 and g5. By symmetry, B has the same function, with subscripts swapped. Also, if $W_A$ is zero, then we would expec g1 to be zero, and similarly for the other functions in (3). If the latrine used by A uses water, then the use of that latrine is facilitated by provision of water supply inside A's house. In writing (3), we are treating water inside the house and the presence of the latrine inside the house as continuous variables whereas they are discrete. However, we will stay with this for the simplicity of the exposition, and when the first order conditions (FOCs) are derived, will indicate how the substance of the FOCs is not different even if the we consider discreteness.

We assume that A and B have two sources of income: wage income and self-production of agricultural goods. We denote time spent working outside by $t_W^O$, and the wage received by $p_W$. We expect $p_W$ to depend on educational characteristics ($Z^E$) and occupation ($Z^O$). We denote time spent working on the villager's own land by $t_W^I$. We expect output on this land, O, to be a function of:

$$O = O(t_W^I k(S), Z^L), \tag{3.4}$$

where k is a shift operator depending on sickness, and $Z^L$ is the land owned. The dependence of the villager's labor productivity on his/her health, is a feature of efficiency wage models (Bardhan and Udry, 1993).

We assume that the villager sells all his/her agricultural output, and together with his/her wage earnings, buys food, other consumables, water supply, latrine and village drain cleaning. Thus the budget constraint, denoting prices by p with suitable subscripts, is:

$$t_W^O p_W + t_W^I p^O = p_F C_F + p_{Other} C_{Other} + p_{water} W + p_L^{NW} L^{NW} + p_L^W L^W + p_D D \tag{3.5}$$

Since water supply inside the house and latrine have important discrete and durable components, their 'prices' in (5) can be thought of as annualized costs. The villager's time constraint is:

$$T = t_L - S - t_W^O - t_W^I \tag{3.6}$$

The villager aims to maximize his/her utility subject to the time and budget constraints. We substitute for $t_L$ from (6) into the utility function, and then maximize the resulting utility subject to the budget constraint. Denoting the Lagrange by J, the FOCs are listed and discussed below.

$$\frac{\partial J}{\partial C_F} = \frac{\partial U}{\partial C_F} + \frac{\partial U}{\partial S}\frac{\partial S}{\partial C_F} - \lambda p_F = 0 \tag{3.7}$$

In (7), the villager gets two kinds of benefits from consuming an extra unit of food: the direct utility from eating and the utility from lower sickness. The cost of the extra unit of food in utility terms is the product of the multiplier and the price of food.

In the case of other consumption, there is only a direct utility benefit, and so FOC:

$$\frac{\partial J}{\partial C_{Other}} = \frac{\partial U}{\partial C_{Other}} - \lambda p_{Other} = 0 \tag{3.8}$$

$$\frac{\partial J}{\partial W_A} = \left[\frac{\partial U}{\partial S} - \frac{\partial U}{\partial t_L} + \lambda \frac{\partial O}{\partial t_W^I}\frac{\partial k}{\partial S}\right]\frac{\partial S}{\partial E}\left[-\frac{\partial g1}{\partial W_A} - \frac{\partial g1}{\partial L_A^W}\frac{\partial L_A^W}{\partial W_A}\right] - \lambda p_{water} = 0 \tag{3.9}$$

In the FOC (9) we see that having water in the house leads to the following benefits through less sickness, a direct utility benefit, greater leisure time, and greater productivity of the villager in agricultural production. The reduction in sickness is through a reduction in bacterial exposure which in turn is through the direct effect of water in the house and the indirect effect of water availability on latrines that use water.

As we have said above, water supply inside the house versus getting water supply inside the house has an important discrete and durable component. Our interest is in tracing the pathways of effects between health and poverty and in embedded externalities. It is easy to see the discrete version of (9), in which the household will go in for the water supply if the benefits exceed the costs. The discrete version of (9) is:

$$\left[\frac{\partial U}{\partial S} - \frac{\partial U}{\partial t_L} + \lambda \frac{\partial O}{\partial t_W^I}\frac{\partial k}{\partial S}\right]\frac{\partial S}{\partial E}\left[-\Delta E1W_A - \Delta E3W_A\right] > XW_A, if\, W_A > 0, \quad (3.10)$$

where $\Delta E1W_A$ denotes the reduction in bacterial contamination due to water supply inside A's house, and $\Delta E3W_A$ denotes the reduction in B due to water supply inside A's house (via encouraging water latrines). Also $XW_A$ denotes the expenditure on $W_A$. For the rest of FOCs, we will treat the discrete choices as continuous.

If A only considers the effect of water supply on his own utility, he/she will ignore the positive externality of water supply inside his/her house on B. This is (since the agents are identical) equal to:

$$\left[\frac{\partial U}{\partial S} - \frac{\partial U}{\partial t_L} + \lambda \frac{\partial O}{\partial t_W^I}\frac{\partial k}{\partial S}\right]\frac{\partial S}{\partial E}\left[-\frac{\partial g5}{\partial L_A^W}\frac{\partial L_A^W}{\partial W_A}\right] \quad (3.11)$$

The increase in latrine use inside A's house by A reduces bacterial exposure of B through the function $g5$ in (11). This lower bacterial exposure reduces B's sickness and affects B's utility directly, through increased leisure and through greater productivity when B works on his/her farm.

The FOC arising out of the choice of latrines is similar to (9), and these choices are also going to generate externalities similar to (11).

$$\frac{\partial J}{\partial L_A^{NW}} = \left[\frac{\partial U}{\partial S} - \frac{\partial U}{\partial t_L} + \lambda \frac{\partial O}{\partial t_W^I}\frac{\partial k}{\partial S}\right]\frac{\partial S}{\partial E}\left[-\frac{\partial g2}{\partial L_A^{NW}}\right] - \lambda p_{LNW} = 0 \quad (3.12)$$

$$\frac{\partial J}{\partial L_A^W} = \left[\frac{\partial U}{\partial S} - \frac{\partial U}{\partial t_L} + \lambda \frac{\partial O}{\partial t_W^I}\frac{\partial k}{\partial S}\right]\frac{\partial S}{\partial E}\left[-\frac{\partial g3}{\partial L_A^W}\right] - \lambda p_{LW} = 0 \qquad (3.13)$$

The FOC for choice of $D_A$ is:

$$\frac{\partial J}{\partial D_A} = \left[\frac{\partial U}{\partial S} - \frac{\partial U}{\partial t_L} + \lambda \frac{\partial O}{\partial t_W^I}\frac{\partial k}{\partial S}\right]\frac{\partial S}{\partial E}\left[-\frac{\partial g6}{\partial D_A}\right] - \lambda p_D = 0 \qquad (3.14)$$

The choice of level of cleaning of drains by a household ($D_A$) that affects the quality of drains, a key channel of transmission as we show in our empirical results. It is far more likely to suffer from sub-optimal provision than that of water supplied in A's house or latrine inside A's house, because A will be tempted to free-ride on B's provision of $D_B$, a tendency that will be strengthened if the number of agents is large.

