Risk and Rationality

Effects of contextual risk and cognitive dissonance on (sexual) incentives

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Abstract

The thesis consists of an introductory part and four self-contained papers.

Paper [I] theoretically analyzes how the level and uncertainty of future prospects affect incentives to abstain from sexual risk taking in the presence of HIV. The results suggest that, for individuals with limited access to HIV treatment, uncertainty of future health may be an important factor driving unsafe sex practices and support the empirical finding of a weak link between sexual behavior, HIV prevalence, and HIV knowledge in poor countries; therefore suggesting that AIDS policy needs to be calibrated in order to fit within different social contexts.

Paper [II] empirically tests the hypothesis derived in paper [I] on young adults in Cape Town, South Africa. In order to adequately measure sexual risk taking we combine a wide range of variables measuring risky sexual behavior such that the maximum information possible is extracted from, and adequate weights are attached to, each measure. This approach differs from studies that commonly use individual measures or arbitrary aggregations. The findings indicate that expected income and health and future uncertainty are significant determinants of current patterns of sexual risk taking. However, the empirical results only provide limited support to a link between expected health and sexual risk taking.

Paper [III] theoretically analyzes effects of affect and defensive denial on incentives to engage in sexual risk taking related to HIV. The theoretical approach incorporates ideas from psychology on decision-making processes and risk evaluation, and ideas from economics on utility maximization. The results of the theoretical analysis suggest that the effect of rationalization of personal risk depends on the risk of being HIV positive. Although rationalization causes excessive risk taking behavior for individuals with a relatively low lifetime risk, it may prevent fatalism among individuals whose lifetime risk of HIV is perceived as overwhelming.

Paper [IV] theoretically analyzes the role of identity conflict for the evolution of female labor supply over time. The results suggest the fear of becoming an outsider in society may have prevented a complete transition of women from housewives to breadwinners. In addition, our analysis shows that not recognizing that the weights attached to different social identities are endogenous may imply that the long-run effects on labor supply of a higher wage may be underestimated.

Keywords: HIV/AIDS, Health risk, Uncertainty, Risk aversion, Self-Control, Time-inconsistency, Cognitive dissonance, Regret, Norms, Social identity.

Acknowledgments

My late grandfather always told me to do things the easy way instead of the hard, in terms of making sure that the proper knowledge was in place before aspiring to do some difficult task. Unlike him, however, who only got half deaf during old age (and then only heard what he wanted to hear), I've been half deaf most of my life. Consequently, I never paid much attention to his advice but rather continued to base my decisions on the strategy to plunge in and hope that I would keep my nose over the surface. Admittedly, leaping into unknown waters may not be such a daring strategy for an experienced swimmer. However, it may present an inexperienced one with some unpleasant surprises.

To be honest, my swimming skills were quite poor upon entering the cliffs of PhD-studies. As with my grandfather's advice, I naturally ignored these facts. Instead I convinced myself that the force was strong in me and happily dove into the murky waters of writing this dissertation. Unsurprisingly, I've had a few involuntary gulps of cold water on the way. Indeed, there have been moments when I seriously thought that I would perish in the waves. Lucky for me, I've had a couple of wonderful people offering moral support, swimming advice and a life-west when things got tough. Needless to say, I would not have made it to the other side if it was not for them.

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Umeå, May 2010
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This thesis consists of an introductory part and four self-contained papers:

[I] Mannberg, A., (2011), Risky Sex in a Risky World: Sexual behavior in a HIV/AIDS environment, Forthcoming in *Scandinavian Journal of Economics*.

[II] Bezabih, M., Mannberg, A. & Visser, M., (2010), Sexual Risk Taking among Young Adults in Cape Town – Effects of Expected Health and Income, Umeå Economic Studies No. 804

[III] Mannberg, A., (2010), Risk and Rationalization – The role of affect and cognitive dissonance for sexual risk taking, Umeå Economic Studies No. 803

[IV] Mannberg, A. & Sjögren, T., (2010), Conflicting Identities & Social Pressure – Effects on the long-run evolution of female labor supply, Umeå Economic Studies No. 805

Paper [I] is reproduced with kind permission from Blackwell Publishing, *Scandinavian Journal of Economics*.

Introduction

How can we explain seemingly irrational engagement in sexual practices that expose individuals to the risk of an HIV infection? The main purpose of this thesis is to address this question. I first started thinking about sexual risk taking in terms of HIV/AIDS when I was writing my master's thesis on macroeconomic consequences of the HIV epidemic in Malawi in 2004. During my stay in the country, and upon doing the background research on the HIV/AIDS epidemic in sub-Saharan Africa, I became both devastated and intrigued. Devastated to see and learn about the magnitude of the epidemic and the consequences on the individual and household level, and intrigued because I could not quite understand why individuals with adequate HIV knowledge engage in sexual behavior that exposes them to the risk of an HIV infection. During the six years that have passed since my stay in Malawi, I have been trying to sort out the underlying mechanisms for sexual risk taking both in terms of what distinguishes the epidemic development in different countries, and in terms of what binds it together. The first three papers of this thesis constitute an attempt to disentangle these mechanisms.

The questions raised in the last paper of this thesis are not related to sexual behavior. Instead, paper [IV] addresses issues related to how social norms and personal behavior affect the development of personal preferences in the long run.

The rest of this introductory essay is outlined as follows: In section 1 a brief overview of the state of the HIV/AIDS epidemic and of sexual risk taking in the presence of HIV is given. Section 2 addresses the issues discussed in paper [I] and [II], and section 3 gives an introduction to the role of affect on sexual decision making. After these two sections a summary of paper [I], [II] and [III] is given. Finally, in section 4 the role of social norms and social identity for the evolution of personal norms is discussed. The section concludes with a summary of paper [IV].

1. HIV/AIDS and sexual risk taking

Since 1990, the global prevalence of HIV has increased more than threefold. According to UNAIDS (2009), 2.7 million new HIV infections occurred globally in 2008. In the same year, 2 million individuals died of AIDS related diseases, whilst an estimated 33.4 million were still living with HIV.

Poor regions in general and sub-Saharan Africa in particular continue to carry a disproportionally heavy burden in terms of HIV victims; in 2008, 67 percent of all HIV infections in the world were found in sub-Saharan Africa. During the same year, 68 percent of new adult infections, 91 percent of HIV infections in children, and 72 percent of all AIDS related deaths occurred in sub-Saharan Africa.[1]

On the positive side, the development of antiretroviral (ARV) drugs and the combination of different ARV drugs into Highly Active Antiretroviral Treatment (HAART) have substantially increased the life length of HIV-positive individuals.[2] In addition, access to ARV treatment in low and middle income countries increased ten-fold between 2003 and 2008. Similarly, reports on HIV knowledge are encouraging. For example, surveys in Burundi. Kenya, Zambia and Tanzania suggest a nearly universal awareness of HIV.[3] However, although ARV coverage rates and HIV related knowledge have improved, a large share of HIV positive individuals in poor countries does not have access to HIV treatment.[4] In addition, myths and misinformation[5] about HIV still prevail.[6] It should also be

[1] UNAIDS (2009).

[2] For rich countries, reduced mortality has been documented on the population level. However, in poor countries results are only available from small sample studies: In Malawi, access to ARV reduced AIDS related mortality by 35 percent during the first 8 months of the intervention (Jahn *et al*., 2008). Likewise, in Kwa-Zulu Natal, the introduction of ARV:s reduced AIDS related mortality among women by 22 percent and among men by 29 percent (Herbst *et al.,* 2009).

[3] UNAIDS, (2009); Caldwell, (1999); see also, e.g. Varga, (2001), Williams *et al.,* (2003).

[4] The percentage of pregnant women receiving antiretroviral treatment has improved substantially over that past couple of years. In many countries with reports of coverage rates, numbers are as high as 80 percent. However, although the trend in antiretroviral treatment distribution in poor countries has been positive, the number of new HIV infections each year outnumbers the increase in individuals on ARVs, by 2.5 to 1; See e.g. UNAIDS (2008); Rao *et al.* (2006).

[5] See e.g. the misconception that HIV is transmitted via mosquito bites, that condoms can carry the virus and that having sex with virgins can cure the disease.

[6] See e.g. UNAIDS (2009); Campbell (1997); Tillotson & Maharaj (2001).

noted that, although important breakthroughs have been achieved, there is to date no cure for HIV and although HIV testing in sub-Saharan Africa has increased substantially, a majority of the population remain undiagnosed. For example, although HIV testing more than doubled in Kenya between 2003 and 2007, 83 percent of Kenyans living with HIV do not know their sero-status.[7]

In sub-Saharan Africa, the main mode of transmission of HIV is heterosexual sex. Now, heterosexual sex is a relatively inefficient mode of transmission of HIV.[8] However, sub-Saharan Africa may be particularly vulnerable to HIV for several reasons: First, the relatively high prevalence of untreated Sexually Transmitted Infections (STI:s) and traditions such as dry sex[9] makes the transmission rate of HIV during vaginal intercourse substantially higher in sub-Saharan Africa than elsewhere.[10] Second, the social acceptance of simultaneous sex partners in combination with a low degree of condom use increases the risk of an HIV transmission.[11] For example, in Lesotho, 24 percent of adults have simultaneous sex partners, and in Uganda the percentage of men reporting having multiple sex partners *rose* from 24 percent in 2001 to 29 percent in 2005.[12]

Although interventions have resulted in improvements in HIV knowledge, increased condom use and reduced number of sexual partners, the lack of

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[7] UNAIDS, (2009)

[8] The risk of an HIV infection via unprotected vaginal sex has been estimated to 0.0001, see e.g., Gray *et al.,* (2001).

[9] Dry sex is a method for tightening the female genitalia by the use of herbs or synthetics. Since dry mucous membrane are vulnerable to cuts and sores, the tradition increases the risk of HIV transmission.

[10] See e.g. Oster (2005); Campbell (1997); Buvé *et al.* (2001); Morison *et al.* (2001); Wojcicki and Malala (2001).

[11] The reason for why having multiple sex partners is associated with such a high risk stems from a change in virus activity during the incubation of AIDS. As HIV enters the body, the virus is very active in terms of multiplying itself. This makes the individual highly contagious. However, as the virus attacks the body, the immune system tries to fight back. Although the human immune system is unable to completely eliminate HIV, it does bring down the viral load, and thus the degree of contagiousness. However, since HIV specifically attacks the immune system viral loads will eventually begin to soar again, thus making the individual once again highly contagious. For individuals with simultaneous sex partners, this implies that if one individual contracts HIV the likelihood of transmitting the disease is much higher than in cultures where individual have sequential sex partners, see e.g., Piasani (2008).

[12] For example, in Lesotho, 24 percent of adults have multiple sex partners, and in Uganda the percentage of men reporting having multiple sex partners rose from 24 percent in 2001 to 29 percent in 2005 (UNAIDS, 2009).

behavioral change in high risk groups effectively means that there are very few signs of a significant reduction in HIV prevalence in sub-Saharan Africa.[13] Indeed, in spite of the risk of an HIV infection, the price of unprotected sex has been found to be substantially *higher* than that of safe sex in areas where HIV prevalence rates among commercial sex workers (CSW's) can reach 70 percent,[14] and in Burundi, only 1 in 5 people report using condoms during commercial sex.[15] Perhaps most puzzling is the high degree of sexual risk taking in groups where HIV knowledge is not necessarily inadequate.[16]

According to economic theory, individuals form decisions by equating marginal costs to marginal benefits of given alternatives. Applied on sexual behavior, an economist would thus expect an individual to use all information available to him/her with regards to marginal costs and benefits of unprotected casual sex and choose the amount of 'risky sex' that maximizes utility. Using this approach, an increase in HIV prevalence should intuitively increase the marginal cost of unsafe sex and thus increase incentives to abstain from risky activities. This implies that, as HIV prevalence and HIV knowledge levels increase, we would expect to see a change in behavior towards safer sex practices and thus to a reduction in the spread of HIV.[17] In many countries, this description fit the data

[13] Lagarde *et al.*, (2001) estimate condom coverage at 27-31 percent for men and 11-17 percent for women in a number of highly affected cities in sub-Saharan Africa. In Zambia, the share of unprotected sexual acts with non-cohabiting partners actually increased during the late 1990s. See also UNAIDS, (2009); Caldwell, (1999, 2000); Bloom *et al.* (2000); Hearst & Chen (2004); Mwaluko *et al.* (2003).

[14] Robinson & Yeh (2008) estimate the compensating differential for condom-free sex to 7.8% for CSWs in Busia District in Kenya, while Rao *et al.* (2003) find a 66% price differential for CSWs in Calcutta. Sociological case studies have reported prices for unprotected sex that are up to four times those for sex with condoms; see e.g. Abdool-Karim, *et al.* (1995); Pettifor *et al.* (2000); Morison *et al.* (2001). See also, e.g. Campbell (1997); Williams *et al.* (2003); Caldwell (1999); Varga (2001).

[15] UNAIDS (2009).

[16] Studies on South African miners (one of the most AIDS susceptible groups) suggest that risky sex prevails in spite of free access to condoms and a sufficient knowledge about HIV (Campbell, 1997).

[17] It should also be noted that ARV treatment have been suggested as a potential explanation to persistent sexual risk taking and high HIV prevalence rates. The intuition behind this argument is that, since ARV treatment increases the life length of HIV positive individuals, the opportunities to infect other individuals also increase. In addition, since ARV reduces viral load, it reduces the risk of contracting the virus from a HIV positive individual *and* the potential cost of an infection. Hence, the availability of ARV treatment may actually spur sexual risk taking behavior and thereby increase HIV incidence. Indeed, a number of empirical results suggest that this is the case, at least in the United States (Lakdawalla *et al.,* 2006; Mechoulan, 2007; UNAIDS, 2009).

relatively well.[18] However, the simple cost-benefit approach to sexual behavior can neither explain why HIV intervention has been relatively successful within some groups, such as the gay community in industrialized countries (at least until recently), but not in others,[19] nor why increased levels of HIV awareness has not been accompanied by larger reductions in sexual risk taking.[20]

2. Expectations of future prospects and sexual risk taking

> *"Interviewer: Why is it that men think about pleasure first before thinking about their health?*
> *Informant: The dangers and risks of the job we are doing are such that no one can afford to be motivated with life - so the only thing that motivates us is pleasure"* (Interview with a South African mineworker, Campbell, 1997, p. 277)

During my stay in Malawi 2004, I became painfully aware of how the high degree of uncertainty of the future affected both individuals' ability and incentives to plan for the future. I especially remember a young carpenter who, after having a good day, went out and used all his hard earned money for alcohol. When I asked him why he didn't use the money to invest in better tools he simply replied: "Why should I? I may get robbed or hit by a car tomorrow". After my stay in Malawi, I started to think that perhaps the same reasoning could be applied on sexual behavior.

Paper [I] and [II] address issues related to how uncertainty of the future affects incentives to abstain from sexual risk taking. In these papers, I argue that persistent sexual risk taking may reflect a rational decision process if future health is uncertain. The relatively long incubation time of AIDS[21] implies that while the benefits of unsafe sex occur in the present, the cost does not occur until in a

[18] e.g. Philipson & Posner (1993; 1995); Schroeder & Rojas (2002).
[19] For example mine workers, refugees, soldiers and migrant workers
[20] See e.g., Caldwell (1999).
[21] 9-11 years without treatment; see e.g. UNAIDS (2008).

distant future. In addition, although the benefit is almost certain, the cost is most uncertain: not all sex partners are HIV positive and even if they are, the probability of an HIV infection is still just a probability. Similarly, since the future is always to some extent uncertain, the potential benefit of abstaining from pleasurable, but risky, activities is also uncertain.

For risk averse individuals, the more uncertain the future is the lower will the expected utility of experiencing that future be. Indeed, the tangible presence of risk and uncertainty of future prospects is a common feature among many HIV susceptible populations. For example, miners in sub-Saharan Africa face daily threats of mutilation or death in work related accidents. Similarly, WHO & UNAIDS (2002) reports that HIV prevalence soars in times of civic unrest: In Sierra Leone, estimated HIV prevalence surmounted to 60-70 percent among soldiers in 2002 and HIV frequencies among prostitutes increased from 26.7 percent to 70.6 during the civil war.[22]

The analysis of investment decisions under uncertainty of the future has a relatively long history in economics. Prominent examples include North's (1990) theory of institutions, which suggests that uncertainty of the future may have detrimental effects on investments in human and physical capital and thus hamper economic growth. Similarly, Brock *et al.,* (1982) argue that uncertainty about prices on foreign markets makes firms prone to focus on the domestic market even if the expected profit from selling abroad is higher, and Johansson & Löfgren (1985) and Koskela (1989) suggest that uncertainty of future prices increases incentives to harvest forest earlier than would be optimal without uncertainty. Applied on health related behavior, Dow *et al.*, (1999) show that immunization programs, by reducing pressing mortality risks, increase incentives to invest in health. Similarly, but not explicitly focused on uncertainty, Oster (2007) shows that life expectancy is inversely correlated with number of sex partners.

[22] UNAIDS & WHO (2002), see also e.g., Benz (2005).

The argument put forward in paper [I] and paper [II] is that, for individuals living in areas where the risk of dying of something else than HIV is relatively high, the return to investments in health, such as abstaining from unsafe sex, is uncertain. Consequently, the presence of uncertainty of future health may make it rational for risk averse individuals to act shortsightedly.

Admittedly, it may be argued that the indulgence in sexual risk taking behavior is a consequence of hyperbolic discounting.[23] However, hyperbolic discounting is likely to exist in all cultures and there is little evidence that HIV susceptible groups have more hyperbolic utility functions than others. Hence, although the existence of present bias preferences is probably a part of the problem, the first and second paper in this thesis does not focus on this aspect of sexual risk taking. Instead, paper [I] and [II] focus on the mechanism that differentiates the situation in countries with a soaring HIV epidemic from the situation in countries where HIV prevalence have remained at low levels: expectations of future prospects.

2.1 Measuring sexual risk taking

The second paper in this thesis empirically assesses the link between expectations of future prospects and sexual risk taking among young adults in Cape Town, South Africa.[24] In addition to the focus on uncertainty of future health, the empirical approach in paper [II] differs from previous research with regards to two aspects: 1) instead of using a single indicator we use a combined measure of sexual risk taking and, 2) instead of focusing on sexually active individuals we control for the potential selection mechanism underlying the decision to enter the sexual market.

[23] See e.g. O'Donoghue & Rabin (2000).

[24] The Cape Area Panel Study (CAPS) Waves 1-2-3 were collected between 2002 and 2005 by the University of Cape Town and the University of Michigan, with funding provided by the US National Institute for Child Health and Human Development and the Andrew W. Mellon Foundation. Wave 4 was collected in 2006 by the University of Cape Town, University of Michigan and Princeton University. Major funding for Wave 4 was provided by the National Institute on Aging through a grant to Princeton University, in addition to funding provided by NICHD through the University of Michigan.

In previous research, sexual risk taking has commonly been measured with a single variable, such as age of first sex, condom use or number of sex partners.[25] In paper [II], we argue that these variables in isolation may not give an adequate measure of sexual risk taking. Although condoms may admittedly fall off or break during sexual intercourse, it is not clear that individuals with relatively many sex partners that use condoms consistently engage in more risk than individuals with relatively few sex partners with whom condoms are used inconsistently. However, focusing only on sexual *activity* implies that we would make this assumption. Similarly, focusing only on condom use may give a distorted picture of sexual risk taking if the *type of relationship* is not considered. Finally, although having sex at a young age may imply that the individual will have relatively more sex partners in life than an individual that abstains from sex until older age, it may also reflect a culture where the social custom is to get married (and stay married) at a young age.