Finally, we have the conditions relating to choice of how much time is spent in earning wages or in agricultural production.

$$\frac{\partial J}{\partial t_W^O} = -\frac{\partial U}{\partial t_L} + \lambda p_W = 0 \qquad (3.15)$$

In (15) there is a loss of utility from less leisure, while the benefit is income earned.

$$\frac{\partial J}{\partial t_W^I} = -\frac{\partial U}{\partial t_L} + \lambda \left[\frac{\partial O}{\partial t_W^I} k(S)\right] = 0 \qquad (3.16)$$

In (16) the income earned is affected by the level of sickness, and the cost is the loss of utility from reduced leisure.

## 3.3 Context and Data

Uttarakhand is the 27th state of India and was carved out of Uttar Pradesh (geographically the largest state in India) on November 9, 2000. The state has two Divisions (Garhwal and Kumaun), with 13 Districts, which can be grouped into three distinct geographical regions: the High mountain region, the Mid-mountain region and the Terai region. It is spread over an area of 55,845 square kilometers having 78 Tehsils, 95 blocks and 7,227 Gram Panchayats. It has a total of 16,826 inhabitated villages, 86 cities/towns and only five are major cities with population over 100,000. Its population is 8.5 millions with average density of 159 persons per square kilometer, which varies from as high as 612 in Haridwar and 414 in Dehradun districts to as low as 37 in Uttarkashi. 89% of the villages have population less than 500. The decadal population growth rate is 20.41% (against 21.54% for the country) and the infant and maternal mortality rates are 42 and 517 respectively, which are higher than the national averages. The sex ratio in the state is 962 as compared to 933 for the country.

Only half of the state is estimated to be fully covered by functioning water supply schemes. In addition, the state faces severe water shortages. Nearly 30% of the schemes suffer from a decrease in the availability of water, especially during the summer months, because of depletion of water sources. This causes some of the villagers to spend one to three hours per day collecting water for domestic uses. While water-related diseases are a major health problem for the rural areas in the state, particularly for infants and children. For instance, at any given time, 18% of all children suffer from diarrhea. Therefore, the state government prioritized rural water supply and sanitation as a key area of its development agenda in its Tenth Plan (2003-7).

In terms of socioeconomic characteristics, Uttarakhand is not very different from the other states of India. But what distinguishes it from other states of India, is its geographical features wherein 93% of the area of the state is hilly and 63% of the land is covered with forests. Being primarily a hilly state, it has starting disadvantages for the prosperity of agriculture, and easy accessibility of clean drinking water vis-a-vis other states of India. Thus, some of the factors that affect the incidences of ill-health and economic status of households in the state are expected to be distinctively different from the factors of poverty and ill-health incidences in other states.

We use the survey data of 1,530 households from rural regions of Uttarakhand. The data was collected as the part of an exercise to develop a Strategy for Sanitation and Hygiene promotion conducted by The Energy and Resources Institute (TERI), New Delhi, with support from the World Bank. The primary survey involved 39 gram panchayats, the smallest administrative unit at the rural level spread across all thirteen districts of rural Uttarakhand. The 39 gram panchayats (three per district), were selected based on multiple criteria. Gram panchayats were selected from a list of representative gram panchayats provided by State Water and Sanitation Mission. In addition, villages were selected to ensure representation from villages with varying characteristics. The sample villages were also chosen from villages both with and without the Swajal program[2], an earlier the World Bank and the Government of India funded program for ensuring safe water access to some of the villages in the state. More specifically, 12 out of 39 Gram Panchayats were covered under the Swajal program; and 9 out of 39 villages were in plains. A structured questionnaire was used to collect both the quantitative and qualitative data on family characteristics, income and expenditures, poverty status, health, sanitation, and hygiene behavior. The survey was implemented between November 2004 and January 2005.

### 3.3.1 Measures of Household's ill-Health

We use a count measure as our dependent variable: household's incidence of water borne diseases. It captures the household's incidences of ill-health defined as the number of household members with incidents of water borne diseases (i.e. diarrhea, cholera, typhoid, dysentery, worm infestation and jaundice). To arrive at this measure of health at the household-level, each member of the household a value of 1 is assigned if he/she had suffered from any (some or all) of the ailments in the twelve months preceding the survey date. Next, members of the household having suffered from any of the ailments are aggregated. Being a discrete count measure, we use count data models. The estimation equations are specified following with implications from theory.

[2]Swajal program is a World Bank assisted project between 1996-2002 to improve water supply and environmental sanitation services in some of the water scarce regions of the state

### 3.3.2 Measures of community level sanitation

The key empirical contribution of this paper is providing evidence for community level sanitation, particularly evidencing the link between quality of drains and water borne disease incidence.

We construct two measures to analyze the community level negative externalities of poor sanitation practices. Our first measure is a village level average of access to toilets as reported in the household survey. These averages are highly correlated to two other independent surveys conducted in 2001 and 2003[3]. Villages with higher percentage households having access to latrines would correspondingly have lower percentage members practicing open defecation.

Our second measure of community level sanitation is the reported quality of drains around the household. The households had to report their drain quality on a scale going from very dirty to very clean[4]. We construct a binary variable that takes the value of 1 if the a household's neighborhood drainage is reported clean or

[3]Census reports the average at 31% and another sample survey (RGNDWM) in 2003 puts the sanitation coverage at 22% compared to 51% in the survey data used in this paper. Besides the increase in sanitation coverage between the first two surveys due to high rate of toilet construction in the last two years, disparity in the coverage figures may be attributed to the differences in the definition of individual household latrines. The RGNDWM survey includes only sanitary latrines in its coverage data, excluding pit latrines and other latrines, which were included in the Census data

[4]The full scale of options available to the respondents in the survey were: very dirty; dirty; moderate; clean; very clean

very clean[5].

Our measure of village level latrine average, following from our model hypothesizes that contamination load at the village level is a negative externality and affects the average health of all the households in the village. In essence it captures the effect of one household's lack of access to safe toilets, increasing the contamination load on neighbors and other members in the village due to open defecation. Spears (2012) work provides evidence for the interaction of open defecation with population density in its effect of children's health, suggesting negative externalities. Hammer and Spears (2013) randomized a community level sanitation intervention and find similar evidence for spillovers of safe household sanitation practices (owning and using latrine) on other local households.

Since the village level sanitation average would preclude us from using a fixed effects model to control for unobservable factors at the village level, we interact it with the drain quality in our specification testing for interaction between the two community level effects. In addition to allowing us to estimate a fixed effects model, this specification also examines the overall reduction in exposure to contamination, including fecal load, due to clean and safe drains. Clean drains are either fully or partially covered, often lined with cement or concrete, if not piped to prevent seepage and ground water contamination. They are regularly maintained to keep them unclogged and free flowing to dispose waste water. Unclean drains are characterized by poor construction, usually open and unlined channels resulting in seepage into the

[5]We also construct measures of the corollary, a dirty dummy for those households reporting drains being dirty or very dirty.

soil. Combined with poor maintenance, they are often clogged and overflow into the streets[6]. Unclean drains present higher exposure likelihood to fecal contamination as it is open/overflowing and seepage would also lead to ground water contamination.

### 3.3.3 Potential Determinants of Households' ill-Health

The list of potential determinants of household's ill-health are presented in Table 1. It includes household size, poverty status of the household, educational achievements of the head (male or female) of household, household's hygiene behavior, and community hygiene behavior.

We use household size as a control variable because a large household is more likely to have higher number of total ill-health incidences than a small household. The economic status of the household is captured by inclusion of a measure representing the household's poverty status. Households were to asked to identify their poverty status in the survey. Thus poverty status is self-reported by households. In India, poverty is officially linked to a nutritional intake as measured in calories. The Planning Commission of the Government of India defines poverty lines as a per capita monthly expenditure of Rs. 49 for the rural areas and Rs. 57 in urban areas at 1973-74 all-India prices. These poverty lines correspond to a total household per capita expenditure sufficient to provide, in addition to basic non-food items - clothing, transport - a daily intake of 2,400 calories per person in rural areas and 2100 in urban areas (WB, 1997). Individuals who do not meet these calorie norms fall below the poverty line. The Government of India issues differential ration cards

[6]There is a high positive correlation in our data between unclean streets and unclean drains

which entitles households to some government supplies at subsidized prices (e.g. rice, sugar, and Kerosene oil). Poor households, below the poverty line are entitled to other governmental support as well.

One of the key components of human capital endowments of households in the literature is educational achievements of the household head. Many studies including Pritchett and Summers (1996) have shown that the income of an individual is positively associated with his or her educational achievements. Moreover, we can reasonably expect that a household's hygiene behavior is also determined by it's level of education. In particular, a household with an educated (or with higher average level of educational achievement) household head is expected to have better hygiene behavior than a household with an uneducated (or less educated) head. To account for education, we define four dummy variables representing if the head of the household is illiterate (no formal schooling at all), primary school educated, high school educated, and college educated respectively. However, in order to avoid "dummy variable trap" we drop the dummy variable representing household head with no formal schooling. Consequently, marginal effects of included education variables convey the relative contribution of a particular education level compared to no schooling at all.

We measure the household's hygiene practice and sanitation by a variable representing whether the household has access to latrine inside the house. It is a binary dummy variable that takes the value of 1 if the household has access to latrine inside the house; otherwise it takes the value of zero.

Table 2 presents corresponding summary statistics of the defined data characteristics. Note that approximately 59% of the households in the sample are below poverty line (or in poverty status); 39.4% of the household heads are illiterate, 31.2% of the household heads have the primary schooling as their highest education, 22.6% have high school eduation, while only 6.0% of the all household heads have college education. 38% of villages are located in plain terrain. As far as the households' hygiene is concerned, we find from Table 1 that approximately 51% of the households in the village have latrine availability inside their houses, and 41% of the households have water availability inside the house. Regarding community hygiene, we find that on average only 51% of the households in a village have access to latrine inside their houses, and approximately 8% of drains in the village are reported clean.

## 3.4 Empirical Models and Estimation Strategy

Our estimation strategy exploits the variation in reported drain quality around the household as a measure of the externality from the network good - drains around the household. As predicted by our model, there would be undersupply of efforts in keeping the drains clean arising from the public good nature of drains and each household may have incentives to free-ride on provision of efforts by other households to keep the drain network unclogged and flowing. We assume that the reported drain quality capture the average effort of other households connected to the drain network and thereby a measure that captures the health externalities of unclean drains. Our dependent variable of interest is the incidence of water borne diseases in the households and our estimation strategy we control for a variety of channels in the literature that have been documented to cause water borne disease. After the inclusion of these channels and controlling for village level fixed effects, our model specification would identify the effect of reported drain quality on ill health incidence.

The dependent variable being the number of household members reporting from suffering at least one incident of any of the six water borne diseases could go from zero to the maximum number of members in the household. We control for the number of members in the household by including them as an explanatory variable. Since the dependent variable takes discrete values, we naturally estimated poisson specifications, but rejected them in favor of negative binomial models, due to over dispersion in the dependent variable.

The other variable of interest that measures sanitation externalities at the village level is the percentage households in the village with toilet access. We estimate the effect of this variable alongside drain quality variable in the first set of specifications. We drop the "% village toilet" variable from our village fixed effects estimations, as they would not vary within the villages, and only include "neighborhood drain" variable to measure the community level health externalities of poor sanitation practices. Our original specification without fixed effects is as follows:

$$H_{ij} = \beta_0 + \beta_1 * \%\ village\ toilet_j + \beta_2 * Neighborhood\ drain\ clean_{ij} + \beta_3 * HH\ size_i + \tag{3.17}$$

$$\beta 4 * Program\ village_j + \beta_5 * HH\ latrine_{ij} + \beta_6 * Plain\ dummy_j + \beta_7 * HH\ level\ factors_{ij} + \epsilon_i$$

Our primary specification are with village level fixed effects ($\theta_j$) and thereby excludes explanatory variables that do not vary within the village, below:

$$H_{ij} = \beta_0 + \beta_1 * Neighborhood\ drain\ clean_{ij} + \beta_2 * HH\ size_i + \beta_3 * HH\ latrine_{ij} + \beta_4 * HH\ level\ factors_{ij} + \theta_j \qquad (3.18)$$

The household level (HH) factors we include in the original specification besides size of the HH or number of family members, whether drinking water is away from the latrine, whether drinking water is covered and the poverty status of the household. Now, poverty status besides being documented to influence disease incidence through prevention and vulnerability, also needs to be addressed for feedback effects. There are several studies in the health economics and related literature about the simultaneous relationship between poor health and poverty. Poverty affects health status, but in turn poor health lowers the ability to work and therefore lowers income, leading to a vicious cycle of poor health and low incomes. We note that our measure of ill health, water borne disease incidents and not the duration or the gravity of these incidents. Using this measure of incidence mitigates the feedback effect, unlike using length and gravity of sickness, where there might be further more variation between those who are poor and the other households who may be capable of dealing with these sickness episodes swiftly and also reduce the gravity. Nevertheless, we address the possible endogeneity between poverty status and ill health episodes by instrumenting for poverty.