Hence, one of the main challenges for testing the hypothesis derived in paper [I] was to construct an adequate measure of sexual risk taking. This challenge was made more difficult due to the lack of previous theoretical and empirical research on the issue. The approach taken in paper [II] draws on a series of psychological studies by van der Velde & van der Pligt (1991), van der Velde *et al.,* (1994) and van der Velde *et al.,* (2002). In these studies, information concerning condom use, number of sexual partners and type of partner is combined in order to measure sexual risk taking among high risk individuals in Amsterdam.[26] The approach taken in paper [II] constitutes an effort to extend the measure used in these studies, by empirically estimating the weights on each sexual risk indicator. This

[25] See e.g. Dinkelman *et al.* (2007); Oster (2007).

[26] The measure used in these studies was achieved by multiplying the type (i.e. private or prostitution partner) and number of sexual partners with the degree of condom use (past 4 months preceding the interview). In addition, information related to the frequency of vaginal intercourse with each partner was included in the measure. The measure of condom use and frequency of vaginal intercourse was measured on ordinal scale (from never to always). The measure was constructed by transforming the Likert scales into multipliers. For example: A participant who had 5 private partners with whom the participant often had vaginal intercourse and with whom condoms were never used, and 5 prostitution partners with whom the participant always had vaginal intercourse while used condoms half of the time received the risk score: (5*0.75*1)+(5*1*0.5).

was achieved by conducting a factor analysis for ordinal variables and estimating the latent factor scores for our hypothesized variable sexual risk taking in LISREL 8.80.[27]

The second challenge for assessing the effects of health related uncertainty concerns how to deal with individuals not yet sexually active. The decision to abstain from sex altogether may reflect a strategy to avoid an HIV infection. Hence, excluding sexually inactive individuals from the analysis may give biased results. Accordingly, in the empirical model in paper [II] we control for selection into the sexual market.

Although the results of the empirical analysis in paper [II] lend some support to the hypothesis derived in paper [I], some of the results are mystifying and several questions remain unanswered. For example, expected health, which we proxy by subjective life expectancy, should intuitively be closely related to sexual risk taking. According to the theoretical hypothesis derived in paper [I] a lower level of expected health reduces the expected value of abstaining from unprotected casual sex. In addition, there may also be a relationship going the other way around: A high degree of sexual risk taking should intuitively reduce the expected level of future health. However, our results show that life expectancy is a relatively poor predictor of our measure of sexual risk taking, and we cannot reject exogeneity of the variable. How can this be?

First, note that regardless of whether the future is uncertain or not, the marginal cost associated with HIV risk does not only depend on the per-coital risk of an HIV infection, it also depends on the probability of being HIV positive since, disregarding altruistic objectives, an HIV positive individual has little to lose from having unprotected sex.[28] As was mentioned above, many individuals (especially in poor countries) remain untested for HIV. For these individuals, an increase in HIV prevalence thus implies two things: 1) that the per-coital risk of

[27] Jöreskog *et al* (2006).

[28] Admittedly, unprotected sex for an HIV positive individual is still risky since the individual may acquire another STI which in turns reduces the immune system's ability to keep maintain the viral load at low levels. See, e.g., Piasani (2008).

an HIV infection is greater and, 2) that the risk of already being HIV positive is greater.[29] This implies that, at sufficiently high perceived risk of HIV, individuals may deem the likelihood of already being infected with the virus to be sufficiently high to make abstaining from risky sex relatively meaningless.

Second, although bringing uncertainty into the picture perhaps provide some answers to differences in the spread of HIV between countries and groups of individuals it doesn't fully explain why individuals all over the world engage in sexual risk taking although we know we shouldn't. Uncertainty of the future cannot explain the fact that although most individuals *overestimate* the risk of an HIV infection of an unprotected sexual act with a HIV positive individual, they nonetheless tend to *underestimate* their personal risk of HIV.[30] Could it be that individuals that engage in sexual risk taking also *overestimate* their life expectancy for the same reasons? In that case, what are those reasons?

Paper [III] attempts to provide some answers to these issues, in terms of modeling effects of sexual arousal on decision making capacity and how the desire to maintain psychological wellbeing may induce incentives to underestimate personal HIV risk.

3. Emotions and rationalization of past behavior

3.1 Visceral cues and time-inconsistent behavior

Emotions may have both beneficiary and detrimental effect on decision making capacity. According to Lowenstein & Lerner (2003), emotions of low and moderate levels of intensity play a largely advisory role in terms of informing the individual about his or her preferences. However, at higher levels of intensity, physical arousal may block a systematic evaluation of the situation and of the potential consequences of a given behavior. In addition, the immediate emotion experienced at the time of the decision also indirectly impact decision making by

[29] Kremer (1996).
[30] See e.g., Bauman & Siegel (1987); van der Velde & van der Pligt (1991); van der Pligt, *et al.* (1993); Van der Velde *et al.* (2002).

changing the decision maker's expectations about the probability and desirability of potential outcomes of the decision. In general, happy moods have been shown to favor a decision making process based on heuristics, to create an optimistic bias of the probability of positive outcomes and induce an underestimation of the negativity of emotions experienced due to a negative outcome. Similarly, strong negative emotions such as fear have been shown to induce a reliance on heuristics.[31]

The decision to use condoms or not are usually taken at a state of heightened physical arousal. Consequently, if preferences in the heat of the moment differ from preferences in colder states, it may not be entirely possible for an individual to act in accordance with his or her optimal life plan. The question that we have to ask ourselves is thus whether individuals truly can assess the marginal costs and benefits related to unsafe sex. Since decisions related to sexual behavior are usually taken in a positive mood, we may expect the decision to use condoms or not to be based on rules of thumb rather than on a systematic evaluation of marginal costs and benefits and that the probability of an HIV infection may be underestimated. Similarly, if this behavior later on induces fear of an HIV infection (or any other type of STI), we may once again expect that the individual experiencing this emotion will engage in heuristic based decision making.

So how can we understand how rational individuals deal with the presence of strong emotions? According to Ainslie (1974; 1975; 2001) the human mind can be described as a set of different interests which differ with respect to the time-horizon for need-fulfillment. For example, consider an individual with the desire to have a well trained and healthy body. Actions that work towards satisfying this interest clearly have a long term pay-off. However, upon coming home from work the same individual may have the short term interest to dodge in front of the TV instead of heading out for a 10 km run. In other words, the individual experiences a conflict of interests. According to Ainslie, the outcome of the decision process depends on the relative bargaining power of each interest.

[31] See e.g. Johnson & Tversky (1983); Griffin *et al.* (1999); Bodenhausen, *et al.* (1994); Forgas (1998); Tiedens & Linton (2001).

Bargaining power in turn, depends on the proximity of need-fulfillment, how benefits and costs are bundled, and on contextual cues.

According to Loewenstein (1996), states of heightened physical arousal make present benefits more salient and future costs less distinct, and may therefore give rise to time-inconsistent preferences.[32] Indeed, Loewenstein goes as far as arguing that visceral factors, such as sexual arousal, hunger or fear, tend to 'crowd out' virtually all goals other than that of mitigating the visceral factor, and thus to hamper the long term interests' ability to exert power. This hypothesis is supported by a number of empirical studies. For example, in a series of experiments, Ditto *et al.* (2006) found that respondents induced to experience sexual arousal or hunger were significantly more likely to act myopically (i.e. being more positive towards unprotected sex in a sexually aroused state and accepting a smaller immediate reward when exposed to the smell of chocolate chip cookies) than respondents not exposed to visceral cues. Similarly, Ariely and Loewenstein (2006) found that experimentally induced sexual arousal was associated with a higher degree of acceptance of norm-violating and risky behaviors that increased the likelihood of having sex.

Time-inconsistent behavior in terms of hyperbolic utility functions is today relatively standard procedure in economics.[33] However, although the assumption of hyperbolic discounting has been well motivated by state-dependent utility or by modeling the individual as a sequence of temporal selves with different preferences, it was not until relatively recently that the analysis of the *mechanisms* underlying the excess weight on present utility was addressed in economic papers. Loewenstein (1996) and Loewenstein & O'Donoghue (2007), argue that the human brain can be modeled as consisting of two systems: an affective/short-sighted, and a cognitive/forward-looking system. Visceral cues, such as hunger or sexual arousal, activates the affective system of the brain and makes decisions

[32] See e.g., Ainslie (1974; 1975; 2001); Loewenstein (1996); O'Donoghue & Rabin (2000); Loewenstein & O'Donoghue (2007); Fudenberg & Levine (2006); Gul & Pesendorfer (2001; 2005).
[33] See: e.g. Strotz (1955-1956); Loewenstein & Prelec (1992); Laibson (1997); Laibson (1998); O'Donoghue & Rabin (1999; 2001).

consistent with long term goals more costly (i.e. resisting the temptation to eat sweets is more difficult when exposed to the lovely scent of a newly baked bun than when not exposed to the scent). If the cognitive cost of resisting the temptation is sufficiently high, the individual may thus indulge in behavior that is later regretted.[34]

3.2 Defensive denial and cognitive dissonance

> *"People think: we are not simple reinforcement machines. And, because we think, we frequently get ourselves into a tangled muddle of self-justification, denial, and distortion."* (Aronson, 1992, p. 304)

Although the presence of emotions may explain how time-inconsistent behavior occurs, much of the research conducted within the field of economics have not studied the *consequences* of inconsistent behavior on attitudes and preferences. In other words, very little economic research has focused on the question: what happens inside an individual upon realizing that long term goals (perhaps closely associated with the individual's actual or ideal self-image) has been violated?

The aim of *Cognitive dissonance theory*[35] is to answer this important question. The theory predicts that holding two cognitions that are psychologically inconsistent will give rise to a negative physiological arousal (cognitive dissonance). According to Festinger (1957), the arousal caused by the psychological inconsistency is sufficiently uncomfortable to motivate people to reduce the conflict by changing one of the cognitive elements so that they fit better together.[36] Festinger's original theory predicted that any two inconsistent cognitions would give rise to dissonance and thus to incentives to change either cognition. However, as shown by Aronson (1968), dissonance theory makes its strongest predictions when a person's freely chosen behavior violates an important element of the self-concept. Accordingly, Aronson's revised version of cognitive dissonance theory suggests

[34] See also, e.g., Fudenberg & Levine (2006); Gul & Persendorfer (2001).
[35] Festinger, (1957), Aronson, (1968; 1992)
[36] Aronson, (1992)

that only cognitions that are inconsistent with the individual's self-concept will give rise to aversive physical arousal.[37] Aronson (1992) further suggests that most individuals strive for three things: 1) to preserve a consistent, stable, predictable sense of self, 2) to preserve a competent sense of self, and 3) to preserve a morally good sense of self. Hence, what makes an individual to perform a dissonance reducing behavior depends on whether the individual has performed something that a) surprises him, b) questions his intelligence, or c) makes him feel guilty.[38] Aronson (1989) gives an illustrative example: Consider a smoker that receives information about the relationship between smoking and cancer. The information about cancer and smoking presents him/her with two inconsistent cognitions: a) information of the dangers of smoking, and b) the knowledge that he/she is engaging in this potentially lethal habit. In combination these two cognitions clearly questions the individual's intelligence. The individual can handle this information in mainly two ways; 1) by a change of behavior (quit smoking), or 2) by discrediting the information given. In Aronson's own words: *"When a person reduces dissonance, he defends his ego, and keeps a positive self-image. But self-justification can reach startling extremes: people will ignore danger in order to avoid dissonance, even when that ignorance causes their death"* (Aronson, 1989, p.135). Dissonance theory further suggests that although people tend to use all available information *before* making a decision, they tend to seek reassurance that they did the right thing *after* the decision has been made. In order to do so they either seek information that supports the rightness of their behavior, or try to rationalize their behavior by a benevolent interpretation of the information already in their heads.[39]

Sexual risk taking behavior in areas where the risk of an HIV infection is significant clearly questions the individual's perception of being an intelligent and competent person. In addition, given the risk of being HIV positive, continuing to have unprotected sex with potentially *uninfected* individuals questions the self-image of being morally good. Hence, if an individual engages in risky sex, due to

[37] Thibodeau & Aronson, (1992)
[38] Aronson, (1992)
[39] Aronson (1989).

for example the reasons discussed in the previous section, we may expect that this individual will experience cognitive dissonance and thus have incentives to rationalize behavior in order to maintain a positive and consistent self-concept. This hypothesis is supported by a number of empirical studies: Gerrard, *et al.,* (2000) asked adolescents to report risk behaviors and the extent to which concerns about health and safety would influence those behaviors in the future. The results showed that the more the adolescent reported concerns, the less likely they were to engage in risk behavior. However, once they initiated in risky behaviors they entered into a 'denial-like' process in terms of avoiding thinking about the danger associated with that behavior. According to Gerrard *et al.,* (2000) the motivation behind the tendency to minimize the perception of risk and severity of the outcome is the justification that one is normal and rational. Similarly, Benthin *et al.*, (1995) found that respondents who used condoms were more likely to associate positive concepts and positive outcomes with condoms, and less likely to associate negative concepts and negative outcomes.

The theoretical model presented in paper [III] attempts to incorporate ideas relating to the role of emotions concerning both decision making capacity and the tendency to rationalize behavior in order to maintain a positive and consistent self-image. The theoretical approach relates most closely to the work of Akerlof and Dickens (1982), who in accordance with the ideas of Aronson (1968; 1992) assume that individuals that accept being exposed to health risks will experience aversive arousal related to both fear and a questioning of their self-image as an intelligent person. In the setting of their theoretical model, rationalization is modeled as deliberately (but perhaps unconsciously) understating the risk taken.

Akerlof and Dickens model the exposure to risk as to a large extent exogenously given. Since the decision to use condoms in most circumstances is endogenous, the approach taken in Paper [III] differs from the Akorelof and Dickens (1982) approach in terms of the assumption related to the exogeneity of risk exposure. Instead, the approach taken to model the effect of sexual arousal is closely related to the work of Loewenstein & O'Donoghue (2007) and

O'Donoghue & Rabin (2000). However, whereas the Loewenstein & O'Donoghue (2007) and O'Donoghue & Rabin (2000) papers end with the analysis of how affect may give rise to excessive sexual risk taking, the model presented in paper [III] continues with an analysis of how affect induced myopia creates incentives to adjust long run preferences and behavior.

3.3 A final remark related to sexual risk taking

In the theoretical models presented in this thesis, individuals are assumed to remain ignorant about their HIV status. This is naturally a relatively stark assumption. However, as mentioned in section 1, a majority of individuals in HIV susceptible groups actually do remain undiagnosed. To some extent, the low level of HIV testing is explained by insufficient supply of affordable HIV tests. However, I also find it intuitive to apply the reasoning from the previous discussion on the decision to test for HIV. Since HIV is still not curable and effective treatment is not universally available, and since being HIV positive in many instances is associated with social stigma, resistance to HIV testing may not be that surprising. As stated by a 28 year old trucker in Varga (2001, p. 359): *"I would never take an AIDS test voluntary… Such a decision would be premature and suicidal"*. Similarly, a quote from an informant in a study on sex workers in Johannesburg show that fear prevent HIV testing: *"No. I'll do the HIV test when there is a cure for AIDS. I don't want to make myself miserable."* (Wojcicki & Malala, 2001, p. 114).

Finally, it should be noted that one important aspect of sexual risk taking is missing in this thesis: It takes two to tango. All the way through this thesis, decisions are treated as made by a single individual. However, decisions related to sex are in general made by two individuals. Hence, even if one individual finds the direct benefits of condom use to outweigh the direct costs, it is not certain that his or her partner makes the same evaluation. This implies two things: 1) that the decision to use condoms or not may best be represented by a bargaining game where the outcome depends on the relative bargaining power of each player and, 2) that additional costs associated with condom use needs consideration.

If women lack sexual bargaining power, they may not be able to choose their individual optimal bundle unless their preferences are the same as their partners. Similarly, social norms may foster attitudes towards condoms that increases the social cost of safe sex practices. For example, studies in sociology suggest that condoms in many cultures are associated with lack of trust, lack of masculinity for men and promiscuity of women.[40] Hence, the inclusion of social norms and sexual bargaining is important areas of future research. In addition, *empirical* investigations on the role of cognitive dissonance in sexual risk taking need further attention.

Summary of papers [I], [II], and [III]

Paper [I]: Risky Sex in a Risky World – Sexual risk taking in an HIV/AIDS Environment

In the first paper in this thesis, a theoretical model is developed in order to analyze how observations of seemingly irrational sexual behavior, such as unprotected casual sex in areas and populations with high HIV frequencies, fits with existing knowledge on human incentives under uncertainty of future health prospects. In addition, effects of improvements in expected health and income are analyzed. The results of the theoretical analysis suggest that, for individuals with no access to HIV treatment, uncertainty of future health reduces the expected benefits of health investments and the expected cost of health destructive behavior. Similarly, low levels of expected future health contribute to low levels of perceived costs regarding unsafe sex activities and may thereby reduce incentives to abstain from unsafe sex practices. These results support the empirical finding of a weak link between sexual behavior, HIV prevalence, and HIV knowledge in poor countries. In regions where access to ARV drugs is limited, interventions that improve general health and reduces uncertainty may thus constitute an important ingredient in an effective AIDS policy. The results

[40] See e.g. Campbell (1997); Campbell (2000); MacPhail & Campbell (2001).

also suggest that the recommendations for policy changes with the availability and quality of ARV drugs; the larger the share of the HIV positive population that is covered by HAART, the less beneficial will policy that focuses on reductions in uncertainty be for sexual risk taking. Hence, while it may be major importance to focus AIDS policy on social insurance etc. in poor countries, it may be of little interest (it may even be destructive) to focus AIDS policy on reducing uncertainty in rich countries. In addition, the more *effective* HIV treatment becomes, the more important it may become to invest resources in improving overall health in areas where access to drugs is limited. Thus, if a cure for HIV is found in the future and if we lack resources to distribute this cure to all, it may be of great value to intensify efforts on general health interventions such as immunization programs etc. Finally, as long as we cannot cure HIV, risk preferences among targeted individuals will affect the outcome of AIDS policy. More specifically, the more risk prone an individual is, the more likely it is that a policy aimed to improve general health will increase the incentives to abstain from unsafe sex consumption. Some of the most HIV susceptible populations can be suspected to be less risk averse than the average person (e.g. CSW's, mine workers, military workers, and drug users). Hence, health focused interventions may be of great importance in these populations.

Paper [II]: Sexual Risk Taking among Young Adults in Cape Town – Effects of Expected Health and Income

The second paper in this thesis empirically analyzes the link between expectations of future prospects and sexual risk taking on a dataset consisting of young adults in Cape Town, South Africa. More specifically, the effects of uncertainty of future health, the expected level of future health and the expected level of future income on sexual risk taking are assessed. In order to adequately measure sexual risk taking we use factor analysis to combine a wide range of variables measuring risky sexual behavior such that the maximum information possible is extracted from, and adequate weights are attached to, each measure.

The estimated measure of sexual risk taking is then regressed on the set of explanatory variables using a Tobit model with selectivity. Since expectations of future health are possibly endogenous to the level sexual risk taking, we instrument this variable with mean life expectancy in the community in which the young adult resides.