### 3.4.1 Poverty endogenous?

In estimating the regression equation (in 17 &18), we have to address the possibility of the explanatory variable, poverty status, being potentially endogenous.[7] If endogenous, we use the IV estimation procedure to obtain consistent and efficient parameter estimates of the model in (17 &18). Here an additional contribution of our paper is arguing for caste and land ownership as instruments for poverty status in the next section. As our dependent variable, ill health incidence in the household ($H$) is a count variable, we use an Instrumental Variables Poisson model. This model is estimated by GMM methods to correct for the endogeneity of poverty status.

### 3.4.2 Instrument for Poverty Status

The first stage regression for IV strategy is:

$$Poverty\ Status_i^* = \pi_0 + \pi_1 * Caste_i + \pi_2 * X_i + \mu_i \tag{3.19}$$

where $Caste_i$ is the instrumental variable, which takes the value of 1 if the household is identified to be Scheduled Caste or Tribe; otherwise it takes the value 0; and $X_i$

[7] There is large body of empirical literature documenting economic effects of health (Strauss, 1986; Fogel, 1994; Strauss and Thomas, 1998; Glick and Sahn, 1998; Schultz, 1999, 2001, 2002; Thomas and Frankenberg, 2002; Case, Lubotsky and Paxson, 2002; Bloom and Mahal, 1997; Bloom and Sachs, 1998; Bloom and Canning, 2000; Bhargava et al., 2001; Bloom, Canning, and Sevilla, 2001). Using the Health and Retirement Survey (HRS), a multiyear random sample of households in the US, Smith (1999) found people with disease onset tend to draw down on household wealth in a range of 3,620 to 25,371 dollars, depending on onset of severity and income levels.

are other control variables (mainly geography). We argue for a second instrument, the ownership of land by the household. Both the instruments perform jointly and independently as the significant determinant of poverty status in the first stage (over the thumb rule of 10, while also exceeding the Stock-Yogo critical values for multiple instruments).

#### 3.4.2.1 Caste and land dummy

Caste is historically and exogenously determined and in the Indian context widely recognized as influencing social and economic outcomes (Srinivas 1955). Besides, caste and land ownership could be inter related, with a high correlation between belonging to a lower caste[8] and low land ownership. Anderson (2011) uses village level variation in caste dominance (caste owning the majority of land) to identify the trade breakdown in irrigation water across caste groups resulting in higher incomes for low-caste households residing in villages dominated by a low caste. Our argument for exogeneity of caste is based on the fact that one is assigned to a caste grouping by birth (Srinivas 1955; Dumont 1970). Caste is hereditarily transmitted and there is no possibility of individuals or groups migrating to a different caste group (ibid). A stronger claim of the exogeneity of village level variation in caste dominance with regard to economic outcomes in large parts of India today has been previously argued in the economics literature (Banerjee and Somanathan 2000; Besley and Burgess 2000; Anderson 2011). Their claim is based on the his-

[8] We use a binary classification with lower castes belonging to either Scheduled Caste or Scheduled Tribe in this paper

torical record of caste composition and land settlement patterns that have be stable for centuries. Recent work by Kaivan Munshi and Mark Rosenzweig (2005) also evidence for the fact that there is very little caste-based migration in India.

Our sample from Uttarakhand villages have both upper castes (predominantly Rajputs and Brahmins) and lower castes (26%) consisting of several sub groups belonging to SC/ST classification. There is also variation in land ownership within and across the caste classification. In our survey 54% of the lower caste households own land compared to 75% for other castes. The 54% is ownership of some land, but on the intensive margin, of those who own land, other castes own significantly more than the lower caste households.

Poverty status of a household will not influence the caste, as we noted that individuals inherit caste from their parents by birth. Therefore caste is exogenous to poverty status. Caste is likely to affect water borne disease incidence primarily through socio-economic status of a household. If SC/ST households are located in segregated neighborhoods and may have higher exposure to contamination due to proximity this would not satisfy the exclusion restriction. Owning land is associated with higher agricultural income and therefore lower likelihood of BPL status (poverty). We do not expect land ownership to affect water borne disease incidence directly, unless the households owning land are located in neighborhoods that have differential exposure to fecal contamination. There is no evidence for this in our sample and a priori, we do not expect such variation in exposure resulting from land ownership by itself.

The *Poverty Status** is the household's unobserved poverty status, or propensity to be poor. What we observe is a binary variable, *Poverty Status*, indicating whether the household is poor (or in poverty status):

$$PovertyStatus_i = \begin{cases} 0 & \text{if } PovertyStatus_i \leq z \\ 1 & \text{if } PovertyStatus_i > z \end{cases}$$

The results of this regression in Table 2-3 show that *Caste* is statistically significant predictor of *Poverty Status**.

## 3.5 Empirical Findings

### 3.5.1 No fixed effects

Table 3 presents the estimates of impact of neighborhood drain clean dummy and includes "% village toilet", our first primary specification without fixed effects (equation 17). The main estimate of interest are in the first two rows: a large and statistically significant (at 1%) effect. As we discussed earlier, we progressively augment our primary specification with other relevant controls at the household level. Note that including the controls increases the precision on our estimates, particularly inclusion of gender and age of the head of the household[9]. The last two columns have lower observations, as about 100 households could not identify the head of the household,largely because it was not clearly defined within the household. Due to higher precision with the inclusion of controls, our preferred estimates include the full set of household level controls.

[9]Development economics literature has documented women headed households to allocate resources differently from male headed household, resulting to variation to developmental outcomes

### 3.5.2 Village fixed effects

Table 4 presents the estimates of the impact of neighborhood drain clean dummy including fixed effects at the gram panchayat level.[10] One gram panchayat can administer multiple villages, but in our sample, there is little variation within the gram panchayat: 39 gram panchayats contains 46 villages. Standard errors are clustered at the gram panchayat level.

The estimate on the neighborhood drain clean dummy even after the inclusion of fixed effects shows a large negative impact on water borne disease incidents in the household. As expected, the household size control variable shows a positive and significant effect on the number of members reporting ill health episodes. Having an individual household latrine, a key determinant of household health, as expected shows to have a negative effect. Having the drinking water source away from a latrine (10 meters at least) shows up the expected sign. The poor household dummy (reported BPL households) do not seem to be strong predictors of ill-health incidents. As we noted earlier, our dependent variable is defined as number of incidents rather than the gravity of length of each episode, which might explain why poverty is not persistently significant predictor. The coefficients on the controls are in the expected direction (although we are surprised some of them are not significant), and are only shown in Table 3 and 4 for completeness, but not in the later tables as they are not of interest in this paper.

[10]The gram panchayat is the lowest administrative unit with an elected body of officials including the village head (Sarpanch).

To interpret our results in terms of incidence rate, we find that the drain clean dummy has an incident rate of 0.33 times the reference group incidence rate (those with dirty drains). In other words, the dirty drain households have over three times higher risk of getting water borne disease episodes compared to those households reporting clean drains. We understand that this is a large estimate, but related work estimating the impact of open defecation on height and other measures child health find similar range of effects as well. Our finding of large effects we interpret as a call for further study. Another relevant comparison for cost benefit analysis is juxtaposing it with the incidence rate on households having toilets compared to those without toilets. Those with toilets have 0.65 times the incident rate compared to those without. Essentially, having clean drains seem to have bigger impact that having access to own toilets (almost twice as much).

### 3.5.3 Interaction effect

The externalities in our paper, 1) open defecation and 2) dirty drain effects are interlinked, in that clogged and overflowing drains exasperate the problem of open defecation. Ideally, we would have liked to unpack their effects separately, even if a reduced form through a fixed effects model. Since a village level contamination load effect is not amenable in itself to inclusion of village level fixed effects, we exploit the fact that the interaction of the two effects are causal to the level of contamination exposure. Our theoretical model does not directly capture this interaction effect, but implicitly via the differential exposure to contaminants of own and other household latrine conditional on water provision inside the house. We estimate this interaction effect of clean drains with percentage households in the village without access to toilets, presented in Table 5. Here the interpretation is involved, but the results indicate that clean drains mitigate the effect of fecal contamination, despite the levels of open defecation. This is particularly relevant for policies on subsidies, if it is the case that improved drain quality can reduce the burden of open defecation impact [11].

[11]It suggests that a multi pronged strategy is necessitated when addressing the open defecation issue in the developing world. The network nature of the drains and the free riding associated with this public good would imply that rather than just focus on subsidies for individual latrine construction, emphasis should be given to a community or village level subsidy for improving the network goods. The Total Sanitation Campaign program by the Indian government, is a good example of community level incentives. Villages certified as open defecation free receive a trophy and a cash prize. Only 4 percent of all Indian villages have won the prize (Hammer & Spears 2013), but community level incentives/subsidies for improving quality of drains, our results suggest may have significant effects on reducing water borne disease incidents. Such village/community level incentives are crucial, additionally since toilet construction is hindered by the fact that pipelines transporting the cumulatively discharged waste to a safe point needs collective resources. Even pit latrines need to be maintained and cleaned periodically depending on the size of the pit, and assistance/support is required to trucks service villages at an affordable cost. Another option is getting a collective pit based on the size of the neighborhood and technology support to extract methane to power the community streets lights and water pumps.

## 3.6 Robustness Checks

While the results presented in the previous section suggests that the quality of neighborhood drains affect the incidence of water borne disease in the household, we present checks to address some of the concerns that may arise with our empirical strategy. Firstly, we address the concern of endogeneity of poverty and ill health incidence as defined in our study. Second, we present alternative definitions of drain quality, continuous measure of drain quality rather than a clean/dirty dummy. Third, we present alternative model estimations: poisson and OLS for the original specification. Fourth, we use a direct measure of reported open defecation rather than percentage households without toilets.

### 3.6.1 IV estimation

Table 6 presents the IV poisson estimation with poverty instrumented by caste and land dummy. Note that the first stage F statistic is well over the thumb rule of 10 (see rows at the bottom of Table 6), and exceed the Stock-Yogo critical values for multiple instrument estimation (refer to Kleibergen-Paap F statistic). Note that the magnitude of effect on drain clean variable increases across specifications. Also note that when instrumenting for poverty status, the effect of college educated households and the gender of the head of the household continues to have the expected sign and is now significant.

### 3.6.2 Alternative measure of drain quality

To reiterate, the households had to report their drain quality on a scale going from very dirty to very clean[12]. We construct a new "drain dirty" dummy, if the drains were reported very dirty or dirty. If the hypothesis that clean drains (clean, very clean) reduce the incidence of water borne disease, then dirty drains should increase disease incidents. Note that moderate drains were included in the reference category in both these constructs.

The estimates on the dirty drain dummy (see Table 9) produces the corollary effect, an increase in water borne disease incidents: the sign is opposite (as expected) and the significance remains the same. To interpret, the incidence rate increase to 1.91 times the base rate (the group with not dirty drains). Essentially households with dirty drains have twice the water borne disease incidents compared to other households.

Furthermore, as an additional check, we use a continuous measure of drains quality rather than the drain clean dummy. Yet, again the results persist.

### 3.6.3 Alternative estimation: Poisson, OLS

We noted in the preceding section that Poisson model is not suitable for our data. But we present the results here for the sake of comparison with the negative

[12]The full scale of options available to the respondents in the survey were: very dirty; dirty; moderate; clean; very clean

binomial model and also as a robustness check of the results [13].

We present the OLS estimation (in Table 8), and note that the sign and significance on our variables of interest persists.

### 3.6.4 Alternative measure of village level fecal load

The survey asked the households to report the members defecating in the open within the household. We use this measure to construct the percentage members in the sample from the villages reporting open defecation. Since this suffers from the same issue of no within village variation and therefore not amenable to fixed effects, we run this model (see Table 11) without fixed effects (akin to equation 17, results in Table 3). Although we are surprised that the aggregate of reported open defecation does not seem to be significant predictor of water borne disease at the household level (unlike Table 3, where we found negative impact of % village toilet), the sign and significance on the drain clean variable continues. The incidence rate remains about the same on drain clean variable (0.30 times the reference group with moderate or dirty drains), but it is now significant at 1% level.

[13]The goodness of fit test rejected the poisson model in favor, which is the reason we chose to use the Negative Binomial Model. It can be considered as a generalization of Poisson regression since it has the same mean structure as Poisson regression and it has an extra parameter to model the over-dispersion. If the conditional distribution of the outcome variable is over-dispersed, the confidence intervals for the Negative binomial regression are likely to be narrower as compared to those from a Poisson regression model.

## 3.7 Concluding Remarks

In this paper, we throw light on a previously unexamined channel of water borne disease transmission, drain quality, and show evidence for the magnitude of its impact. We find that households reporting clean drains in their neighborhood have about one-third the incidence rate of water borne disease compared to those reporting not clean drains.This large result persists even after controlling for a variety of observable covariates, but the estimated correlation coefficients do not vary substantially. The strong and systematic effect we treat as preliminary evidence of the importance of improving drain quality in consonance with increasing access to sanitation facilities given the externalities associated with neighborhood drain quality and open defecation.