The results of the empirical analysis suggest that uncertainty of future health is a significant determinant of current patterns of sexual risk taking. Similarly, risky sexual behavior tends to be associated with low current income. Hence, if current household income is a viable proxy for income expectations, this result suggests that an expectation of a prosperous future may reduce the incentives to engage in sexual risk taking in the present. Finally, the empirical analysis does not lend support for a relationship between expected life length and the combined measure of sexual risk taking. Since the reliability of the estimated sexual risk taking measure is relatively low, we also consider the degree of condom use with the young adult's latest sexual partner as a proxy for sexual risk taking. Controlling for selectivity and for the type of relationship the young adult had with his or her latest sexual partner, this regression produces a significant effect of life length expectations on the degree of sexual risk taking in terms of condom use. However, the degree of variance explained in the regression is relatively low. Hence, the evidence for a link between subjective life expectancy and condom use is relatively weak. Since our test of exogeneity indicates that subjective life expectancy is not affected by the degree of sexual risk taking, we suggest that this weakness may be a result of optimistic bias. If the fear of HIV induces incentives to rationalize behavior, in terms of downplaying the risk associated with the young adult's sexual behavior, then subjective life expectancy may not appear to be affected by the degree of sexual risk taken. In addition, if the measure of life expectancy is biased due to rationalization tendencies, we perhaps should not be surprised to only find a weak link between the two measures.

The results for the covariates suggest that females are exposed to HIV risk to a higher degree than men. Even though women are less likely to be sexually

active, they are also less likely to use condoms frequently. This result points to the social taboos related to women's use of condoms and to women's general lack of sexual bargaining power. We also find a significant relationship between HIV knowledge and the degree of sexual risk taking. However, although previous research has found that knowing someone with HIV reduces the degree of sexual risk taking, our analysis suggests that a personal experience of HIV actually *increases* the degree of sexual risk taking.

Paper [III]: Risk and Rationalization – The Role of Affect and Cognitive Dissonance for Sexual Risk Taking

In the third paper of this thesis, a theoretical model is developed in order to analyze how affect and defensive denial affect incentives to engage in sexual risk taking with respect to an HIV infection. The theoretical approach incorporates ideas from psychology on decision-making processes and risk evaluation, and ideas from economics on utility maximization. In the model, an individual is assumed to live during three time periods. In each time period, the individual is exposed to sexual temptations with potentially HIV infected partners. During these occasions the individual can choose whether or not to use a condom.

However, although the individual in cold states is assumed to be able to correctly estimate the risk associated with unprotected sex, a sexually aroused individual is assumed to suffer from myopia in terms of being unable to correctly assess the correct risk and the experienced utility of a negative outcome (i.e. acquiring HIV). Accordingly, I assume that the individual consist of a sequence of different selves (or interests) whose individual objective functions may differ in the evaluation of long term costs. At the onset of each time period, a rational long term self is assumed to use all available information to him at that point in time to maximize lifetime utility. However, this long term self is not in actual charge of future sexual decisions. Instead, sexual arousal is assumed to transfer the executive power to a more short-sighted self. Since sexual risk taking in the presence of HIV questions the individual's self-image as an intelligent person and

induces fear of an HIV infection, an individual that has given in to the temptation to have unprotected sex is assumed to experience incentives to downplay the risk taken. This rationalization is assumed to not only relieve immediate stress but also to distort the information set of future selves.

The results of the theoretical analysis suggest that sexual risk taking may, in addition to increasing the risk of an HIV infection directly, increase the inclination to engage in unsafe sex practices in the future and that the mechanism behind this behavior is two-fold: First, sexual risk taking during young age increases the likelihood of being infected with HIV and thus reduces the perceived marginal benefit of abstaining from unsafe sex during later periods in life. Second, if affect induced risk taking is associated with defensive denial in terms of rationalizing, the underestimation of personal per-coital risk of HIV may lead to an underestimation of the marginal cost of unprotected sex later in life and therefore to excessive risk taking behavior. However, the defense mechanism to rationalize may not be destructive in all circumstances. Since denial of risk also reduces the perceived probability of being infected with HIV it may create incentives to use protection for individuals who would otherwise resort to fatalism and reckless behavior. The results further suggest that anticipating the regret associated with sexual risk taking increases incentives to engage in precautionary behavior.

4. Conflicting Identities and Social Pressure

As was mentioned in the introduction, the final paper in this thesis is not related to sexual risk taking. Nonetheless, the approach taken in paper [IV] is related to paper [III] in that it focuses on how behavior that questions our self-image affects incentives to both change our behavior and to update our self-image. Paper [IV] thus continues the analysis of cognitive dissonance. However, in this paper we utilize cognitive dissonance theory in order to analyze changes in gender roles and the evolution of female labor supply over time. To do this, we

draw on psychological theories on the role of social norms and conflicting social identities for changes in preferences over time.

4.2 Social norms and identity

According to Rimal and Real (2003, p. 185), a social norm in its most general sense is a *"…code of conduct that either prescribe or proscribe behaviors that members of a group can enact."* In order for it to be a norm, a violation must trigger a sanction of some form, and in order for it to be a *social* norm it must be understood through social interaction. In other words, social norms impose non-pecuniary costs for norm-violating behavior and may therefore create incentives to conform to social expectations. However, social norms in isolation cannot explain why people conform when there is no surveillance or why they engage in sanctions of norm-violating behavior that, at least at first glance, does not affect them personally.[41] In order to understand these phenomena, it is fruitful to consider the role that *personal* norms and *identity* plays for an individual's well-being.

Personal norms may be defined as internalized rules prescribing certain values, beliefs and behaviors that are consistent with an individual's desired self-image or identity. While social norms are maintained by external sanctions or rewards, compliance with personal norms is enforced by the fear of negative (guilt, shame, reduced self-esteem) or wish for positive (pride, enhanced self-esteem) self-evaluations.[42] A violation of a personal norm questions the credibility of the individual's identity and, in accordance with the discussion in section 3.2 therefore threatens to cause aversive arousal.

Although social and personal norms may differ, they are nonetheless closely interlinked. This is so since the more an individual *identifies* with a certain social group the more likely it is that part of the individual's personal identity will be

[41] An example given in Elster (1989) is the presence of vengeance norms. The threat of vengeance is only credible if it is believed that the individual will follow through regardless if the expected benefit is positive or negative.

[42] Kerr *et al.* (1997); Swartz (1977); Steele (1988); Bamberg *et al.,* (2007).

related to that of other group members in terms of a *social identity*.[43] To see this, consider an individual who aspires to become an accepted member of a given social group. When this individual interacts with the other members of that group, she becomes exposed to the prevailing social rules. Naturally, although she identifies with the group, she may not agree completely with all of these prescriptions. However, in order to avoid sanctions and to 'fit in' she may nonetheless feel compelled to adjust her behavior to that of the social expectations. If the social rules are inconsistent with her personal norms, this conformity may give rise to dissonance related arousal and therefore create incentives to either leave the group (stop identifying with the group members) or to convince herself that her values and beliefs are the same as those prevailing in the group.[44] Due to this adjustment, individuals that categorize themselves as a member of a certain social group, also tend to ascribe prototypical attitudes in the group as their own.[45]

The close relationship between our self-image and our social identity implies that the behavior of other group members affects our self-image. If these individuals conform with/deviate from the socially prescribed behavior, this behavior confirms/questions our identity and therefore has the potential to give rise to positive/negative arousal. Consequently, behavior that at first glance does not affect an individual may nonetheless present him or her with incentives to engage in positive or negative social sanctions via the effect on his/her identity.

Now, if all individuals only had one social identity we might expect personal norms to be relatively stable over time: We would simply affiliate with one social group, adjust our values and behavior and live 'happily ever after'. However, most of us are not that one-dimensional. Instead, psychological theories of personality suggest that, although most individuals perceive themselves to have a coherent overall personal identity, they nonetheless define themselves in terms of a *set* of

[43] Social identity is defined as the individual's knowledge that he or she belongs to certain social groups, together with some emotional or value significance for him or her attached to the membership in the group (Tajfel, 1982).
[44] Cooper & Hogg (2002).
[45] Tajfel (1974); Hogg (2000); Abrams & Hogg (1990), Cooper & Hogg (2002).

identities related to the different social groups to which they ascribe membership.[46] For example, if you would ask a certain female researcher in economics to describe who she is, she would probably respond in terms of a set of identities related to her gender, her nationality, her profession, her religious, political and cultural affiliation and perhaps in terms of her hobbies. Although these identities together constitute the building blocks of her overall personality, there is no guarantee that these different identities prescribe compatible values and behavior, thus leaving the door open for cognitive dissonance. In line with this argument Roeske and Lake (1977), in a study of identity conflict, found that female medical students defined themselves in terms of different social identities such as being a 'physician', a 'woman', etc. For many of the respondents, these social identities coexisted relatively peacefully. However, Roeske and Lake found that, upon reaching the age when children becomes incorporated in the social identity of being a woman, the respondents experienced negative emotions related to the conflict between the incentives to be a (good) mother, and incentives to have a career as a physician. Hence, in accordance with cognitive dissonance theory, these women experienced a motivation to either change their interpretation of the norms associated with each social identity or to change the relative weight of the social identities in their overall personal self-concept.

4.2 The role of identity for the evolution of female labor supply

During the last century, the roles of men and women have changed dramatically in most industrialized countries. For example, since the end of World War II, the female labor force participation (LFP) in the US has increased from 30 percent[47] to over 70 percent. As can be seen in *Figure 1*, the same trend can be found in many other countries and in Iceland and Sweden female LFP rates today reaches 80 percent and higher.[48]

[46] See e.g., Abrams & Hogg (1990); Hogg & Terry (2000).
[47] See e.g., Schweitzer, (1980)
[48] UN Gender Info 2007

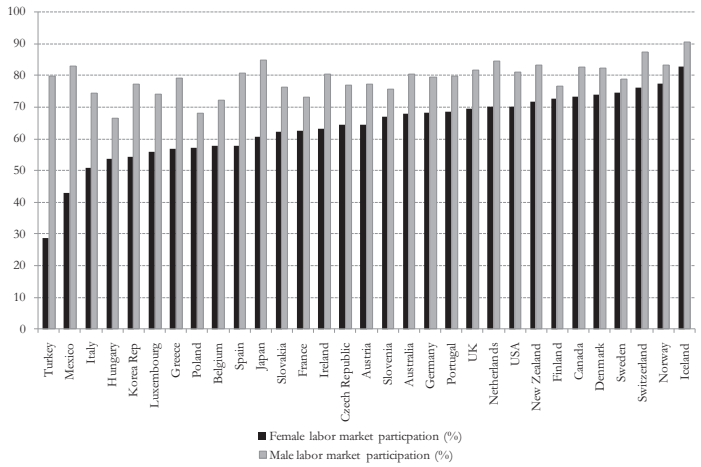


Figure 3: Labor force participation in 2006 in OECD countries.[49]

However, as is also depicted in the figure, large differences in female LFP persist between countries and there is to date no OECD country where women participate on the labor market to the same extent as men.

Possible explanations for the increase in female LFP are higher female wages, lower fertility rates and higher educational attainment among women.[50] However, these factors have only been partially successful in explaining the evolution of female employment rates.[51] Instead, it has been suggested that changes in social norms are important for understanding these developments.[52]

The role of social norms for human behavior has a relatively long history in economics.[53] However, as mentioned above, social norms in isolation provides us with insufficient information to explain changes in behavior and preferences over time.

In the model presented in paper [IV] we argue that social norms, *in combination* with the presence of conflicting identities and individuals' need to maintain a

[49] UN gender info 2007
[50] See, for e.g., Killingsworth & Heckman (1986), and Goldin (1990).
[51] Neumark & Postlewaite (1998).
[52] See Golding (1990, 1994), Romme (1990), and van der Lippe and Siegers (1994).
[53] See e.g,. Akerlof (1980); Bernheim (1994); Lindbeck (1995, 1997) and Lindbeck *et al.* (1999).

consistent self-image, may have important implications for individual behavior *and* for the evolution of preferences over time. More specifically, we argue that we, in order to fully understand the mechanisms underlying both the increase in female labor force participation *and* the persistence of part-time labor among women, need to incorporate identity conflict and social norms in the analysis. The theoretical approach taken in the paper relates to the economic literature of social sanctions[54], internalized personal norms[55] and social identity[56]. It is most closely related to the work of Akerlof & Kranton (2002) and Vendrik (2003).

Akerlof & Kranton (2002) show that if social group membership provides individuals with utility in terms of a social identity, deviant behavior that questions this identity will cause utility loss and therefore contribute to conformity even in the absence of external sanctions. Our approach differs from the Akerlof & Kranton (2002) model mainly in that we model how individual behavior may change the relative importance of different social identities and how this in turn affects female labor supply, whereas Akerlof & Kranton focus on the importance of a single (and static) identity for school performance.

Vendrik (2003) develops a theoretical model in order to analyze the evolution of female labor supply. According to Vendrik, the social identity of many women was previously to a large extent related to being a housewife. For these women, a 'successful' life was intimately associated with how well they lived up to the prescribed behavior of a 'good' housemother, and full-time market work may therefore not have been an option due to both social sanctions and to guilt of not taking properly care of the home. According to Vendrik, the increase in the demand for (and wage of) female labor during World War II provided women with incentives to act in discordance with the prescribed behavior of housewives and this norm-violating behavior in turn created incentives to erode the belief in the traditional household norm.

[54] See e.g., Akerlof (1980); Bernheim (1994); Lindbeck (1997); Lindbeck *et al.,* (1999).
[55] See e.g., Akerlof, (1991); Andreoni (1990; 1995); Bruvoll & Nyborg (2004).
[56] See e.g., Akerlof and Kranton (2000; 2002; 2005) and Oxoby (2004).

Although the Vendrik (2003) model provides interesting insights on the mechanisms underlying the female transition from housewives to breadwinners, we argue that his model can be augmented in several aspects. First, Vendrik's analysis suggests a complete erosion of norms prescribing that women should take care of the family. However, in most countries women work part-time to a higher extent, and have a larger responsibility for household work, than men. In addition, great differences in both female LFP and gender norms persist between countries.[57]

Second, Vendrik assumes that women only have *one* social identity and therefore only derive utility from work in terms of consumption. However, from our discussion above, we know that most individuals derive utility from *several* identities. Hence, we may expect working women to have (or form) a *professional* identity as well as an identity related to their role within the household. In contrast to Vendrik (2003), we therefore assume that it is not only the conflict between *one* personal and social norm that drive the evolution of behavior over time, but rather that conflict between *different* identities. In accordance with the psychological literature referred to above, our main idea is that an individual's overall self-concept is constituted by a set of different identities, where the *weight* attached to each identity (i.e., the relative importance of that aspect for the individual's overall self-image) may differ both between individuals and within an individual over time. The argument put forward in paper [IV] is that changes in wages and social norms related to female market work may have induced changes in behavior that, via cognitive dissonance, changed the relative weight on women's social identities as housewives and increased the relative importance of their identities as career women. The inclusion of different identities and the separation between personal and social norms in the model enables us to identify steady states where women do not make the full transition and therefore continue to work part-time. In addition, we show that in countries or social groups where the prevailing social norms prescribe traditional values, women with professional

[57] OECD labor market statistics, UN Gender info 2007, and ISSP 2002

ambitions may resort to changing their identity towards being more 'traditional' in order to better fit into society.

Summary of paper [IV]:

Paper [IV]: Conflicting Identities and Social Pressure – Effects on the long-run evolution of female labor supply

In the fourth paper of this thesis, we utilize ideas developed by psychologists concerning peoples need to both fit into social groups and to maintain a positive and consistent self-image to analyze changes over time and between countries in female labor market participation. More specifically, we argue that part of the explanation to the change in both social norms and personal preferences for market work amongst women can be found by an analysis of conflicting social identities. We make the simplifying assumption that women mainly define themselves in terms two identities, one related to their role within the household (i.e., being a 'good' wife/mother) and another related to their work (i.e., their professional identity), each of which is associated with both personal and social prescriptions concerning behavior that may vary over time and between different societies. We further assume that behavior consistent with the prescriptions of a valued identity confirms that identity and therefore results in a boost in self-esteem. In contrast, a violation of a personal norm creates feelings of guilt and low self-esteem. Finally, we assume that the individual's personal norms related to a given identity need not coincide with the social prescriptions related to that identity. Hence, if the individual values the membership of a given social group, she may feel compelled to act in discordance with her personal norms in order to satisfy social expectations. This violation of her personal norms is assumed to give rise to cognitive dissonance and thus to incentives to revise the relative importance of fulfilling that personal norm. In addition, since the individual is assumed to have two conflicting identities, an individual may experience cognitive dissonance even if personal and social norms coincide.

Applying this approach within the context of a dynamic model of labor supply, we are able to make some novel predictions about what may cause labor supply to change over time. For example, we show that the effect of a change towards more positive social attitudes to female labor market participation may become enforced in long-run due to the induced change in the self-image of women. Similarly, we show that not recognizing that the weights attached to different social identities are endogenous may imply that the long-run effects on labor supply of a higher wage is underestimated. Finally, our results suggest that women living in societies characterized by traditional gender norms with 'high ambitions', in terms of having strong personal preferences for market work, may find it optimal to adjust their self-image to the social representation of women.

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I

Risky Sex in a Risky World: Sexual behavior in a HIV/AIDS environment*

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Abstract

In spite of increased awareness of HIV/AIDS, unprotected casual sex is still widespread in many HIV infected countries. In this paper, a two-period model for sexual decisions under uncertainty is developed. The results suggest that, for individuals with limited access to HIV treatment, uncertainty of future health may be an important factor driving unsafe sex practices. The results support the empirical finding of a weak link between sexual behavior, HIV frequency, and HIV knowledge in poor countries; therefore suggesting that AIDS policy needs to be calibrated in order to fit within different social contexts.

Keywords: Uncertainty, risk aversion, health risk
JEL - Classification: D81, D91, I10

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I. Introduction

The questions asked in this paper relate to how observations of seemingly irrational sexual behavior, such as unprotected casual sex in areas and populations with high HIV frequencies, fits with existing knowledge on human incentives under uncertainty of future health prospects. The results indicate that the degree of uncertainty of future health, as well as the availability and quality of HIV treatment, needs to be incorporated in the analysis in order to understand risky sexual behavior in the presence of HIV.