Table 3.1: VARIABLE DEFINITIONS

| **Variables** | **Definition** |
|---|---|
| Household's ill-Health | Number of members in the family with incidence of illness in the last twelve months |
| Poverty Status | Household is below the poverty line |
| Male-Headed Household | Head of the Household is Male |
| Age of Household Head | Age of the household head (in years) |
| Household Size | Total members in the household |
| Caste | Scheduled Caste or Scheduled Tribe Household |
| No Formal Schooling | No Formal Schooling of the household head |
| Primary School | The household head has primary school education |
| High School | The household head has high school education |
| College and Above | The household head has atleast college education |
| Agriculture | The primary occupation of the household is agriculture |
| Casual Labor | The primary occupation of the household is casual labor |
| Services | The primary occupation of the household is Services |
| Others | The primary occupation of the household is Others |
| Land Ownership | Household owns some amound of land |
| Distance to Road | The distance between the household and the main road is greater than 1 km (0.62 mile) |
| Latrine Availability | Household has a latrine in the house |
| Village Latrine Availability | Percentage latrine availability in the village |
| Neighborhood Clean Drain | Neighborhood drainage is clean or is in good sanitary condition |
| Plain | The terrain of the village is plain |
| Swajal Program | The village had the Swajal program |

Table 3.2: SUMMARY STATISTICS

| Variable | Mean | Std. Dev. |
|---|---|---|
| **Measures of ill-Health:** | | |
| Household's ill-Health | 0.211 | 0.554 |
| Household's ill-Health Index | 0.041 | 0.113 |
| **Socioeconomic Characteristics:** | | |
| Poverty Status | 0.578 | 0.494 |
| Male Head of Household (HH) | 0.951 | 0.216 |
| Age of Household Head | 47.003 | 13.842 |
| Household Size | 5.242 | 2.015 |
| Caste | 0.262 | 0.44 |
| No Formal Schooling | 0.394 | 0.489 |
| Primary School | 0.312 | 0.464 |
| High School | 0.226 | 0.418 |
| College or Above | 0.067 | 0.251 |
| Agriculture | 0.324 | 0.468 |
| Casual Labor | 0.263 | 0.441 |
| Services | 0.241 | 0.428 |
| Other | 0.171 | 0.377 |
| Land Ownership | 0.691 | 0.462 |
| Distance to Road | 0.322 | 0.467 |
| **Hygiene Behavior:** | | |
| Latrine Availability | 0.512 | 0.5 |
| Village Latrine Availability | 0.512 | 0.268 |
| Neighborhood Clean Drain | 0.075 | 0.267 |
| Toilet Scheme | 0.205 | 0.404 |
| Water Source away from Latrine | 0.841 | 0.366 |
| Covered Drinking Water | 0.895 | 0.306 |
| Water Availability | 0.41 | 0.492 |
| **Others:** | | |
| Plain | 0.379 | 0.485 |
| Swajal Program | 0.297 | 0.457 |

Table 3.3: Negative Binomial Regression: No fixed effects

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dependent variable: Family ill health incidents | | | | | | |
| % village toilet | -1.050** | -1.010* | -1.023* | -1.000** | -1.089** | -1.135** |
| | (-2.61) | (-2.47) | (-2.55) | (-2.59) | (-2.82) | (-3.02) |
| Neighborhood drain clean | -0.633* | -0.630* | -0.641* | -0.622* | -1.115** | -1.109** |
| | (-2.44) | (-2.37) | (-2.40) | (-2.18) | (-3.06) | (-2.98) |
| Household size | 0.202** | 0.199** | 0.197** | 0.197** | 0.241** | 0.236** |
| | (4.82) | (4.72) | (4.63) | (4.61) | (5.09) | (5.20) |
| Program village (Swajal) | 0.425 | 0.385 | 0.382 | 0.360 | 0.331 | 0.253 |
| | (1.62) | (1.45) | (1.45) | (1.39) | (1.22) | (0.83) |
| HH latrine available | -0.556* | -0.525* | -0.536* | -0.513* | -0.545* | -0.654** |
| | (-2.35) | (-2.27) | (-2.34) | (-2.25) | (-2.26) | (-3.05) |
| Plain dummy | -0.244 | -0.294 | -0.314 | -0.294 | -0.278 | -0.230 |
| | (-1.10) | (-1.28) | (-1.40) | (-1.37) | (-1.21) | (-1.08) |
| Poor household dummy | 0.408* | 0.319+ | 0.336* | 0.292+ | 0.299+ | 0.265 |
| | (2.51) | (1.89) | (2.03) | (1.83) | (1.81) | (1.63) |
| DW source away from latrine | -0.944** | -0.934** | -0.930** | -0.935** | -0.948** | -0.933** |
| | (-2.79) | (-2.86) | (-2.86) | (-2.96) | (-3.23) | (-3.31) |
| Drinking water covered | -0.340+ | -0.338+ | -0.382* | -0.356* | -0.413* | -0.430* |
| | (-1.91) | (-1.94) | (-2.20) | (-2.09) | (-2.10) | (-2.13) |
| Soap washing dummy | | | 0.187 | 0.173 | 0.220 | 0.241 |
| | | | (0.92) | (0.87) | (1.06) | (1.19) |
| Subsidy toilet | | | | | | 0.321 |
| | | | | | | (1.22) |
| Observations | 1530 | 1530 | 1530 | 1530 | 1431 | 1431 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Other controls include occupation dummies, education, age and gender of household head

Table 3.4: Negative Binomial Regression: Gram panchayat fixed effects

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Neighborhood drain clean | -0.869* | -0.859* | -0.867* | -0.837* | -1.105* | -1.104* |
| | (-2.25) | (-2.28) | (-2.29) | (-2.28) | (-2.16) | (-2.16) |
| Household size | 0.182** | 0.186** | 0.184** | 0.184** | 0.222** | 0.222** |
| | (4.34) | (4.37) | (4.28) | (4.17) | (4.67) | (4.67) |
| HH latrine available | -0.397+ | -0.390+ | -0.398+ | -0.413* | -0.436* | -0.429* |
| | (-1.85) | (-1.88) | (-1.91) | (-1.96) | (-1.97) | (-2.01) |
| Poor household dummy | 0.254+ | 0.170 | 0.187 | 0.183 | 0.198 | 0.200 |
| | (1.68) | (1.04) | (1.15) | (1.11) | (1.12) | (1.11) |
| DW source away from latrine | -0.347 | -0.340 | -0.338 | -0.363+ | -0.465+ | -0.464+ |
| | (-1.47) | (-1.53) | (-1.53) | (-1.66) | (-1.91) | (-1.92) |
| Drinking water covered | -0.150 | -0.147 | -0.172 | -0.171 | -0.268 | -0.267 |
| | (-0.81) | (-0.82) | (-0.98) | (-0.98) | (-1.33) | (-1.32) |
| Soap washing dummy | | | 0.152 | 0.125 | 0.121 | 0.120 |
| | | | (0.70) | (0.59) | (0.53) | (0.54) |
| Subsidy toilet | | | | | | -0.0213 |
| | | | | | | (-0.09) |
| GP dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1530 | 1530 | 1530 | 1530 | 1431 | 1431 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Other controls include occupation dummies, education, age and gender of household head