In 2008, 2.7 million new HIV infections occurred globally. In the same year, 2 million individuals died of AIDS related diseases, whilst an estimated 33.4 million were still living with HIV. Poor regions, in general and sub-Saharan Africa in particular, continue to carry a disproportionally heavy burden in terms of HIV victims; 68 percent of all adult HIV infections and 72 percent of the AIDS deaths in 2008 occurred in sub-Saharan Africa.[3] In recent years, the development of antiretroviral (ARV) drugs and the combination of different ARV drugs into Highly Active Antiretroviral Treatment (HAART) has enabled HIV-positive individuals to live a relatively healthy and long life. However, although there have been important breakthroughs, HAART still only reduces mortality with 50-80 percent and ARV treatment is still associated with severe medical side effects. In addition, there is some evidence that the availability of an imperfect HIV treatment may increase the spread of HIV, since treatment reduces the marginal cost of sexual risk taking and increases the potential number of new infections through an increase in the time span between HIV infection and death.[4] It should, however, be noted that, although the distribution of antiretroviral drugs have improved substantially during the past decades, a large share of HIV positive

[3] See UNAIDS (2009); Rao *et al.* (2006)
[4] See Lakdawalla *et al.* (2006); Mechoulan (2007)

individuals, especially in poor countries with soaring HIV epidemics, still have no access to HIV treatment.[5]

The inefficiency of HIV/AIDS prevention programs are still puzzling researchers and policy makers. Despite some signs of increased condom use and reduced numbers of sexual partners, the lack of behavioral change in high risk groups effectively means that there are almost no signs of significant reductions in HIV rates.[6] Although the transmission rate of HIV during vaginal intercourse is substantially higher in sub-Saharan Africa than elsewhere,[7] where HIV prevalence rates can be as high as 70 percent among commercial sex workers (CSW's), the price of unprotected sex has been found to be substantially higher than that of safe sex.[8] Admittedly, myths and misinformation about HIV still prevail;[9] however, HIV/AIDS knowledge is not necessarily inadequate in communities with unsafe sex practices and high HIV prevalence rates.[10]

In this paper, I argue that we, in order to understand the persistent practice of unprotected casual sex in the presence of HIV, need to consider contextual uncertainty about the future. The tangible presence of risk and uncertainty of

[5] The percentage of pregnant women receiving antiretroviral treatment has improved substantially over that past couple of years. In many countries with reports of coverage rates, numbers are as high as 80 percent. However, although the trend in antiretroviral treatment distribution in poor countries has been positive, the number of new HIV infections each year outnumbers the increase in individuals on ARVs, by 2.5 to 1; See e.g. UNAIDS (2009); Rao *et al.* (2006).

[6] Lagarde *et al.*, (2001) estimate condom coverage at 27-31 percent for men and 11-17 percent for women in a number of highly affected cities in sub-Saharan Africa. In Zambia, the share of unprotected sexual acts with non-cohabiting partners actually increased during the late 1990s. See also UNAIDS, (2006); Caldwell, (1999, 2000); Bloom *et al.* (2000); Hearst & Chen (2004); Mwaluko *et al.* (2003).

[7] Oster (2005) suggests that the high transmission rate of HIV in sub-Saharan Africa is a consequence of the high frequency of other untreated sexually transmitted diseases. In addition, the practice of so called dry sex, where the female genitalia is tightened through use of herbs and synthetics widespread; see e.g. Campbell (1997); Buvé *et al.* (2001); Morison *et al.* (2001); Wojcicki & Malala (2001). For exact transmission rates, see Gray *et al.* (2001); Quinn *et al.* (2000).

[8] Robinson & Yeh (2008) estimate the compensating differential for condom-free sex to 7.8% for CSWs in Busia District in Kenya, while Rao *et al.* (2003) find a 66% price differential for CSWs in Calcutta. Sociological case studies have reported prices for unprotected sex that are up to four times those for sex with condoms; see e.g. Abdool-Karim *et al.* (1995); Pettifor *et al.* (2000); Morison *et al.* (2001).

[9] See e.g. Swart-Kruger & Richter (1997)

[10] Demographic and Health Surveys (DHS) show that most individuals have a reasonably high level of HIV/AIDS awareness, whilst studies on South African miners (one of the most AIDS susceptible groups) suggest that risky sex prevails in spite of free access to condoms and a sufficient knowledge about HIV; See Campbell, 1997; South African Presidential AIDS Advisory Panel Report, 2001:75, cited in Benz (2005); See also Pettifor *et al.* (2000)

future prospects is a common feature among many HIV susceptible populations such as migratory workers, refugees, miners, intravenous drug users and CSW's.[11] Indeed, it has been shown that HIV frequencies soar in countries with malfunctioning institutions and civic unrest.[12]. The basic intuition behind the theory presented below is that, for people living under harsh conditions, HIV constitutes a significant threat but it is not dominant in daily life. In other words, if private actions only determine the future health status to a minor extent, the gain in abstaining risky activities with potential future health costs is low.

Although sexual behavior is not a conventional subject within economic research, expected utility theory has the potential to provide an understanding to the mechanisms that drive both destructive and protective behavior in the presence of HIV.[13] For example, in their seminal paper on the subject, Philipson and Posner (1993) were able to explain why HIV frequencies actually remain at relatively moderate levels in many countries.[14] By explicitly modeling the marginal costs and benefits of unsafe sex in a sexual bargaining game, Philipson and Posner have shown that, as the HIV frequency increases so does the marginal

[11] Campbell (1997) refers to a report produced by the South African Chamber of Mines, which estimates that mine workers face a 2.9 percent chance of being killed in a work related accident and a 42 percent chance of suffering a reportable injury in a 20-year working life. In her interviews with CSWs in Durban, Varga (1997) finds that HIV is perceived as a distant threat in comparison to daily survival.VanLandingham *et al.* (1993) find that soldiers in Thailand visit prostitutes to a higher extent and use condoms to a lesser extent than other Thai men. In the literature survey produced by UNAIDS & IOM (2003), several examples of the heightened HIV susceptibility of mobile populations are discussed, where Rhodes (1997) finds excessive sexual risk taking among intravenous drug users.

[12]In Sierra Leone, estimated HIV prevalence surmounted to 60-70 percent among soldiers in 2002 and HIV frequencies among prostitutes increased from 26.7 percent to 70.6 during the civil war; UNAIDS/WHO (2002: 35). See also Benz (2005).

[13] The engagement in risky sexual activities is naturally likely to be affected by other things than contextual uncertainty, among those the presence of hyperbolic discounting and of destructive social norms. Hyperbolic discounting of the future gives rise to myopic behavior and is likely to exist in all cultures. However, there is little evidence that sub-Saharan Africans should discount hyperbolically to a larger extent than, for example, Europeans. As for social norms, sexual preferences and gender ideals clearly differs geographically and between cultures, thus supporting the idea that social norms could hold important information for explaining risky sexual behavior. However, I will not focus on norms in this paper (this is done in a forthcoming paper). To maintain simplicity, I instead turn to the economic theory of behavior under uncertainty. According to economic theory, the presence of future uncertainty reduces the value of expected future utility and thus makes it rational for a risk-averse individual to act shortsightedly.

[14] Early epidemiological models predicted that HIV rates would explode as the pool of potential virus hosts increased and spread the virus (Philipson and Posner, 1993)

cost of engaging in unsafe sex for HIV negative individuals. Hence, at sufficiently high HIV frequencies the marginal cost of unsafe sex will surmount the marginal benefit and the epidemic will therefore level off.[15] However, although the predictions of models for sexual bargaining fit relatively well with the situation in the United States and Europe, they cannot fully explain the persistent presence of unprotected casual sex in regions with extreme prevalence rates of HIV.[16] Philipson and Posner (1995), suggest that the prevailing differences in HIV prevalence rates between rich and poor countries can be explained in terms of an inelastic supply of sexual services among CSWs in poor countries. This hypothesis has been confirmed in a number of empirical papers on sex markets in poor countries.[17] The results in these papers suggest that CSWs accept unprotected sex due to the substantial income loss associated with condom use (see footnote 4).[18] The driving mechanism behind the price differential for condom-free sex is partly explained by strong preferences for unprotected sex among clients. However, neither of the cited papers investigates why clients are willing to pay a premium for a sexual service associated with the risk of HIV.

In his seminal work from 1996, Kremer provides a potential explanation to observed differences in epidemiological development between countries and between groups within countries. In his theoretical analysis, Kremer shows that the effect of changes in HIV prevalence, on incentives to engage in sexual risk taking, depends on the initial level of sexual activity. More specifically, an increase in HIV prevalence may actually cause an *increase* in the number of sexual partners among individuals with a history of high sexual activity. The mechanism behind this result is that, although an increase in HIV prevalence increases the *lifetime* risk of acquiring HIV for all types of individuals, the *marginal* risk of becoming infected with HIV falls with increasing HIV prevalence for high activity

[15] See also Schroeder and Rojas (2002).
[16] Philipson and Posner (1993) have also been criticized for not including asymmetric power in the bargaining game; see Christensen (1998)
[17] See e.g. Rao *et al.* (2003); Gertler *et al.* (2005); Robinson & Yeh (2008)
[18] It is interesting to note that the price and supply of commercial sex (with or without condoms) has been shown to be an increasing function of the presence of men-in-transit, (c.f. Edlund & Korn, 2002; Cunningham & Kendall, 2008; Oster, 2007b).

individuals.[19] This implies that, within countries or groups of individuals where sexual activity is initially high, an increase in HIV prevalence may create fatalistic sexual behavior. Although the Kremer (1996) model has contributed with important insights on the mechanisms behind sexual risk taking, the model does not account for differences in reactions towards changes in HIV prevalence and HIV knowledge *within* high- or low activity groups.[20]

The theoretical analysis presented in this paper relates most closely to a number of economic papers that incorporate the effect of the physical and social contexts within health related behavior.[21] Dow *et al.* (1999) suggest that health oriented policy in poor countries may have positive spill-over effects on private health-seeking behavior. Interventions, such as immunization programs, reduce pressing mortality risks and thereby increase the marginal benefit of private health investments. Thus, health interventions that seem cost-inefficient when only direct effects are evaluated may well prove cost-efficient if indirect effects on health investments are considered. Benz (2005) follows the same line of argument and suggests that the correlation between high HIV prevalence and experiences of civil conflict can at least partly be explained by an increase in uncertainty due to crumbling civic institutions. Dinkelman *et al.* (2007) are unable to show a direct link between economic shocks and sexual risk taking in South Africa, but do show that youth from poor households have an earlier sexual debut and use condoms less frequently than young adults from richer households. In the paper most closely related to the one presented here, Oster (2007a) suggests that a reduction in expected life length or future earnings reduces the expected cost of risky sexual behavior. Using cross-sectional data on nine African countries[22], Oster finds that while HIV knowledge and HIV frequency does not have a

[19] For a longer discussion on the intuition behind this result, see proposition 3 below.
[20] Within the high risk groups during the early phases of the epidemic, such as the gay community, sexual risk taking fell as a response to HIV knowledge and increasing HIV prevalence. However, within HIV susceptible groups such as intravenous drug users, migratory workers and refugees there are few signs of changes in sexual risk taking (UNAIDS & IOM, 2003)
[21] See e.g. Dow *et al.* (1999); Benz (2005); Dinkelman *et al.* (2007); Oster (2005; 2007a)
[22]Demographic and Health data on Benin, Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Mali, Namibia and Zimbabwe

significant effect on the number of sex partners, income levels and expected life length does affect sexual risk taking.[23]

The aforementioned papers have contributed with important insights on potentials and pitfalls for HIV prevention. However, none of the above studies have theoretically considered the link between future uncertainty and risk on one hand and sexual behavior on the other. The model presented below can be seen as a complement to Oster's (2007a) contribution in that it provides an analysis of the reason behind risky sexual behavior in these populations. The main contribution of my model is the explicit analysis of health related uncertainty of the future. My hypothesis is that health related uncertainty (unrelated to the individual's own behavior) *by itself* holds an important key for explaining risky sex. Admittedly, the future is always, to some extent, uncertain. Indeed, few individuals know with certainty that they will be alive and healthy in the future. However, in poor countries the future is likely to be both more uncertain and less bright than in rich countries, due to for example malfunctioning economic and political systems. In such an environment, investments in health are likely to be more risky than elsewhere. It may thus be optimal for an individual to focus on the present instead of investing in the future. Hence, although individuals in poor countries appear to act myopic, they are acting completely rational within the context of uncertainty.

II. Theoretical approach

The theoretical model in this paper relates to the question of how an uncertain future affects sexual choices in the present. In order to retrieve qualitative results, the analysis is kept simple. The model is based on the lifetime utility of an individual (man), who faces a trade-off between sexual pleasure and

[23]In order to deal with the obvious endogeneity between life expectancy and HIV prevalence, malaria frequency and maternal mortality is used as a proxy for life expectancy. Oster (2007a) further acknowledges the link between sexual promiscuity and HIV prevalence and therefore uses the distance to the (believed) origin of the HIV virus (the Democratic Republic of Congo) as an instrument for HIV frequency.

future health. The assumption that the individual is a man, who is able to make an independent choice in a sexual relationship, is based on the dominating position of men in many poor countries. The model can be seen as an analysis of a price-taking man facing a supply of commercial sexual services.[24]

The theoretical approach used in this paper is loosely based on a modeling idea developed by Katz *et al.* (1982).[25] In the analysis presented below I use some of their ideas to model sexual behavior in a world where future health prospects are uncertain.

The Health Risk Model

Consider an individual that lives for two time periods. The preferences in period *t* are described by the lifetime utility function:

$$U = U(\boldsymbol{c}, \boldsymbol{h}, \boldsymbol{x}_s, \boldsymbol{x}_{us}) \tag{1}$$

where $\boldsymbol{c} = (c_1, c_2)$ is consumption, $\boldsymbol{h} = (h_1, h_2)$ health, $\boldsymbol{x_s} = \left(x_{s,1}, x_{s,2}\right)$ safe sex, and $\boldsymbol{x_{us}} = \left(x_{us,1}, x_{us,2}\right)$ unsafe sex.[26] The instantaneous utility function is assumed to be twice continuously differentiable, increasing in each argument and strictly concave.[27] It is also assumed that, at a given level of sexual consumption, the

[24] In other words, we assume that the individual only consumes marketed sex. This assumption is clearly a stark simplification. However, safe sex within a relationship is a complex issue. Not only do we need to include the uncertainty of the fidelity of the partner, we also need to take into consideration the desire to bring children into the world, for which unprotected sex is necessary. In addition, we would have to include bargaining between spouses and preferences for extramarital sex. However, if we disregard the complexities of bargaining and reproduction wishes, a model with marital sex would only differ with respect to unsafe sex within the marriage having zero monetary cost (for safe sex within the marriage, the monetary cost would be constituted by the cost for condoms). Hence, the qualitative results are unlikely to be altered.

[25] See also Brock *et al.* (1982); Johansson & Löfgren (1985); Koskela (1989). Katz *et al.* (1982) analyze a firm operating on an international market under price uncertainty, while Brock *et al.* (1982), Johansson and Löfgren (1985) and Koskela (1989) analyze optimal forest harvesting under uncertainty of future prices.

[26] Sex is assumed to be safe if the individual uses a condom. Now, sexual consumption is in reality a discrete variable. However, economists commonly treat consumption as a continuous variable although this is rarely the case. Thus, in order to facilitate our analysis we assume that sex, as well as other consumption goods, can be treated as a continuous variable.

[27] i.e., $U_c, U_h, U_{x_s}, U_{x_{us}} > 0, U_{cc}, U_{hh}, U_{x_s x_s}, U_{x_{us} x_{us}} > 0$

marginal utility from sex with a condom is lower than that of unprotected sex due to, for example, reductions in sensation and interrupted foreplay.[28]

Health and consumption are assumed to be complements, in the sense that the marginal utility of consumption is an increasing function of health and vice versa.[29] Likewise, the marginal utility of sex is most likely positively related to health status and possibly to the level of consumption. However, with a two-period model and a purpose to analyze how changes in future prospects affect present sexual incentives, the inclusion of sex in period two and health in period one adds little to the analysis. I therefore normalize health in period one to unity and disregard sexual activities in period two. Consequently, the assumption that sex and health are complements is superfluous within the framework of this model. For simplicity, I furthermore assume that consumption and sex are additively separable. Concerning safe and unsafe sex, I assume that the marginal utility of safe sex is a decreasing function of unsafe sex.[30]

Before we specify the lifetime utility function, let us first discuss the uncertainty part of the model. Future health status is affected by two kinds of uncertainty, the risk of contracting HIV via unprotected sexual intercourse and an exogenous stochastic health shock. The latter can, for example, be thought of as a work or traffic related accident when negative, while a positive shock may reflect improved sanitation or distribution of malaria prophylaxis.

The individual is assumed to be HIV negative in the beginning of period one. However, consumption of unsafe sex is associated with a known risk of acquiring HIV.[31] Let us assume that a fraction δ of HIV positive individuals receive and

[28] In addition to the physical reduction in sensitivity caused by condoms, social norms concerning sexuality are likely to affect experienced utility of safe and unsafe sex. The analysis of social norms, sexuality, and risk is analyzed in a forthcoming paper.

[29] That is, health and consumption are not necessarily complements in a Hicksian sense (as derived from the cross derivatives of the Hicksian demand function)

[30] Research regarding whether safe and unsafe sex should be treated as substitutes or complements is scarce, whilst the few papers that exist give conflicting advice. For example, Remien *et al.* (1995), in a study of gay men, found that safe and unsafe sex was considered both as complements and substitutes.

[31] The individual is assumed to know the HIV frequency and the risk of transmission among commercial sex workers. This is clearly a stark assumption; it is extremely hard to find consistent data on HIV transmission rates per sexual act for sub-Saharan Africa. However, it may be reasonable to

respond to HIV treatment. Let us for simplicity also assume that if the individual acquires HIV in period one and does *not* access HIV treatment, he dies of AIDS before reaching period two. Furthermore, each time the individual has unprotected sex with a casual contact, he is exposed to a risk of contracting HIV, given by $\Pr(HIV)$.[32] Consequently, the probability of staying HIV negative after an unprotected sexual act is $1 - \Pr(HIV) = \varphi$. This means that, if the individual engages in x_{us} risky sexual acts, the probability of remaining HIV negative is given by $\varphi^{x_{us}}$ (a complete list and description of all Greek letters used in the analysis is given in the appendix).

In addition to the risk of acquiring HIV, the individual also faces an exogenous risk of experiencing reduced health via a stochastic health shock. Keeping the analysis as simple as possible, I assume that there are only two possible outcomes for an individual with a given HIV status; h^i_{low} and h^i_{high}, where $0 < h^i_{low} < h^i_{high}$ and where $i = -, +$ represents HIV status. Unless HIV treatment is fully efficient, in terms of completely restoring the health of an HIV infected individual, both positive and negative health shocks should produce lower health levels for a HIV positive individual than for a HIV negative individual. In other words, $h^+_{high} < h^-_{high}$ and $h^+_{low} < h^-_{low}$.

The probability of a positive health shock is given by ρ, while the probability of a negative health shock is given by $(1 - \rho)$, where $0 < \rho < 1$.[33] The possible health scenarios are presented in *Figure 1* below.

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assume that the perceived risk of acquiring HIV via unprotected sex is proportional to the perceived risk of the partner being HIV infected and that individuals have a relative good idea about the HIV frequency in a certain population group.

[32] Formally, the probability of contracting HIV from one risky sex act is constituted by the product of the probability that the partner is HIV positive and the risk of transmission

[33] We disregard any effects of health shocks on earning capabilities in period two. Treating income as a function of health would affect the analysis marginally. However, the most striking effect is the production of relatively meaningless algebra. We therefore focus on the simpler version of the model (results are available from the author upon request).

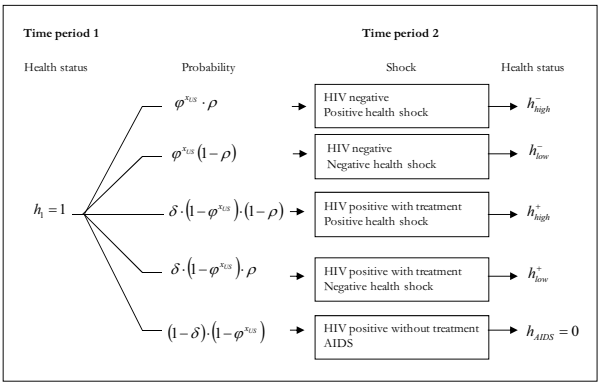


Figure 1: Health scenarios

Let us define the spread between high and low health levels for both HIV positive and HIV negative individuals as, $\gamma = h^i_{high} - h^i_{low}$, and the expected health level in period two of an HIV negative individual as, $\tilde{h}^-_2 = \rho \cdot h^-_{high} + (1-\rho) \cdot h^-_{low}$.[34] I also define the expected health status of an HIV positive individual as a scaled version of the expected health of an HIV negative individual, $\tilde{h}^+_2 = \theta \cdot \tilde{h}^-_2$, where $\theta;\ 0 \leq \theta \leq 1$ measures the efficiency of HIV treatment. This implies that if $\theta = 1$; HIV treatment is fully efficient in terms of providing a HIV infected individual with the same health as that of an uninfected individual. This definition enables us to write the possible outcomes of future health as:[35]

$$h^-_{low} = \tilde{h}^-_2 - \rho \cdot \gamma \tag{2}$$

$$h^-_{high} = \tilde{h}^-_2 + (1-\rho) \cdot \gamma \tag{3}$$

$$h^+_{low} = \theta \cdot \tilde{h}^-_2 - \rho \cdot \gamma \tag{4}$$

$$h^+_{high} = \theta \cdot \tilde{h}^-_2 + (1-\rho) \cdot \gamma \tag{5}$$

[34] The conditional variance is given by:
$\sigma^2_{\tilde{h}_2} = \rho \cdot \left(h^-_{high} - \tilde{h}^-_2\right)^2 + (1-\rho) \cdot \left(h^-_{low} - \tilde{h}^-_2\right)^2 + \delta \cdot \left[\rho \cdot \left(h^+_{high} - \tilde{h}^+_2\right) + (1-\rho) \cdot \left(h^-_{low} - \tilde{h}^+_2\right)^2\right] = \left[\rho \cdot \left((1-\rho) \cdot \gamma\right)^2 + (1-\rho) \cdot (-\rho \cdot \gamma)^2\right] + \delta \cdot \left[\rho \cdot \left((1-\rho) \cdot \gamma\right)^2 + (1-\rho) \cdot (-\rho \cdot \gamma)^2\right] = (1+\delta) \cdot \rho \cdot (1-\rho) \cdot \gamma^2$

[35] $E[h^+_2] = \theta \cdot \tilde{h}^-_2 = \theta \cdot \left[\rho \cdot h^-_{high} + (1-\rho) \cdot h^-_{low}\right] = \left[\rho \cdot h^+_{high} + (1-\rho) \cdot h^+_{low}\right]$
$\rightarrow \theta \cdot \tilde{h}^-_2 = \theta \cdot [\rho \cdot \gamma - h^-_{low}] = \rho \cdot \gamma - h^+_{low}$
$\rightarrow h^+_{low} = \theta \cdot \tilde{h}^-_2 - \rho \cdot \gamma$

The discussion above implies that we can define the expected utility function as:

$$E[U] = u(c_1) + g(x_{us}, x_s) + \beta \cdot E[u(c_2, h_2)] \tag{6}$$

where β: $0 < \beta < 1$, is an exogenous discount factor, and where

$$\begin{aligned} &E[u(c_2, h_2)] \\ &= \varphi^{x_{us}} \cdot \left[\rho \cdot u\left(c_2, h_{high}^{-}\right) + (1-\rho) \cdot u(c_2, h_{low}^{-})\right] \\ &+ \delta \cdot \beta \cdot (1 - \varphi^{x_{us}}) \cdot \left[\rho \cdot u\left(c_2, h_{high}^{+}\right) + (1-\rho) \cdot u(c_2, h_{low}^{+})\right] \end{aligned} \tag{7}$$

is the expected utility in period two. Next, let us define the individual's budget constraint. In order to capture the main mechanism of the effect on uncertainty on risky sexual choices, we disregard from saving possibilities:[36]

$$Y_1 = c_1 + q_{x_s} \cdot x_s + q_{x_{us}} \cdot x_{us} \tag{8}$$

$$Y_2 = c_2 \tag{9}$$

where q_{x_s} is the price of safe sex, $q_{x_{us}}$ the price of unsafe sex and c_t the numeraire good in each time period. Labor supply is assumed to be completely inelastic, where Y_1 and Y_2 represents the exogenous incomes in period one and two, respectively.[37] Substituting equations (7) - (9) into equation (6) and maximizing with respect to x_s and x_{us}, produces the following first order conditions:

$$\frac{\partial E[U_t]}{\partial x_s} = U_{x_s} = -u_{c_1} \cdot q_{x_s} + g_{x_s} = 0 \tag{10}$$

[36]The derived mechanisms, analyzed in this paper, remain if we include saving possibilities in the model. However, with a fully inter-temporal budget constraint, the results become more complex. Hence, since the main interest in this paper is to analyze health related constraints rather than budget constraints, I have chosen to simplify the analysis in terms of setting savings to zero. I will, however, comment on the effect of savings at the end of section 2.2. For a full analysis of risky sexual choices with positive savings, see the background working paper by Mannberg (2009).

[37] The monetary cost of antiretroviral (ARV) drugs has been estimated to $13,000 per patient and year by Lakdawalla *et al.* (2006). However, in order to keep the analysis as simple as possible, I disregard the monetary cost of ARV drugs. This seemingly stark simplification is partly motivated by the presence of government subsidies and partly by that the focus of this paper is on health related costs rather than monetary costs.

$$\frac{\partial E[U_t]}{\partial x_{us}} = U_{x_{us}} = -u_{c_1} \cdot q_{x_{us}} + g_{x_{us}} + \beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \Big[\Big(\rho \cdot u\big(c_2, h^-_{high}\big) + (1-\rho) \cdot u\big(c_2, h^-_{high}\big)\Big) - \delta \cdot \Big(\rho \cdot u\big(c_2, h^+_{high}\big) + (1-\rho) \cdot u(c_2, h^+_{low})\Big)\Big] = 0 \quad (11)$$

where $g_{x_s} = \partial g/\partial x_s$, $g_{x_{us}} = \partial g/\partial x_{us}$, $u_{c_1} = \partial u_1/\partial c_1$ and $u_2 = \partial u_2/\partial c_2$.[38] Let us briefly interpret these first order conditions. For safe sex, equation (10) implies that the marginal benefit, in terms of sexual pleasure, is equalized to the marginal cost, in terms of forsaken consumption in period one. Turning to equation (11), we see that unsafe sex is associated with an additional marginal cost compared with equation (10). This additional cost, which is captured by the last term on the right hand side (RHS) in equation (11), reflects the reduced survival probability caused by an unprotected sexual act. As can be seen in the equation, the more efficient the HIV treatment is and the larger share of the HIV positive population that is receiving this treatment, the lower is the expected future marginal cost of unsafe sex.

Let us now turn to the main question of how uncertainty and exogenous changes of future health influence sexual choices today.[39] In order to analyze the effect of health related uncertainty on sexual incentives, we need to isolate the effects induced by changes in the variance of future health from changes in the expected level of health.[40] In terms of equations (2)-(5), the effect of an increased variability of future health corresponds to an increase in the spread (γ), whereas the effect of improvements in expected health corresponds to increases in $\tilde{h}_2^-$.[41]

[38] $\varphi^{x_{us}} = e^{x_{us} \cdot \ln(\varphi)} \rightarrow \partial \varphi^{x_{us}}/\partial x_{us} = \ln(\varphi) \cdot \varphi^{x_{us}}$

[39] For an analysis on the effects of changes in future income, see the background working paper by Mannberg, (2009).

[40] Expected health is, to be formal, affected by five possible outcomes, $h^-_{high}, h^-_{low}, h^+_{high}, h^+_{low}$, and dying of AIDS. However, since the purpose of this paper is to isolate the effects of exogenous changes in future prospects on sexual incentives and since the individual's own effect on health is incorporated via $\varphi^{x_{us}}$, expected health is conditioned on being alive.

[41] It can easily be shown that an induced change in $\tilde{h}_2$ does not alter the conditional variance of future health as: $\sigma^2_{\tilde{h}_2} = (1+\delta) \cdot \rho \cdot (1-\rho) \cdot \gamma^2$.

The effect of changes in the direct riskiness of engaging in unprotected casual sex corresponds to changes in δ, θ and φ. Let us therefore totally differentiate the first order conditions (10) and (11) with respect to the parameters, $\gamma, \tilde{h}_2^-, \delta, \theta$ and φ. This gives us the system:

$$\begin{pmatrix} U_{x_{us}x_{us}} & U_{x_{us}x_s} \\ U_{x_sx_{us}} & U_{x_sx_s} \end{pmatrix} \cdot \begin{pmatrix} dx_{us} \\ dx_s \end{pmatrix} = \begin{pmatrix} -U_{x_{us}\gamma} & -U_{x_{us}\tilde{h}_2^-} & -U_{x_{us}\delta} & -U_{x_{us}\theta} & -U_{x_{us}\varphi} \\ -U_{x_s\gamma} & -U_{x_s\tilde{h}_2^-} & -U_{x_s\delta} & -U_{x_s\theta} & -U_{x_s\varphi} \end{pmatrix} \cdot \begin{pmatrix} d\gamma \\ d\tilde{h}_2^- \\ d\delta \\ d\theta \\ d\varphi \end{pmatrix} \quad (12)$$

where $U_{x_{us}x_{us}} = \partial E^2[U]/\partial(x_{us})^2$, $U_{x_{us}\gamma} = \partial E^2[U]/\partial x_{us}\,\partial\gamma$, etc.[42] Let us denote the determinant of the $2 \cdot 2$ matrix on the left hand side (LHS) D. Thus, if we have an interior solution, it follows from the second order conditions for a maximum that $D > 0$.

As described in the introduction, many HIV susceptible individuals live in an environment where ARV drugs are unavailable. For these individuals the decision to engage in unsafe sex or not is unlikely to depend heavily on marginal changes in the quality or distribution of HIV drugs. Let us therefore start our analysis by investigating the effect of changes in uncertainty in a world without HIV treatment, i.e. $\delta = \theta = 0$.[43]

Sexual Risk Taking in a World without HIV Treatment

For HIV susceptible individuals living in an environment where antiretroviral drugs are not available, the last term in the first order condition for unsafe sex in equation (11) vanishes.[44]

[42] Calculations of all terms can be found in the background working paper (Mannberg, 2009)
[43] See Oster (2007a) for a similar approach
[44] The analysis presented in this paper focuses on the effects of incentives to consume unsafe sex. Results on corresponding effects on consumption of safe sex are available from the author upon request.

Proposition 1. *If* $\delta = \theta = 0$, *a mean preserving increase in the spread of future health increases the consumption of unsafe sex, i.e.,*

$$(\partial x_{us}/\partial \gamma)|_{\delta=\theta=0} = \left(-U_{x_{us}\gamma} \cdot U_{x_s x_s}/D\right) > 0$$

Proof: See the appendix

A mean preserving increase in the spread of future health implies that the *distance* between the possible outcomes of future health increases, while the *expected health level* remains the same. As can be seen in Proposition 1, if $\delta = \theta = 0$, an increase in the uncertainty about future health has only one effect; uncertainty about future health reduces the expected utility of surviving to old age and therefore makes the cost of unsafe sex less salient. This in turn reduces the expected return to investments in health and increases incentives to engage in pleasurable, but risky, activities in the present. Next, let us analyze the effects of an increase in the expected level of health ($\tilde{h}_2^-$). Consider the following proposition:

Proposition 2. *If* $\delta = \theta = 0$, *a spread preserving increase in the expected value of future health reduces incentives to consume unsafe sex, i.e.,*

$$\left(\partial x_{us}/\partial \tilde{h}_2^-\right)\big|_{\delta=\theta=0} = \left(-U_{x_{us}\tilde{h}_2^-} \cdot U_{x_s x_s}/D\right) < 0$$

Proof: See the appendix

A spread preserving increase in the expected value of future health implies that, while the *distance* between high and low health outcomes remains the same, the *level* of both high and low health outcomes increases. To interpret the result in Proposition 2, let us again return to the first order conditions in equations (10) – (11). When $\delta = \theta = 0$, the only effect of unsafe sex is via the increase in the expected utility of surviving to old age. This implies that an increase in expected health effectively raises the marginal cost of consuming unsafe sex in terms of an increase in the loss of dying. Hence, an improvement in expectations of future health unambiguously reduces incentives to consume risky sex.

Finally, let us briefly analyze the effects of an increase in the per-coital[45] risk of acquiring HIV, represented by a *reduction* in φ. Consider the following proposition:

Proposition 3. *If* $\delta = \theta = 0$, *an increase in the per-coital risk of acquiring HIV,*

i) *reduces incentives to consume unsafe sex if* $1 > |x_{us} \cdot \ln(\varphi)|$ *, i.e.,*
$(\partial x_{us}/\partial\varphi)|_{\delta=\theta=0,1>|x_{us}\cdot\ln(\varphi)|} = \left(-U_{x_{us}\varphi} \cdot U_{x_s x_s}/D\right) > 0$

ii) *increases incentives to consume of unsafe sex if* $1 < |x_{us} \cdot \ln(\varphi)|$ *, i.e.,*
$(\partial x_{us}/\partial\varphi)|_{\delta=\theta=0,1<|x_{us}\cdot\ln(\varphi)|} = \left(-U_{x_{us}\varphi} \cdot U_{x_s x_s}/D\right) < 0$

Proof: See the appendix

An increase in the risk of acquiring HIV via an unprotected sexual act should intuitively increase incentives to abstain from engaging in risky sexual activities. However, as stated in Proposition 3, incentives to engage in sexual risk taking may actually increase if the risk of acquiring HIV via one unprotected sexual act increases. The intuition behind this result is that, if an individual that has engaged in relatively much sexual risk taking discovers that the HIV transmission rate has increased, the risk of already being infected also increases. This in turn causes the marginal cost of engaging in further risk taking to fall. Proposition 3 implies that an increase in HIV risk will create incentives for 'low risk' individuals to behave even more cautiously, while 'high risk' individuals experience increased incentives to engage in risky actions. This result is consistent with that of Kremer (1996).

Due to improved accessibility of ARV treatment and empirical evidence of a positive correlation between the improved availability of HIV treatment and sexual risk taking, the topic of the net value of improved accessibility of HAART and ARV treatment in poor countries has emerged on the donor agenda.[46] Consequently, it is of importance to investigate how the analysis of the previous sections changes as we allow HIV to be non-fatal.[47]

[45] The per-coital risk of HIV refers to the risk of HIV infection per sexual intercourse
[46] See e.g. Lakdawalla *et al.* (2006); Mechoulan (2007)
[47] I am thankful to an anonymous referee for pointing this out

Risky sex in a world with HIV treatment

If a partially or fully effective treatment to HIV exists, the last term in equation (11) is greater than zero. In other words, the presence of HIV treatment reduces the marginal cost of engaging in unsafe sex. Let us start by briefly analyzing the direct effects of improved access to HIV treatment (δ) and improved quality of HIV treatments (θ). Consider the following proposition:

Proposition 4. *An increase in the coverage rate of HIV treatment* (δ) *and/or the effectiveness of HIV treatment* (θ) *increases the incentives to engage in unprotected casual sex, i.e.,* $\partial x_{us}/\partial\delta = \left(-U_{x_{us}\delta} \cdot U_{x_s x_s}/D\right) > 0$ and $\partial x_{us}/\partial\theta = \left(-U_{x_{us}\theta} \cdot U_{x_s x_s}/D\right) > 0$.

Proof: See the appendix

For individuals engaging in sexual risk taking, an increase in the coverage rate of ARV drugs reduces the probability of dying prematurely of AIDS and an increase in the quality of the HIV treatment increases the quality of life given that the individual has access to this treatment. In other words, both the change in coverage and quality of ARV drugs reduces the expected health costs of an HIV infection. Consequently, the larger the share of the HIV infected population that has access to treatment and the better this treatment is, the smaller are the incentives to abstain from unprotected casual sex. The result in Proposition 4 is quite intuitive; if an effective treatment is available for HIV positive individuals; risky sex is not so risky anymore.[48] Thus, if the cost of HIV drugs is not carried by the treated individual, the private cost of engaging in unprotected sex may become negligible. However, the cost of ARV treatment is *not* negligible to governments (nor is it to individuals that may become infected by an HIV positive individual that continues to engage in unsafe sex). Hence, if HIV

[48] Given that treatment is provided for free by the government, naturally, HIV may be associated with other costs than those related to health. In many countries being infected with HIV is associated with social stigma and perhaps even social exclusion. In addition, an HIV infected individual has to endure the risk of infecting other individuals with the virus. However, although social norms and social preferences are likely to be important determinants of sexual behavior, the analysis of social mechanisms are beyond the scope of this paper.

treatment is free of charge, the availability of HAART creates a type of moral hazard in terms of reducing incentives to abstain risky sex.

As long as the available HIV treatment does not fully cure the patient from HIV, it is of great policy importance to investigate how varying levels of HIV treatment coverage (δ) and effectiveness (θ) affects sexual risk taking. However, the moral hazard of ARV treatment is not the main interest in this paper and will therefore not be further analyzed here. Instead, the main interest in this paper lies in how behavior under uncertainty changes when we introduce the possibility of surviving with HIV/AIDS.[49] Let us therefore continue our analysis by investigating the effect of improvements in the coverage rate and quality of HIV treatment on sexual risk taking under uncertainty. Consider the following proposition:

Proposition 5. *If ARV treatment with efficiency θ is freely available to a share δ of the HIV positive population, the effect of a mean preserving increase in the spread of future health on unsafe sexual consumption depends on the relative size of δ and θ.*

a) *If $\delta = \theta = 1$, a mean preserving increase in the spread of future health has no effect on the choice to consume unsafe sex, i.e.,*
$(\partial x_{us}/\partial\gamma)|_{\delta=\theta=1} = \left(-U_{x_{us}\gamma} \cdot U_{x_s x_s}/D\right) = 0$

b) *If $\theta = 1$, and $0 < \delta < 1$, a mean preserving increase in the spread of future health increases incentives to engage in sexual risk taking, i.e.,* $(\partial x_{us}/\partial\gamma)|_{\theta=1,0<\delta<1} = \left(-U_{x_{us}\gamma} \cdot U_{x_s x_s}/D\right) > 0$

c) *If $\delta = 1$, and $0 < \theta < 1$, a mean preserving increase in the spread of future health reduces incentives to engage in sexual risk taking, i.e.,*
$(\partial x_{us}/\partial\gamma)|_{\delta=\theta=1}|_{\delta=1,0<\theta<1} = \left(-U_{x_{us}\gamma} \cdot U_{x_s x_s}/D\right) < 0$

d) *If $0 < \theta < 1$, and $0 < \delta < 1$, a mean preserving increase in the spread of future health creates conflicting effects on the incentives to engage in sexual risk taking (the sign of the derivatives are ambiguous).*

Proof: See the appendix

[49] For an analysis of the presence of moral hazard see Lakdawalla *et al.* (2006)

The intuition behind Propositions 5a and 5b is relatively straight forward. If the treatment is freely and globally available and if the treatment actually cures HIV (or at least provides the infected individual with the same health and longevity as an uninfected individual), unprotected casual sex no longer has a future cost and can thus not be deemed as a risky activity[50]. Hence, with $\delta = \theta = 1$, the introduction of uncertainty does not change the first order conditions, and therefore not behavior, in period one. If treatment is effective but coverage is less than global, unprotected sex is still associated with an expected future cost. Hence, as in Proposition 1, an increase in future uncertainty increases incentives to engage in unsafe sex.