Table 3.5: Interacting % HH's w/o toilet and clean drains (neg. binomial)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Village % no latrine x Drain clean | -2.126** | -2.179** | -2.194** | -2.190** | -2.172** | -2.172** |
| | (-2.95) | (-2.88) | (-2.89) | (-2.98) | (-2.70) | (-2.69) |
| Household size | 0.186** | 0.190** | 0.188** | 0.187** | 0.222** | 0.222** |
| | (4.46) | (4.48) | (4.40) | (4.27) | (4.66) | (4.66) |
| HH latrine available | -0.415+ | -0.407+ | -0.415+ | -0.429* | -0.451* | -0.445* |
| | (-1.89) | (-1.92) | (-1.95) | (-2.00) | (-2.02) | (-2.07) |
| Plain dummy | -2.570** | -2.501** | -0.362* | -0.347* | -2.213** | -2.223** |
| | (-10.68) | (-10.85) | (-2.42) | (-2.42) | (-7.38) | (-6.90) |
| Poor household dummy | 0.255+ | 0.171 | 0.188 | 0.184 | 0.197 | 0.198 |
| | (1.74) | (1.07) | (1.19) | (1.14) | (1.13) | (1.12) |
| DW source away from latrine | Yes | Yes | Yes | Yes | Yes | Yes |
| Drinking water covered | Yes | Yes | Yes | Yes | Yes | Yes |
| Soap washing dummy | | | Yes | Yes | Yes | Yes |
| Subsidy toilet | | | | | | Yes |
| GP dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1530 | 1530 | 1530 | 1530 | 1431 | 1431 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Other controls include occupation dummies, education, age and gender of household head

Table 3.6: Poverty endogenous: Instrumental Variables Poisson model

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Neighborhood drain clean | -1.829** | -1.259* | -1.409* | -1.276+ | -1.792* | -1.846* |
| | (-2.58) | (-1.99) | (-2.11) | (-1.77) | (-2.21) | (-2.24) |
| Household size | 0.386** | 0.400** | 0.399** | 0.451** | 0.497** | 0.522** |
| | (5.19) | (6.25) | (6.18) | (6.27) | (6.16) | (5.83) |
| HH latrine available | -0.241 | -0.362 | -0.345 | -0.529+ | -0.715* | -0.834* |
| | (-0.78) | (-1.19) | (-1.14) | (-1.72) | (-2.27) | (-2.27) |
| Poor household dummy | 1.592* | 0.343 | 0.504 | 0.182 | 0.246 | 0.233 |
| | (2.04) | (0.42) | (0.61) | (0.21) | (0.28) | (0.27) |
| GP dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1530 | 1530 | 1530 | 1530 | 1431 | 1431 |
| First stage F statistic | 56.24 | 36.50 | 29.95 | 26.54 | 26.48 | 26.20 |
| Kleibergen-Paap rk Wald statistic | 118.93 | 77.34 | 63.52 | 56.40 | 56.49 | 55.92 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Stock-Yogo weak ID test critical values: 10% maximal IV size: 19.93; 15%:11.59; 20% 8.75

Other controls included

Table 3.7: Alternative model specification: Poisson with fixed effects

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Neighborhood drain clean | -1.829** | -1.259* | -1.409* | -1.276+ | -1.792* | -1.846* |
| | (-2.58) | (-1.99) | (-2.11) | (-1.77) | (-2.21) | (-2.24) |
| Household size | 0.386** | 0.400** | 0.399** | 0.451** | 0.497** | 0.522** |
| | (5.19) | (6.25) | (6.18) | (6.27) | (6.16) | (5.83) |
| HH latrine available | -0.241 | -0.362 | -0.345 | -0.529+ | -0.715* | -0.834* |
| | (-0.78) | (-1.19) | (-1.14) | (-1.72) | (-2.27) | (-2.27) |
| Poor household dummy | 1.592* | 0.343 | 0.504 | 0.182 | 0.246 | 0.233 |
| | (2.04) | (0.42) | (0.61) | (0.21) | (0.28) | (0.27) |
| DW source away from latrine | -0.557 | -0.764* | -0.726* | -0.757* | -1.168** | -1.177** |
| | (-1.53) | (-2.19) | (-2.08) | (-2.19) | (-3.03) | (-3.05) |
| Drinking water covered | -0.255 | -0.208 | -0.287 | -0.155 | -0.413 | -0.445 |
| | (-0.89) | (-0.81) | (-1.09) | (-0.56) | (-1.38) | (-1.46) |
| Soap washing dummy | | | 0.325 | 0.122 | -0.0306 | -0.0462 |
| | | | (1.17) | (0.42) | (-0.08) | (-0.13) |
| Subsidy toilet | | | | | | 0.268 |
| | | | | | | (0.55) |
| GP dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1530 | 1530 | 1530 | 1530 | 1431 | 1431 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Other controls include occupation dummies, education, age and gender of household head

Table 3.8: Alternative model specification: OLS

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Neighborhood drain clean | -0.229+ | -0.226+ | -0.227+ | -0.225+ | -0.247+ | -0.248+ |
| | (-1.69) | (-1.69) | (-1.69) | (-1.73) | (-1.84) | (-1.83) |
| Household size | 0.0453** | 0.0461** | 0.0457** | 0.0448** | 0.0520** | 0.0519** |
| | (3.65) | (3.65) | (3.62) | (3.54) | (3.55) | (3.55) |
| HH latrine available | -0.115+ | -0.110+ | -0.114+ | -0.117+ | -0.118+ | -0.126+ |
| | (-1.80) | (-1.74) | (-1.72) | (-1.75) | (-1.69) | (-1.92) |
| Poor household dummy | 0.0497 | 0.0285 | 0.0327 | 0.0343 | 0.0374 | 0.0360 |
| | (1.60) | (0.82) | (0.93) | (0.96) | (0.94) | (0.88) |
| DW source away from latrine | -0.0574 | -0.0573 | -0.0561 | -0.0635 | -0.0748 | -0.0757 |
| | (-0.95) | (-0.98) | (-0.97) | (-1.08) | (-1.22) | (-1.24) |
| Drinking water covered | -0.0379 | -0.0332 | -0.0403 | -0.0441 | -0.0634 | -0.0644 |
| | (-0.66) | (-0.57) | (-0.71) | (-0.77) | (-0.92) | (-0.93) |
| Soap washing dummy | | | 0.0415 | 0.0372 | 0.0454 | 0.0462 |
| | | | (0.74) | (0.67) | (0.75) | (0.78) |
| Subsidy toilet | | | | | | 0.0227 |
| | | | | | | (0.33) |
| Observations | 1530 | 1530 | 1530 | 1530 | 1431 | 1431 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Other controls include occupation dummies, education, age and gender of household head