If coverage of HIV treatment is global but not completely effective (Proposition 5c), an increase in uncertainty reduces incentives to engage in unsafe sex. As before, the increase in uncertainty reduces the expected utility of surviving to old age. However, if the health of an HIV infected individual is lower than that of an uninfected individual, the expected utility of living with infection falls relatively more than the expected utility of living without. Hence, an increase in the spread between high and low health outcomes makes it less tempting to engage in unsafe sex as the spread increases the expected cost of *living* with HIV in period two. The lower the average health of an HIV positive individual is (as long as he or she is still alive), the greater is the reduction in the expected utility of health due to an increase in the spread between high and low health.

Finally, if treatment is not freely available and does not fully restore health, an increase in the uncertainty of future health creates conflicting incentives concerning sexual choices. The larger the share of the HIV positive population that can access treatment, the smaller the expected cost of an unprotected sexual act and consequently the smaller the effect of uncertainty on the choice to engage in unsafe sex. However, the less efficient the accessed treatment is, the more uncertainty will increase the perceived health cost of living with HIV, and the

[50] Naturally, casual unprotected sex may still have other costs in terms of other types of sexually transmitted infections, the risk of violence, etc. These aspects are interesting, but outside of the scope of the paper. They have therefore been left out of the analysis.

greater incentives will be to remain HIV negative in an uncertain environment. Thus, if the share of *un*treated HIV positive individuals is relatively large and the treatment is relatively effective, the net change in the expected cost of engaging in unprotected casual sex will be negative as the reduction in the perceived cost of *dying* of AIDS will outweigh the reduction in utility of *living* with HIV.

Next, let us turn to how the presence of ARV treatment affects incentives to engage in unsafe sex when the expected health level of both HIV positive- and negative individuals changes. If ARV drugs are globally available but unable to fully restore health, the effect of improvements in the expected level of future health ($\tilde{h}_2^-$), on sexual risk taking in the present (x_{us}), cannot in general be signed. The direction of the effect to a large extent depends on a measure that resembles a discrete version of the Arrow-Pratt measure of relative risk aversion.[51] Let us denote this discrete measure of relative risk aversion as *DR*:

$$DR = -\frac{\theta \cdot \tilde{h}_2 \cdot \left(\rho \cdot u_{h^+_{high}h^+_{high}} + (1-\rho) \cdot u_{h^+_{low}h^+_{low}}\right)}{\left(\rho \cdot u_{h^+_{high}} + (1-\rho) \cdot u_{h^+_{low}}\right)} > 0 \qquad (13)$$

where $u_{h^+_{high}h^+_{high}} = \partial^2 u(c_2, h^+_{high})/\partial\left(h^+_{high}\right)^2$ and $u_{h^+_{high}h^+_{high}} = \frac{\partial^2 u(c_2, h^+_{high})}{\partial\left(h^+_{high}\right)^2}$.

Consider proposition 6:

Proposition 6. *If ARV treatment with efficiency θ is freely available to a share (δ) of the HIV positive population, the effect of a spread preserving increase in the mean of future health on unsafe sexual consumption depends on the relative size of δ and θ.*

a) *If $\delta = \theta = 1$, a spread preserving increase in the mean of future health has no effect on the choice to consume unsafe sex, i. e., $\left(\partial x_{us}/\partial \tilde{h}_2^-\right)\big|_{\delta=\theta=1} = \left(-U_{x_{us}\tilde{h}_2^-} \cdot U_{x_s x_s}/D\right) = 0$*

b) *If $\theta = 1$, and $0 < \delta < 1$, a spread preserving increase in the mean of future health reduces incentives to engage in sexual risk taking, i.e., $\left(\partial x_{us}/\partial \tilde{h}_2^-\right)\big|_{\theta=1,0<\delta<0} = \left(-U_{x_{us}\tilde{h}_2^-} \cdot U_{x_s x_s}/D\right) < 0$*

[51] $R = -u''(x) \cdot x/u'(x)$.

c) If $\delta = 1$*, and* $0 < \theta < 1$*, the effect of a spread preserving increase in the mean of future health depends on the degree of "discrete relative risk aversion"* (DR)*.*

i) *If* $DR > 1$*, a spread preserving increase in future health increases incentives to consume unsafe sex, i.e.,*

$$\left(\partial x_{us}/\partial \tilde{h}_2^-\right)\big|_{\delta=1,0<\theta<1,DR>1} = \left(-U_{x_{us}\tilde{h}_2^-} \cdot U_{x_s x_s}/D\right) > 0$$

ii) *If* $DR = 1$*, a spread preserving increase in future health has no effect on incentives to consume unsafe sex, i.e.,* $\left(\partial x_{us}/\partial \tilde{h}_2^-\right)\big|_{\delta=1,0<\theta<1,DR=1} =$

$$\left(-U_{x_{us}\tilde{h}_2^-} \cdot U_{x_s x_s}/D\right) = 0$$

iii) *If* $DR < 1$*, a spread preserving increase in future health reduces incentives to consume unsafe sex, i.e.,*

$$\left(\partial x_{us}/\partial \tilde{h}_2^-\right)\big|_{\delta=1,0<\theta<1,DR<1} = \left(-U_{x_{us}\tilde{h}_2^-} \cdot U_{x_s x_s}/D\right) < 0$$

d) If $0 < \theta < 1$*, and* $0 < \delta < 1$*, the effect of a spread preserving increase in the mean of future health creates conflicting effects on incentives to engage in sexual risk taking.*

Proof: See the appendix

As in Proposition 5, an effective and globally available treatment of HIV implies that unprotected casual sex has no HIV related future cost. Hence, changes in the expected level of future health do not affect incentives to engage in sexual risk taking in the present (Proposition 6a). However, if the coverage rate of HIV treatment is less than global, or if ARV treatment only partially restores health, some cost of engaging in unsafe sex prevails (Propositions 6b and 6c).

With a fully effective treatment but only partial coverage of this treatment, an expected improvement in future health can easily be seen to unambiguously increase the perceived cost of engaging in unsafe sex. However, with global coverage of a treatment that only partially restores health; the effect of an improvement of future health will be affected by the discrete relative risk aversion measure in equation (13). To see this, note that an increase in $\tilde{h}_2^-$ has two effects on the incentives to engage in sexual risk taking; it increases the expected utility of remaining HIV negative, but it also reduces the cost of acquiring HIV since the

expected health of HIV *positive* individuals increases proportionally to that of HIV *negative* individuals. Hence, whether the consumption of unsafe sex increases or decreases will depend on which one of these effects is dominant. This, in turn, depends on our measure of discrete relative risk aversion (*DR*).

Now, for all risk averse individuals, the marginal valuation of future health diminishes as the expected health increases; the greater the risk aversion, the greater the rate at which the marginal utility is reduced. This implies that, if relative risk aversion is "sufficiently" high (in our case DR>1), the *increase* in the expected value of being HIV positive will be smaller than the *reduction* in the expected cost of being HIV positive (i.e., the reduction in the expected marginal utility of being HIV negative is greater than the expected reduction in the marginal utility of being HIV positive). For individuals with a low relative risk aversion (DR<1), on the other hand, the *increase* in the expected utility of remaining HIV positive will outweigh the *reduction* in the expected cost of an HIV infection.

The above analysis abstracts from savings. If saving possibilities were included in the analysis, changes in the marginal utility of consumption in period 2 due to expected changes in future health would spill over on incentives to save. In other words, the incentives to consume unsafe sex would also be affected by changes in the budget space for consumption in period 1.[52] As health and consumption are assumed to be complements, improvements in expected future health raises the marginal value of future consumption and thereby incentives to save, while an increase in uncertainty reduces it. It would thus seem that there are even more incentives to abstain from unsafe sex if the expected health in period 2 improves, and even more incentives to engage in more risky sex if the uncertainty of future health increases. However, since safe and unsafe sex activities are assumed to be substitutes, other mechanisms may work in the opposite direction. For example, if safe sex consumption in period one is reduced as a consequence of increased savings, incentives to consume unsafe sex increases. Consequently, although the

[52] For a technical analysis of this scenario (in the absence of HIV treatment), see the background working paper by Mannberg (2009)

improvement in future health increases incentives to *abstain* from unsafe sex, the reduction in safe sex contributes to an increase in the incentives to *engage* in unsafe sex.

III. Discussion and policy implications

The main question asked in this paper, is whether the high degree of uncertainty and low level of general health can help us understand the persistent presence of sexual risk taking in countries where HIV prevalence is high. The above analysis suggests that there is no such thing as "one size fits all" when it comes to AIDS policy. Instead, we need to calibrate interventions for different social and physical contexts. As showed above, the degree of uncertainty and expected level of future health, the access to and quality of ARV drugs, and the individual risk preferences, all interact and affect the outcome of AIDS interventions. Although the model is highly stylized, it nevertheless provides a number of interesting results and I would like to linger around some possible policy implications.

For individuals with no access to HIV treatment, uncertainty of future health contributes to low expected benefits of health investments and a low expected cost of health destructive behavior. Likewise, low levels of expected future health contribute to low levels of perceived costs regarding unsafe sex activities. In regions where access to ARV drugs is limited, interventions that improve general health and reduces uncertainty may thus constitute an important ingredient in an effective AIDS policy. For a large share of the HIV susceptible population in sub-Saharan Africa, the above scenario fits the picture. Hence, interventions such as the distribution of impregnated mosquito nets and immunization programs may thus be candidates for a more holistic AIDS policy in these areas. Indeed, Oster (2007a) shows that the average number of sex partners in life is an increasing function of the malaria frequency. It is interesting to note that, between 2002 and 2005, a Malaria intervention program in Zanzibar reduced malaria attributed

mortality in children under five with over 70 percent.[53] It may be too early to investigate currently, but it will be of importance to eventually investigate whether this intervention had any effect on sexual behavior.

The results also suggest that the recommendations for policy changes with the availability and quality of ARV drugs. Now, the societal costs and benefits of ARV drugs are outside the scope of this paper. Hence, although it is of great interest to analyze the net social benefit of HIV treatment, it will not be discussed further here. Instead, I will settle with a brief discussion on how the implications for health related policy changes in a world where ARV drugs are increasingly available and effective.

The above results suggest that, the larger the share of the HIV positive population that is covered by HAART, the less beneficial will policy that focuses on reductions in uncertainty be for sexual risk taking. Hence, while it may be major importance to focus AIDS policy on social insurance etc. in poor countries, it may be of little interest (it may even be destructive) to focus AIDS policy on reducing uncertainty in rich countries.

As of today, we are still unable to cure HIV. However, over the years there has been a substantial improvement in the effectiveness of ARV drugs. According to Proposition 5, the more effective HIV treatment becomes, the more important it will be to invest resources in improving overall health in areas where access to drugs is limited. Thus, if a cure for HIV is found in the future and if we lack resources to distribute this cure to all, it may be of great value to intensify efforts on general health interventions such as immunization programs etc.

Proposition 5 further suggests that as long as we cannot cure HIV, risk preferences among targeted individuals will affect the outcome of AIDS policy. More specifically, the more risk prone an individual is, the more likely it is that a policy aimed to improve general health will increase the incentives to abstain from unsafe sex consumption. Some of the most HIV susceptible populations can be suspected to be less risk averse than the average person (e.g. CSW's, mine

[53] See Bhattarai *et al.* (2007)

workers, military workers, and drug users). Hence, according to Proposition 5, health focused interventions may be of great importance in these populations.

In accordance with Kremer (1996), my results suggest that a reduction in HIV prevalence may actually increase the perceived marginal cost of unsafe sex for individuals with a high level of initial sexual activity. In combination with Propositions 5 and 6, the result in Proposition 3 suggests that policy directed to general health improvements and reductions in uncertainty, together with an imperfect vaccine against HIV, may constitute an efficient way to reduce sexual risk taking.

One of the main obstacles left for reducing HIV incidences in poor countries has been identified as the lack of behavioral change in high risk groups such as commercial sex sellers, mine workers, and refugees. Taken together, the above analysis suggests that policies that improves the general health and reduces uncertainty may be of particularly benefit to these populations. In the above, I have distinguished between policies that only changes uncertainty (in terms of the spread between high and low health outcomes) and policies that only affects the expected level of health (thus leaving the variability unchanged). When it comes to policy, it is difficult to design interventions that solely create *mean preserving* reductions in the spread, or *spread preserving* increases in the mean. Policies aimed to reduce uncertainty of health are likely to also affect the expected level of future health. For example, an increase in the presence of police officers, fire brigades, more permanent houses and better sewage systems in refugee camps, would both reduce uncertainty *and* improve health prospects. Likewise, providing miners and CSW's with social insurance and improved work conditions, and providing resources for institution building in countries torn by civil unrest, are likely to improve general health and to reduce uncertainty. However, given the results presented above, both reductions in uncertainty and improvements in health may, in addition to their direct effect on household welfare, provide beneficial spill-over effects on the spread of HIV in poor countries.

Appendix

Table A1 Parameter and variable description

Greek letter	**Description**
β	Discount factor
δ	Coverage rate of ARV drugs in HIV positive population
φ	Probability of remaining HIV negative after one risky sexual act
γ	Spread between high and low health in period two
ρ	Probability of positive health shock
θ	Effectiveness of ARV drugs
Other variables and parameters	
c_t	Consumption
x_{us}	Unsafe sex consumption
x_s	Safe sex consumption
$\tilde{h}_2^-$	Expected health conditional on being HIV negative
h_{high}^-	High health outcome for an HIV negative individual
h_{low}^-	Low health outcome for an HIV negative individual
h_{high}^+	High health outcome for an HIV positive individual
h_{low}^+	Low health outcome for an HIV positive individual
$q_{x_{us}}$	Price of unsafe sex
q_{x_s}	Price of safe sex

Proof of Proposition 1

If $\delta = \theta = 0$, the direct effects of changes in the spread of future health on safe and unsafe sex consumption are given by:

$$U_{x_s\,\gamma} = 0 \tag{A1}$$

$$U_{x_{us}\,\gamma} = \beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \rho \cdot (1-\rho) \cdot \left(u_{h_{high}^-} - u_{h_{low}^-}\right) > 0 \tag{A2}$$

where $u_{h_{high}^-} = \partial u(c_2, h_{high}^-)/\partial\, h_{high}^-$, and $u_{h_{low}^-} = \partial u(c_2, h_{low}^-)/\partial\, h_{low}^-$. Since $U_{x_s\,x_s} < 0$, and $D > 0$ by the second order conditions for a maximum, and

$U_{x_{us}\,x_s} < 0$ by assumption, we see that, $(\partial x_{us}/\partial\gamma)|_{\delta=\theta=0} = \left(-U_{x_{us}\gamma} \cdot U_{x_s x_s}/D\right) > 0$, q. e. d.

Proof of Proposition 2

If $\delta = \theta = 0$, the direct effects of a spread preserving increase in the expected future health status on safe and unsafe sex consumption are given by:

$$U_{x_s\,\tilde{h}_2^-} = 0 \tag{A3}$$

$$U_{x_{us}\tilde{h}_2^-} = \beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \left[\rho \cdot u_{h_{high}^-} + (1-\rho) \cdot u_{h_{low}^-}\right] < 0 \tag{A4}$$

Hence, $\left(\partial x_{us}/\partial \tilde{h}_2^-\right)\big|_{\delta=\theta=0} = \left(-U_{x_{us}\tilde{h}_2^-} \cdot U_{x_s x_s}/D\right) < 0$, q. e. d.

Proof of Proposition 3

If $\delta = \theta = 0$, the direct effect of a reduction in the risk of acquiring HIV via an unprotected sexual act is given by:

$$U_{x_s\varphi} = 0 \tag{A5}$$

$$U_{x_{us}\varphi} = \beta \cdot \varphi^{x_{us}-1} \cdot [\rho \cdot \left(u\left(c_2, h_{high}^-\right) + (1-\rho) \cdot u(c_2, h_{low}^-)\right)] \cdot [1 + x_{us} \cdot \ln(\varphi)] \tag{A6}$$

The sign of equation (A6) depends on the amount of unsafe sex previously consumed by the individual and of the per-coital risk of acquiring HIV. For high values of φ (low per-coital risk of an HIV infection) and low values for x_{us}, (A6) will be negative. Hence, $\left(-U_{x_{us}\varphi} \cdot U_{x_s x_s}/D\right) < 0$. However, for small values of φ, and large values for x_{us}, (A6) will be positive. Hence, $\left(-U_{x_{us}\varphi} \cdot U_{x_s x_s}/D\right) > 0$, q. e. d.

Proof of Proposition 4

The direct effects of a change in the coverage rate of HIV treatment on unsafe sex consumption are given by:

$$U_{x_s\,\delta} = 0 \tag{A7}$$

$$U_{x_{us}\,\delta} = -\beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \left[\rho \cdot u\left(c_2, h^+_{high}\right) + (1-\rho) \cdot u(c_2 h^+_{low})\right] > 0 \tag{A8}$$

Hence, $\partial x_{us}/\partial\delta = \left(-U_{x_{us}\delta} \cdot U_{x_s x_s}/D\right) > 0$. The direct effects of a change in the effectiveness of HIV treatment on unsafe sex consumption are given by:

$$U_{x_s\,\theta} = 0 \tag{A9}$$

$$U_{x_{us}\,\theta} = -\beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \delta \cdot \tilde{h}_2^- \left[\rho \cdot u_{h^+_{high}} + (1-\rho) \cdot u_{h^+_{low}}\right] > 0 \tag{A10}$$

Hence, $\partial x_{us}/\partial\theta = \left(-U_{x_{us}\theta} \cdot U_{x_s x_s}/D\right) > 0$, q. e. d.

Proof of Proposition 5

If $0 < \delta, \theta \leq 1$, $U_{x_{us}\,\gamma}$ is given by:

$$U_{x_{us}\,\gamma} = \beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \left[\rho \cdot (1-\rho) \cdot \left[\left(u_{h^-_{high}} - u_{h^-_{low}}\right) - \delta \cdot \left(u_{h^+_{high}} - u_{h^+_{low}}\right)\right]\right] \tag{A11}$$

Hence if $\theta = \delta = 1$, then $\left|u_{h^-_{high}} - u_{h^+_{low}}\right| = \delta \cdot \left|u_{h^+_{high}} - u_{h^-_{low}}\right|$, and thus $U_{x_{us}\,\gamma} = \partial x_{us}/\partial\gamma = 0$.

If $\theta = 1$, and if $0 < \delta < 1$, then $\left|u_{h^-_{high}} - u_{h^+_{low}}\right| > \delta \cdot \left|u_{h^+_{high}} - u_{h^-_{low}}\right|$. Thus $U_{x_{us}\,\gamma} > 0$ and we thereby have that $\partial x_{us}/\partial\gamma > 0$.

If $\delta = 1$, and if $0 < \theta < 1$, then $\left|u_{h^-_{high}} - u_{h^+_{low}}\right| < \delta \cdot \left|u_{h^+_{high}} - u_{h^-_{low}}\right|$ in absolute value. Thus $U_{x_{us}\,\gamma} < 0$ and we thereby have that $\partial x_{us}/\partial\gamma < 0$.

If $0 < \delta, \theta < 1$, the sign of equation (A11) remains ambiguous. A differentiation of equation (A8) with respect to δ and θ produces the following expressions,

$$\frac{\partial U_{x_{us}\gamma}}{\partial \delta} = -\beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \rho \cdot (1-\rho) \cdot \left(u_{h^+_{high}} - u_{h^+_{low}}\right) < 0 \tag{A12}$$

$$\begin{aligned}\frac{\partial U_{x_{us}\gamma}}{\partial \theta} = &-\beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \rho \cdot (1-\rho) \cdot \delta \cdot \tilde{h}_2^- \\ &\cdot \left(u_{h^+_{high}h^+_{high}} - u_{h^+_{low}h^+_{low}}\right)\end{aligned} \tag{A13}$$

Equation (A12) implies that the smaller δ is, the greater is the value of $U_{x_{us}\gamma}$. Consequently, if $0 < \theta < 1$, then the smaller δ is, the more likely it is that $\partial x_{us}/\partial\gamma > 0$. The sign of equation (A13) depends on the third order derivative of health related utility. If the third order derivative of future utility with respect to health is greater or equal to zero, then equation (A13) implies that the larger θ is, the larger is $U_{x_{us}\gamma}$ Consequently, the probability that $\partial x_{us}/\partial\gamma > 0$ increases with the magnitude of θ, q. e. d.

Proof of Proposition 6

If $0 < \delta, \theta \leq 1$, $U_{x_{us}\tilde{h}_2^-}$ is given by:

$$\begin{aligned}U_{x_{us}\tilde{h}_2^-} = \beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \Big[&\left(\rho \cdot u_{h^-_{high}} + (1-\rho) \cdot u_{h^-_{low}}\right) \\ &- \delta \cdot \theta \cdot \left(\rho \cdot u_{h^+_{high}} + (1-\rho) \cdot u_{h^+_{low}}\right)\Big]\end{aligned} \tag{A14}$$

Thus, if $\theta = \delta = 1$, then $\left(\rho \cdot u_{h^-_{high}} + (1-\rho) \cdot u_{h^-_{low}}\right) = \delta \cdot \theta \cdot \left(\rho \cdot u_{h^+_{high}} + (1-\rho) \cdot u_{h^+_{low}}\right)$, and $U_{x_{us}\tilde{h}_2^-} = \partial x_{us}/\partial \tilde{h}_2^- = 0$. If $\theta = 1$, and $0 < \delta < 1$, then $\left|\rho \cdot u_{h^-_{high}} + (1-\rho) \cdot u_{h^-_{low}}\right| > \delta \cdot \theta \cdot \left|\rho \cdot u_{h^+_{high}} + (1-\rho) \cdot u_{h^+_{low}}\right|$. Hence $U_{x_{us}\tilde{h}_2^-} < 0$, and we thereby have that $\partial x_{us}/\partial \tilde{h}_2^- < 0$.

If $\delta = 1$, and $0 < \theta < 1$ equation (A14) is not signed. However, by differentiating the expression $\theta \cdot \left(\rho \cdot u_{h^+_{high}} + (1-\rho) \cdot u_{h^+_{low}}\right)$ in equation (A14) with respect to θ and rearranging terms we get the expression:

$$\frac{\partial}{\partial\theta}\left[\theta\cdot\left(\rho\cdot u_{h^{+}_{high}}+(1-\rho)\cdot u_{h^{+}_{low}}\right)\right] = \left[1+\frac{\theta\cdot\ \tilde{h}_2\cdot\left(\rho\cdot u_{h^{+}_{high}h^{+}_{high}}+(1-\rho)\cdot u_{h^{+}_{low}h^{+}_{low}}\right)}{\left(\rho\cdot u_{h^{+}_{high}}+(1-\rho)\cdot u_{h^{+}_{low}}\right)}\right] \tag{A15}$$

The expression on the RHS of equation (A15) is positive if the second term within the square brackets is smaller than one in absolute value and negative if the term is larger than one in absolute value. It is tempting to describe the second term within square brackets as some form of discrete measure of relative risk aversion.[54] Let us denote this measure DR. As $\left(\rho\cdot u_{h^{-}_{high}}+(1-\rho)\cdot u_{h^{-}_{low}}\right)-\theta\cdot\delta\cdot\left(\rho\cdot u_{h^{+}_{high}}+(1-\rho)\cdot u_{h^{+}_{low}}\right)=0$ for $\theta=1$, we have the following results:

i. If $\delta=1,\ 0<\theta<1$, and $DR>1$, then $\partial x_{us}/\partial\tilde{h}_2^{-}>0$

ii. If $\delta=1,\ 0<\theta<1$, and $DR<1$ then $\partial x_{us}/\partial\tilde{h}_2^{-}<0$

iii. If $\delta=1,\ 0<\theta<1$, and $DR=1$ then $\partial x_{us}/\partial\tilde{h}_2^{-}=0$ [55], q. e d.

If $0<\theta,\delta<1$, the sign of equation (A14) depends both on the magnitude of DR and on the size of δ. By differentiating equation (A15) with respect to δ we see that:

$$\frac{\partial U_{x_{us}\,\tilde{h}_2}}{\partial\delta}=-\beta\cdot\ln(\varphi)\cdot\varphi^{x_{us}}\cdot\theta\cdot\left(\rho\cdot u_{h^{+}_{high}}+(1-\rho)\cdot u_{h^{+}_{low}}\right)>0 \tag{A16}$$

Hence, if $0<\theta<1$ the larger δ is, the more likely it is that $U_{x_{us}\,\tilde{h}_2^{-}}>0$ and therefore that $\partial x_{us}/\partial\tilde{h}_2^{-}>0$ q. e. d.

[54] This measure should be compared to the continuous measure of relative risk aversion; $-u''(x)\cdot x/u'(x)$

[55] Empirical estimates concerning the size of the relative risk aversion coefficient vary substantially, but estimates are commonly larger than one; see e.g. Meyer & Meyer (2005). However, most empirical estimates have mostly been based on data from financial economics. These estimates have been shown to be inconsistent with the income elasticity of the value of statistical life (VSL), which is commonly estimated at 0.5-0.6, consequently, we know little of the size of the relative risk aversion concerning future health, and even less of expression depicted in equation (A13); Kaplow (2005).

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II

Sexual Risk Taking among Young Adults in Cape Town

- Effects of Expected Health and Income

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Abstract

This paper empirically assesses links between expectations of future health and income on sexual risk taking on a sample of young adults in Cape Town, South Africa. An important contribution of the paper lies in combining a wide range of variables measuring risky sexual behavior such that the maximum information possible is extracted from, and adequate weights are attached to each measure, as opposed to previous studies that are based on individual measures or arbitrary aggregations. The findings indicate that expected income and health and future uncertainty are significant determinants of current patterns of sexual risk taking. From a policy perspective, the results suggest that reducing poverty and improving social insurance as well as reducing the taboo related to talking about HIV may constitute important issues to be addressed.

Keywords: HIV/AIDS, Health risk, Risk aversion
JEL-Classification: D81, D84, D91, I10

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1. Introduction

In 2008, 67 percent of all HIV infections in the world could be found in sub-Saharan Africa and HIV/AIDS is today one of the main causes of premature death in the region (UNAIDS, 2009; Rao *et al.,* 2006). In spite of rising knowledge levels and a nearly global awareness of HIV, sexual risk taking still prevail in many HIV infested countries. Indeed, although HIV prevalence among commercial sex workers (CSW's) can be as high as 70 percent in some areas, demand for unprotected commercial sex has been found sufficiently high to produce a price of 4 times that of commercial sex with a condom (Abdool *et al.*, 1995; Swart-Kruger and Richter, 1997; Robinson & Yeh, 2008).

The purpose of this paper is to address the issue of seemingly irrational sexual risk taking in the presence of HIV/AIDS. More specifically, we test the hypothesis that future prospects of health and income are interlinked with present sexual risk taking on a dataset consisting of young adults in Cape Town, South Africa.

The analysis of how contextual uncertainty and expectations of future health and income affect incentives to engage in safe sex practices is of interest for many reasons. First and foremost, interventions aimed to reduce the spread of HIV have to date been relatively ineffective. Although educational campaigns have contributed to a nearly universal awareness of HIV and to some reductions in sexual risk taking in terms of an increase in condom use and a reduction in the number of sex partners, condom use remains at best inconsistent and the lack of behavioral change in high risk groups effectively means that there are almost no signs of significant reductions in HIV rates[1] (e.g. Caldwell, 1999; Caldwell, 2000; Bloom *et al.*, 2000; Buvé *et al.*, 2001; Williams *et al.*, 2003; Mwaluko *et al.,* 2003; Hearst & Chen, 2004; UNAIDS, 2009).

[1] Lagarde *et al.* (2001) estimate condom coverage at 27-31 percent for men and 11-17 percent for women in a number of highly affected cities in sub-Saharan Africa. In Zambia the share of unprotected sexual acts with non-cohabiting partners actually increased during the late 1990's.

In addition, although the development of antiretroviral (ARV) treatment has improved health and extended the life length of HIV positive individuals, HIV remains incurable and AIDS is still associated with premature death. Similarly, although access to ARV treatment has improved substantially, many individuals remain both undiagnosed and untreated. [2]

Our findings indicate that AIDS policy, in order to be effective, may need to take a more holistic approach than only focusing on information and condom availability. If uncertainty about future prospects affects incentives to invest in health in the present, public policy on information campaigns and condom distribution may need to be complemented by additional investments in social insurance and poverty reduction.

Health related uncertainty and low expectations of the future are naturally not the only explanations to excessive risk taking. Myths and misinformation about HIV/AIDS and condoms still exist, and most likely constitute a part of the explanation. However, the lack of HIV knowledge cannot fully explain persisting unsafe sex practices; a number of surveys and studies on sexual behavior show that sexual risk taking persists in spite of relatively adequate HIV knowledge and access to condoms (e.g. Campbell, 1997; Varga, 1997; Pettifor *et al.* 2000; MacPhail and Campbell, 2001; Pettifor *et al,* 2004). HIV susceptible populations, in both rich and poor countries, are mainly comprised of individuals living under a greater degree of uncertainty than the average population. In sub-Saharan Africa, the main populations at risk are constituted by refugees, commercial sex workers (CSW's), miners, military personnel and transport workers[3] (UNAIDS &

[2] The percentage of pregnant women receiving antiretroviral treatment has improved substantially over that past couple of years. In many countries with reports of coverage rates, numbers are as high as 80 percent. However, although the trend in antiretroviral treatment distribution in poor countries has been positive, the number of new HIV infections each year outnumbers the increase in individuals on ARVs, by 2.5 to 1; See e.g. UNAIDS (2008); Rao *et al.* (2006).

[3] For example, miners in sub-Saharan Africa face daily threats of mutilation or death in work related accidents (2.9 % probability of being killed in a work related accident and 42 % probability of suffering a reportable injury during a 20-year working life, according to the South African Chamber of Mines). Likewise, military personnel live under great risk of having their future cut short. In Thailand soldiers have been found to visit prostitutes to a higher extent, and to use condoms to a lesser extent, than other Thai men (VanLandingham *et al.* 1993). The relatively higher level of consumption of commercial sex in these groups is perhaps partly explained by the fact that, for example, miners and

IOM, 2003). For these groups, HIV is likely to represent a significant threat but it may not be dominant in daily life.[4]

The empirical analysis presented below is based on a longitudinal dataset on young adults in Cape Town, South Africa (The Cape Area Panel Study (CAPS))[5]. In South Africa, the spread of HIV/AIDS has been explosive: HIV prevalence has increased from less than 1 percent in 1990, to over 20 percent only 10 years later[6] (Pettifor *et al.*, 2004; Simbayi *et al.*, 2004; Connolly *et al.*, 2004). Age group analysis suggests that HIV incidence is substantially overrepresented among youth in their late teens and that HIV prevalence varies both between population groups and between regions (e.g. MacPhail & Campbell, 2001; Lam *et al.,* 2008).

2. Previous economic research

Sexual behavior may not be a conventional subject within the economic field of research. However, research in economics has provided interesting insights concerning the incentives to engage in sexual risk taking in the presence of HIV. Important contributions include Philipson & Posner (1993; 1995), Schroeder and Rojas (2002), Kremer (1996), Gertler *et al.,* (2005), Robinson & Yeh (2008) and Oster (2007a). Philipson and Posner (1993) show that the inclusion of marginal costs and benefits associated with unprotected casual sex improves prediction

migrant workers live away from their families. However, this fact does not explain the low degree of condom use.

[4]In Sierra Leone, estimated HIV prevalence was estimated lie between 60 and 70 percent among soldiers in 2002 and HIV frequencies among prostitutes increased from 26.7 percent to 70.6 during the civil war (UNAIDS/WHO (2002).

[5] The Cape Area Panel Study Waves 1-2-3 were collected between 2002 and 2005 by the University of Cape Town and the University of Michigan, with funding provided by the US National Institute for Child Health and Human Development and the Andrew W. Mellon Foundation. Wave 4 was collected in 2006 by the University of Cape Town, University of Michigan and Princeton University. Major funding for Wave 4 was provided by the National Institute on Aging through a grant to Princeton University, in addition to funding provided by NICHD through the University of Michigan.

[6] Estimates are based on pregnant women visiting public clinics in 1990 and 2000. HIV prevalence estimates based on antenatal clinic visitors are problematic. Pregnant women are bound to be both sexually active and to have engaged in unprotected sex. Hence, the estimates presented above are biased upward. However, national figures on HIV are no less alarming than previous estimates from antenatal clinics. Nationally representative surveys on HIV prevalence have only recently been available. In 2003, HIV prevalence amounted to 19.2 percent in a representative sample of the adult population, and the HIV frequency among young adults was estimated at around 10 percent (Pettifor *et al.*, 2004; Simbayi *et al.*, 2004; Connolly *et al.*, 2004)

accuracy of epidemiological models. Early epidemiological models predicted that HIV prevalence would explode as the pool of potential virus hosts increased. However, since an increase in HIV prevalence increases the marginal cost of unsafe sex for HIV negative individuals, it also increases incentives to abstain from risky sex. The predictions of Philipson and Posner (1993) thus suggest that the rate at which HIV spread will not necessarily increase as HIV prevalence increases (see also Schroeder and Rojas, 2003). Philipson and Posner (1995) further suggest that the prevailing differences in HIV prevalence rates between rich and poor countries can be explained in terms of an inelastic supply of sexual services among CSW's in poor countries. This hypothesis is supported by a number of empirical studies in poor countries suggesting that CSW's accept unprotected sex due to the substantial income loss associated with condom use. The driving mechanism behind the price differential for condom-free sex is partly explained by strong preferences for unprotected sex among clients (e.g., Rao *et al.,* 2003; Gertler *et al.,* 2005; Robinson & Yeh, 2008).

Kremer (1996) provides an interesting alternative explanation to observed differences in epidemiological development. Kremer note that the marginal cost associated with HIV risk does not only depend on the per-coital risk[7] of an HIV infection, it also depends on the probability of being HIV positive since, disregarding altruistic objectives, an HIV positive individual has little to lose from having unprotected sex.[8] This implies that, at sufficiently high perceived risk of HIV, individuals may deem the likelihood of already being infected with the virus to be sufficiently high to make abstaining from risky sex relatively meaningless. Hence, within countries or groups of individuals where sexual activity is initially high, an increase in HIV prevalence may create reckless sexual behavior.

The empirical analysis presented in this paper relates most closely to a number of economic papers that incorporates the effect of physical and social context on

[7] i.e., the probability of acquiring HIV through 1 unprotected sexual act

[8] Admittedly, unprotected sex for an HIV positive individual is still risky since the individual may acquire another STI which in turns reduces the immune system's ability to keep maintain the viral load at low levels. See, e.g., Piasani, 2008

health related behavior.[9] The empirical analysis of Dow *et al.* (1999) suggests that health policy in poor countries may have positive spill-over effects on private health seeking behavior. Interventions, such as immunization programs, reduce pressing mortality risks and thereby increase the marginal benefit of private health investments. Benz (2005) follows the same line of argument and suggests that the correlation between high HIV prevalence and experiences of civil conflict can at least partly be explained by increased in uncertainty associated with crumbling civic institutions. Dinkelman *et al.* (2007) do not explore the direct link between economic shocks and sexual risk taking in South Africa. However, the empirical analysis suggests that the sexual debut of youth from poor households occurs at younger age than young adults from richer households. In addition, poor young adults use condoms less frequently than richer young adults. In the paper most closely related to our analysis, Oster (2007a) suggests that a reduction in expected life length or future earnings reduces the expected cost of risky sexual behavior. Using cross-sectional data from nine African countries[10], her findings indicate that, while HIV knowledge and HIV frequency does not have a significant effect on the number of sex partners, income levels and expected life length do affect sexual risk taking.[11]

Although the above mentioned research has contributed with important insights on the mechanisms behind sexual risk taking, several questions remain unanswered. Gertler *et al.* (2005) provide an answer to why commercial sex workers demand a higher price for supplying unprotected sexual services. However, their analysis does not address the fact that the buyer of the sexual service is willing to pay a higher price for the risky alternative. Given the high risk of infection, a rational buyer should intuitively be willing to pay more for *safe* sex

[9] See e.g. Dow *et al.* (1999); Benz (2005); Dinkelman *et al.* (2007); Oster (2005; 2007a).
[10] Demographic and Health data are available for Benin, Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Mali, Namibia and Zimbabwe.
[11] In order to deal with the obvious endogeneity between life expectancy and HIV prevalence, malaria frequency and maternal mortality is used as a proxy for life expectancy. Oster further acknowledges the link between sexual promiscuity and HIV prevalence, and therefore uses the distance to the (believed) origin of the HIV virus (the Democratic Republic of Congo) as an instrument for HIV frequency.

rather than for *unsafe* sex. Similarly, although the consideration of the net effect of an increase in HIV prevalence on the marginal cost of unprotected sex may explain reckless behavior, it does not fully explain differences in reactions towards changes in HIV prevalence and HIV knowledge *within* high- or low activity groups.[12] Oster (2005, 2007a, 2007b), Dow (1999), and Benz (2005) all analyze the link between health behavior and future prospects, but none explicitly study how sexual behavior and uncertainty of future prospects are interlinked. The empirical analysis presented below builds on the theoretical work by Mannberg (2010) and can be seen as a complement to the work of Oster (2007b). Mannberg's theoretical analysis suggests that health related uncertainty contributes to a lower expected benefit of abstaining from pleasurable but risky sex in the present. This implies that, if the social and physical context is more uncertain in sub-Saharan Africa than in other parts of the world, then investments in health should be more risky there than elsewhere. Hence, although individuals in poor countries appear to act myopically, they may be acting completely rational within the context of uncertainty. In order to give a full understanding of the model, the theoretical framework is presented in more detail below.

3. Theoretical Framework

The theoretical framework used for the empirical analysis below is a simplified version of the theoretical work of Mannberg (2010), representing a 2-period model where an individual derives utility from consumption, health and sexual activity.