Table 3.9: Model with drain dirty (base: moderate, clean, very clean)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Neighborhood drain dirty | 0.356+ | 0.353* | 0.367* | 0.384* | 0.388* | 0.388* |
| | (1.92) | (1.96) | (2.04) | (2.17) | (2.10) | (2.09) |
| Household size | 0.180** | 0.184** | 0.182** | 0.180** | 0.214** | 0.214** |
| | (4.36) | (4.39) | (4.30) | (4.16) | (4.53) | (4.53) |
| HH latrine available | -0.419+ | -0.411+ | -0.420* | -0.434* | -0.459* | -0.451* |
| | (-1.90) | (-1.93) | (-1.97) | (-2.02) | (-2.07) | (-2.12) |
| Poor household dummy | 0.221 | 0.141 | 0.159 | 0.154 | 0.163 | 0.165 |
| | (1.52) | (0.89) | (1.01) | (0.96) | (0.94) | (0.93) |
| DW source away from latrine | Yes | Yes | Yes | Yes | Yes | Yes |
| Drinking water covered | Yes | Yes | Yes | Yes | Yes | Yes |
| Soap washing dummy | | | Yes | Yes | Yes | Yes |
| Subsidy toilet | | | | | | Yes |
| GP dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1530 | 1530 | 1530 | 1530 | 1431 | 1431 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Other controls include occupation dummies, education, age and gender of household head

Table 3.10: Model with drain quality (1- Very dirty to 5 Very clean)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Family ill health incidents | | | | | | |
| Neighborhood drain quality | -0.218* | -0.225* | -0.226* | -0.225* | -0.280* | -0.281* |
| (range 1 - 5) | (-2.02) | (-2.09) | (-2.09) | (-2.08) | (-2.47) | (-2.46) |
| Household size | 0.165** | 0.169** | 0.168** | 0.165** | 0.195** | 0.193** |
| | (3.88) | (3.93) | (3.86) | (3.73) | (4.13) | (4.15) |
| Program village (Swajal) | -2.038** | 2.002** | 2.008** | 1.975** | -2.002** | -2.054** |
| | (-12.35) | (5.79) | (5.81) | (5.32) | (-10.93) | (-10.30) |
| HH latrine available | -0.318 | -0.313+ | -0.318+ | -0.327+ | -0.343+ | -0.395+ |
| | (-1.60) | (-1.69) | (-1.70) | (-1.78) | (-1.82) | (-1.85) |
| Plain dummy | -3.137** | -3.262** | -3.257** | -3.146** | -2.985** | -2.929** |
| | (-9.01) | (-10.20) | (-10.05) | (-9.21) | (-8.11) | (-8.11) |
| Poor household dummy | 0.225 | 0.155 | 0.162 | 0.151 | 0.175 | 0.164 |
| | (1.40) | (0.89) | (0.93) | (0.87) | (0.93) | (0.87) |
| DW source away from latrine | -0.357 | -0.347 | -0.346 | -0.370 | -0.457+ | -0.462+ |
| | (-1.36) | (-1.43) | (-1.43) | (-1.55) | (-1.74) | (-1.78) |
| Drinking water covered | -0.174 | -0.175 | -0.186 | -0.184 | -0.297 | -0.305 |
| | (-0.95) | (-1.00) | (-1.09) | (-1.08) | (-1.47) | (-1.50) |
| Soap washing dummy | | | 0.0609 | 0.0345 | 0.00441 | 0.0120 |
| | | | (0.29) | (0.17) | (0.02) | (0.05) |
| Subsidy toilet | | | | | | 0.169 |
| | | | | | | (0.87) |
| GP dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1440 | 1440 | 1440 | 1440 | 1343 | 1343 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Other controls include occupation dummies, education, age and gender of household head

Table 3.11: Percentage village members reporting open defecation

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Family ill health incidents | | | | | | |
| Percentage village open defecation | -0.0530 | -0.159 | -0.123 | -0.104 | -0.594 | -0.565 |
| | (-0.08) | (-0.22) | (-0.17) | (-0.15) | (-1.03) | (-1.03) |
| Neighborhood drain clean | -0.697** | -0.691** | -0.701** | -0.680* | -1.176** | -1.172** |
| | (-2.90) | (-2.79) | (-2.82) | (-2.53) | (-3.35) | (-3.27) |
| Household size | 0.203** | 0.200** | 0.198** | 0.198** | 0.242** | 0.238** |
| | (4.79) | (4.71) | (4.62) | (4.60) | (5.19) | (5.33) |
| Program village (Swajal) | 0.209 | 0.171 | 0.167 | 0.148 | 0.0857 | 0.0181 |
| | (0.76) | (0.62) | (0.61) | (0.55) | (0.32) | (0.06) |
| HH latrine available | -0.769** | -0.730** | -0.740** | -0.707** | -0.765** | -0.856** |
| | (-3.21) | (-3.05) | (-3.10) | (-2.95) | (-2.97) | (-3.79) |
| Plain dummy | -0.288 | -0.325 | -0.348 | -0.333 | -0.243 | -0.213 |
| | (-1.01) | (-1.15) | (-1.25) | (-1.24) | (-0.93) | (-0.86) |
| Poor household dummy | 0.402* | 0.301+ | 0.316+ | 0.269 | 0.261 | 0.235 |
| | (2.31) | (1.67) | (1.78) | (1.59) | (1.49) | (1.37) |
| DW source away from latrine | -0.790* | -0.784* | -0.780* | -0.789** | -0.787** | -0.772** |
| | (-2.43) | (-2.50) | (-2.51) | (-2.62) | (-2.79) | (-2.81) |
| Drinking water covered | -0.371* | -0.371* | -0.407* | -0.379* | -0.452* | -0.464* |
| | (-1.97) | (-2.01) | (-2.26) | (-2.16) | (-2.20) | (-2.22) |
| Soap washing dummy | | | 0.159 | 0.145 | 0.196 | 0.212 |
| | | | (0.76) | (0.71) | (0.96) | (1.08) |
| Subsidy toilet | | | | | | 0.251 |
| | | | | | | (0.95) |
| Observations | 1530 | 1530 | 1530 | 1530 | 1431 | 1431 |

$t$ statistics in parentheses, + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Other controls include occupation dummies, education, age and gender of household head

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