The preferences in period $\boldsymbol{t}$ are described by the utility function, $U(\boldsymbol{c}, \boldsymbol{h}, \boldsymbol{x_{us}}, \boldsymbol{x_s})$ where $\boldsymbol{c} = (c_1, c_2)$ is consumption of other goods, $\boldsymbol{h} = (h_1, h_2)$ is health, $\boldsymbol{x_s} = (x_{s,1}, x_{s,2})$ is consumption of safe sex, and $\boldsymbol{x_{us}} = (x_{us,1}, x_{us,2})$ is

[12] Within the high risk groups during the early phases of the epidemic, such as the gay community, sexual risk taking fell as a response to HIV knowledge and increasing HIV prevalence. However, within HIV susceptible groups such as intravenous drug users, migratory workers, and refugees there are few signs of changes in sexual risk taking (UNAIDS & IOM, 2003).

consumption of unsafe sex. The instantaneous utility function is assumed to be twice continuously differentiable, increasing in each argument, and strictly concave. Safe and unsafe sex are assumed to be additively separable. Safe sex can be represented by either having only one sex partner[13] or using a condom. In addition, the utility of safe sex is scaled by a factor $\alpha; 0 < \alpha < 1$, implying that unsafe sex confers a higher utility than safe sex. Since the individual is assumed to die in the end of time period 2, unsafe sex does not have any health related cost in this period. Let us therefore disregard sexual consumption in time period 2.

The probability of contracting HIV via unprotected sexual intercourse is given by $\Pr(HIV)$, with the corresponding probability of staying HIV negative $1 - \Pr(HIV) = \varphi$. If the individual acquires HIV, she/he is assumed to die before reaching time period 2. In addition to the risk of acquiring HIV, the individual also faces an exogenous risk of experiencing changes in health via stochastic health shocks leading to high or low health outcomes, represented by probabilities ρ and $(1 - \rho)$, respectively. The spread between high and low health is given by $\gamma = (h_{high} - h_{low})$. Thus, if $\tilde{h}_2$ is the expected value of future health conditional on the individual being alive in period two, then $h_{high} = \tilde{h}_2 + (1 - \rho) \cdot \gamma$, and $h_{low} = \tilde{h}_2 - \rho \cdot \gamma$. We define the expected utility function as:

$$E[U] = u(c_1) + g(x_{us}) + \alpha g(x_{s,1}) + \beta \cdot E[u(c_2, h_2)] \quad (1)$$

Where $\beta; 0 < \beta < 1$, is an exogenous discount parameter, and where

$$E[u(c_2, h_2)] = \varphi^{x_{us}} \cdot [\rho \cdot u(c_2, h_{high}) + (1 - \rho) \cdot u(c_2, h_{low})] \quad (2)$$

is the expected utility in period two.[14] The intertemporal budget constraint is given by:

[13] Naturally, being monogamous is not a sufficient condition for sex to be safe. The individual also need to make sure that his sex partner is monogamous and HIV negative to begin with.
[14] Since an HIV positive individual is assumed to die before entering time period 2, the expected utility of an HIV positive individual in this time period is zero.

$$m_1 = c_1 + p \cdot x_s + q \cdot x_{us} + S \tag{3}$$

$$m_2 + (1 + r) \cdot S = c_2 \tag{4}$$

where m_1 and m_2 is income in each time period, assumed to be exogenously given. p is the price of unprotected sex and q the price of unprotected sex with exogenous income in each time period and non-negative savings. Eliminating the intertemporal budget constraint, the first order conditions for safe sex, unsafe sex and saving are given by:

$$\frac{\partial E[U_t]}{\partial x_s} = U_{x_s} = -p \cdot u_{c_1} + \alpha \cdot g_{x_s} = 0 \tag{5}$$

$$\begin{aligned} \frac{\partial E[U_t]}{\partial x_{us}} = U_{x_{us}} = &-q \cdot u_{c_1} + g_{x_{us}} \\ &+ \beta \ln(\varphi)\, \varphi^{x_{us}} \big[\rho u_{c_2}(c_2, h_{high}) \\ &+ (1-\rho) u_{c_2}(c_2, h_{low})\big] = 0 \end{aligned} \tag{6}$$

$$\begin{aligned} \frac{\partial E[U_t]}{\partial S} &= U_S \\ &= -u_{c_1} + \beta \cdot \varphi^{x_{us}} \big[\rho \cdot u_{c_2}(c_2, h_{high}) \\ &+ (1-\rho) \cdot u_{c_2}(c_2, h_{low})\big] \leq 0 \end{aligned} \tag{7}$$

The first order conditions together implicitly define the optimal amount of unprotected sex as $x_{us}^* = x_{us}^*(p, q, \rho, \gamma, \varphi, m_1, m_2, \tilde{h}_2)$. In order to derive a hypothesis concerning the effect of health related uncertainty on sexual incentives, we follow Mannberg's (2010) analysis. Accordingly, we analyze the effect of an increased variability of future health which corresponds to an increase in the spread (γ). The effect of improvements in expected health and income is analyzed by performing comparative statics for an increase in $\tilde{h}_2$ and m_2, respectively. The results of the comparative statics are summarized in *proposition 1* below:

Proposition 1:

a. $\partial x_{us}/\partial \gamma > 0$ *: An increase in the uncertainty of future health reduces incentives to abstain from unsafe sex*

b. $\partial x_{us}/\partial \tilde{h}_2 < 0$*: And increase in the expected level of future health increases incentives to abstain from unsafe sex.*

c. $\partial x_{us}/\partial m_2 \gtrless 0$*: An increase in future income has ambiguous effects on incentives to engage in unsafe sexual practices.*

Proof: See the appendix/or for details on the derivations see; Mannberg (2010).

The results show that health related uncertainty reduces the expected value of the future, not only by lowering the expected utility of future health but also in terms of reducing the expected value of future consumption. Hence, incentives to postpone consumption for the future, in terms of abstaining from risky sex, diminish. The negative relationship between risky sexual behavior and an individual's higher expected health value is a reflection of that an individual that expects to be healthy at an old age consumes less unsafe sex than an individual expecting to have poor health later in life at a given level of exogenous uncertainty. An improvement in expected health makes the cost of unsafe sex more salient in terms of an increase in the potential loss induced by unsafe sex consumption. As health and consumption are assumed to be complements, the improvement in expected health not only increases the value of the future directly, but also raises the marginal value of future consumption. Finally, as in the case of improvements in health, an increase in future income increases the expected benefit of surviving to old age, thus reducing incentives to consume unsafe sex. However, the increase in future income also reduces the need to save for old age. A reduction in savings implies the budget space for current consumption, including unsafe sex, increases. Hence, an expected increase in future income presents the individual with conflicting incentives.

4. Empirical approach

The theoretical model, presented above, suggests an empirical model of the form:

$$y_i = \alpha + \beta_1 \cdot \tilde{h}_2 + \beta_2 \cdot \gamma_{health} + \beta_3 \cdot E[m_2] + \boldsymbol{X_i}'\boldsymbol{\beta} + u_i \qquad (8)$$

where y is a measure of sexual risk taking, $\tilde{h}_2$ as in the above is expected future health, γ_{health} is a measure of uncertainty of future health, $E[m_2]$ is expected future income, $\boldsymbol{X}$ is a vector of control variables, and u is the error term. In this section we set up the econometric framework for analyzing the links between risky sexual behavior, economic and health conditions of the individual, and uncertainties associated with them. We start by giving a short description of the data used for the empirical study, and then proceed with a discussion of the operationalization of each set of variables. In *section 4.3* we describe our econometric considerations.

4.1 Description of the data

The data used for the econometric analysis below stems from the Cape Area Panel Study (CAPS), a longitudinal dataset consisting of a representative sample of Cape Town youth.[15] The first wave of CAPS was implemented in 2002 covering 5250 households and 4750 adolescents between the ages 14 and 22. Three additional survey waves were conducted in the years 2004, 2006 and 2009. The CAPS data is extremely rich and has been used in a number of studies including HIV related issues (e.g. Dinkelman *et al.,* 2007; Anderson & Beutel, 2007; Anderson *et al.,* 2007). The dataset includes detailed information on current socioeconomic characteristics, income and health of young adults, their households (parents) and in the community. In addition, CAPS contains

[15] The Cape Area Panel Study Waves 1-2-3 were collected between 2002 and 2005 by the University of Cape Town and the University of Michigan, with funding provided by the US National Institute for Child Health and Human Development and the Andrew W. Mellon Foundation. Wave 4 was collected in 2006 by the University of Cape Town, University of Michigan and Princeton University. Major funding for Wave 4 was provided by the National Institute on Aging through a grant to Princeton University, in addition to funding provided by NICHD through the University of Michigan.

information on the young adults' sexual behavior, their HIV related knowledge and on how often the young adult discusses HIV issues with parents or step-parents.

The empirical analysis is based on the third survey wave, collected in 2004, since it consists of a wider range of information regarding risky sexual behavior of young adults and regarding expectations of future health[16]. While the previous waves also include such information, certain variables are missing, which made use of the full panel difficult for our purpose. In addition, in order to use the information provided by parents we had to restrict the sample further to young adults whose parents, step-parents or guardians provided information in the parent questionnaire. Taken together this implies that of the nearly 5000 young adults taking part in the CAPS study, only a sample of 2618 individuals were included in the study. The descriptive statistics of the sample is presented in *Table 1*, below.

As can be seen in *Table 1*, most of the respondents in the sample consider using a condom as an effective method to protect against HIV (83 percent), and roughly half of the sample considers abstaining from sex altogether to protect against HIV (47 percent). However, only 35 percent of the sample used condoms consistently[17] with their last sex partner, and 49 percent of the young adults that used condoms inconsistently did this with a non-spousal partner. The descriptive statistics reveal large differences between population groups regarding household per capita income. A *t-test* of group means shows that black young adults have significantly lower mean per capita income than colored and white young adults ($p<0.0001$), and white young adults are significantly richer than their colored and black counterparts ($p<0.0001$). However, the difference in subjective life

[16] For example, wave 3 contains information about whether or not the young adult had simultaneous sex partners during his or her last sexual relationship, a well known risk factor for HIV (c.f. Piasani, year). This wave also includes questions concerning the respondent's relationships to his or her last 10 sexual partners, the young adult's life expectancy, and the behavior and expectations of the young adult's parent or guardian.

[17] Where consistent condom use is defined as having "always" used condoms with most recent sexual partner, and inconsistent condom use is defined as having used condoms "usually", "sometimes", or "rarely"

expectancy[18] between black and white young adults is not significant at the 10 percent level, and black respondents have significantly higher life expectancy than colored young adults (p<0.0001). Colored respondents also live in areas with significantly higher variances in life expectancy and use condoms less frequently than white and black young adults (p<0.0001).

Table 1: Descriptive statistics

	All	Females	Males	Black	Coloured	White
Number of observations	2618	1420	1198	1011	1346	261
Percent	100	54	46	39	51	10
Life expectancy	63.72	62.91	64.62	68.44	58.88	70.19
Parent life expectancy	68.46	68.74	68.14	71.54	65.21	73.03
Houshold per capita income	1399.40	1342.78	1462.66	517.06	1221.47	5589.64
Variance in life expectancy	311.86	311.38	312.41	266.75	363.94	220.9
Education[a]	0.86	0.89	0.82	0.80	0.87	0.98
Age in 2002	17.38	17.39	17.37	17.57	17.35	16.62
HIV discuss[b]	2.32	2.39	2.24	2.45	2.27	2.07
Relation to HIV/AIDS infected	27	32	22	50	14	9
HIVprotct_abstain (%)	47	49	44	40	47	73
HIVprotct_1sexp (%)	11	22	20	10	26	39
HIVprotct_limit (%)	21	10	11	4	13	25
HIVprotct_condom (%)	83	81	85	88	80	80
Age at first sex	16.46	16.87	16.01	15.98	16.86	17.40
Condom use (ordinal)[c]	1.46	1.58	1.33	1.74	1.37	0.79
Inconsistent condom use[d]	35	40	28	39	35	17
Inconsistent condom use with non-spouse[e]	49	58	39	42	59	39
Sex partners past 12 months[d]	1.16	0.66	0.88	1.02	0.60	0.52
Sex partners in life[d]	1.48	1.24	1.77	2.07	1.13	0.99
Type of relationship to most recent sex partner[d]						
Spouse	4.19	5.28	2.99	6.40	2.12	0.98
Someone loved but not married to	76.94	83.10	70.13	81.77	72.42	69.61
Someone known but not loved	10.36	7.16	13.90	4.93	15.13	20.59
Casual	8.51	4.46	12.99	6.90	10.33	8.82
Time before having sex with most recent sex partner[d]						
More than 1 year	39.52	43.83	34.73	29.40	49.36	50.49
less than 1 year but more than 1 month	36.67	39.01	34.07	38.59	35.08	33.01
less than a month but more than 2 days	18.49	14.69	22.72	25.06	11.74	13.59
2 days or less	5.32	2.47	8.49	6.95	3.82	2.91
Other sex partners in most recent sexual relationship[d]						
Definetely no	79.61	87.70	70.61	69.58	88.68	96.12
Unsure	4.56	3.16	6.11	7.39	1.84	0.97
Definetely yes	15.83	9.13	23.28	23.03	9.48	2.91

a: Dummy for secondary education or higher, b: Ordinal variable for how often YA discussed HIV with parent/step parent during the past 12 months preceeding the interview (1=never. 4=Often), c Ordinal variable for condom use (1=Always. 4=Rarely), d: % of sexually active, e: % of inconsistent condom users

[18] Respondents were asked to estimate their expected life length in terms of answering yes or no to the question: "Do you expect to be alive at the age of 30? …40? …50? …60? …70? …80?"

Given the prevalence of HIV in South Africa in general and in Cape Town in particular, the focus of risky sexual behavior is likely to be highly correlated with HIV incidence, making causal inference difficult. Hence, one likely empirical problem could be disentangling the effect of the influence of HIV prevalence on risky sexual behavior from that of expected income and health (our main variables of interest). The focus of our analysis being on *individuals* enables us to control for the behavioral effect of HIV prevalence, as, for an individual agent, HIV frequency is likely to be exogenous.

4.2 Variable operationalization

4.2.1 Sexual risk taking

Theoretically, sexual risk taking related to HIV may be defined as the quantity of unprotected sexual acts with sexual partners whose HIV status is unknown. However, empirically, it is difficult to separate sexual *activity* from sexual *risk taking*. In general, economic research on sexual risk taking related to HIV or other STIs utilize measures such as condom use, age at sexual debut, and the number of sexual partners in a specified time interval (e.g., Dinkelman *et al.*, 2007). Although it may be argued that inconsistent condom use *or* having numerous sex partners is always to some degree risky, especially in countries where HIV prevalence is high and simultaneous sex partners common, these variables in isolation tell us relatively little about sexual risk taking. For example, inconsistent condom use may be relatively safe if the young adult only has sex with his or her spouse and knows that this partner is HIV negative and monogamous. Likewise, having many sexual partners is risky only if the young adult uses condoms inconsistently. Hence, using *only* condom use, *or* number of sexual partners tells us very little about sexual risk taking.

Despite this, previous research in both economics and psychology have usually resorted to using single variables as indicators of sexual risk taking, such as age of first sex or condom use at last sex. Given no solid theoretical foundation to direct our choice of variables to include in the combined measure or how to

combine these measures, we have two challenges at hand: what variables to include and how to sensibly aggregate the alternative risky sex measurement variables. A few papers on sexual risk taking conducted by psychologists have used more adequate measures of sexual risk taking by combining condom use with number of sex partners (i.e. by explicitly asking about condom use with each sexual partner during a specified time interval, see van der Pligt *et al.*, 1996). However, even in these instances, simple aggregations are used where the number of sexual partners over a specified time interval is multiplied with information about condom use.

In light of this, one of the major aims of the paper is to generate a measure of risky sexual behavior by combining a wide range of variables such that the maximum information possible is extracted from, and adequate weights are attached to each measure, as opposed to previous studies that are based on individual measures or arbitrary aggregations. In our case, since we have information on the young adult's sexual behavior in terms of condom use, type of relationship with most recent sexual partner, the time the young adult knew the partner before having sex, whether or not the young adult or his/her partner had additional sex partners during the relationship, and the young adult's number of sexual partners in both life and in the most recent 12 months, we are able to construct such a measure of sexual risk taking.

In order to do this, we draw on a series of psychological studies by van der Velde & van der Pligt (1991), van der Velde *et al.,* (1994) and van der Velde *et al.,* (2002). In these studies, information concerning condom use, number of sexual partners and type of partner is combined in order to measure sexual risk taking among high risk individuals in Amsterdam.[19] We augment their measure by

[19] In these studies, the type (i.e. private or prostitution partner) and number of sexual partners was multiplied with the degree of condom use (past 4 months preceding the interview). In addition, information related to the frequency of vaginal intercourse with each partner was included in the measure. The measure of condom use and frequency of vaginal intercourse was measured on ordinal scale (from never to always). The measure was constructed by transforming the Likert scales into multipliers. For example: A participant who had 5 private partners with whom the participant often had vaginal intercourse and with whom condoms were never used, and 5 prostitution partners with

adding more detailed information about the type of relationship, the time the young adult knew the sex partner before having sex, and whether or not the young adult had additional sex partners during the relationship. This gives us a measure of the degree of riskiness associated with the young adult's last sexual partner. In addition, in order to include information related to the frequency of sexual encounters, we also include a measure of sexual activity in terms of the number of sex partners relative to the average in the young adult's age group.[20] However, simply adding and multiplying different indicators of sexual risk taking is problematic for several reasons. First, the weights of the individual variables are ad hoc. Second, due to the ordinal nature of the indicators available in CAPS, it is difficult to interpret the risk level associated with the different values of the constructed variable. In order to derive adequate weights of each indicator, we analyze the data with explanatory factor analysis (EFA) in SPSS and thereafter derive latent factors scores from a confirmatory factor analysis (CFA) for ordinal variables in the LISREL 8.80 software (Jöreskog, 2005; Jöreskog & Moustaki, 2001; Jöreskog *et al.,* 2006).

As mentioned above, it is important to not only analyze the degree of risk associated with the young adult's last sex partner, but also to include information about condom use. However, for rational individuals with a higher number of casual sexual relationships, condom use is likely to be positively correlated with the number of sex partners and with the degree of risk posed by each sex partner. This correlation causes CFA to produce a positive relationship between the degree of condom use and sexual risk taking. Although a high frequency of casual sexual relationships is always to some extent risky, an individual with a consistent use of condoms should intuitively be considered as less exposed to risk than an individual with inconsistent condom use, given that the two individuals have the

whom the participant always had vaginal intercourse while used condoms half of the time received the risk score: (5*0.75*1)+(5*1*0.5).

[20] This variable was created by dividing the young adult's lifetime sex partners by the average number of sex partners in his/her age group. In order to facilitate the analysis in LISREL (discussed below) we transformed the variable into an ordinal variable where each group represents quartiles of the distribution.

same number and type of sex partners. Hence, in order to avoid the positive association between condom use and sexual risk, the variable related to condom use is not included in the combined measure constructed by CFA. Information about condom use is instead included in the estimation procedure by multiplying the combined measure by 1 if condoms were used inconsistently and 0 if condoms were used consistently during the young adult's last sexual relationship (see section 4.3, below).

The basic idea behind factor analysis is that the correlation between a set of observed variables may be explained in terms of one or more latent factors theoretically hypothesized to underlie the observed variables. EFA enables us to investigate the number of factors underlying the set of observed variables in terms of an analysis of the variance explained in the indicator variables by each latent construct. EFA also enables us to evaluate the relative strength in the relationship between each indicator variable and the latent construct. Using CFA we may then test whether our hypothesized relationship between the set of indicator variables and the latent construct is significantly better than an unrestricted model assuming no relationships between the observed variables and the latent factor. The basic model that we want to estimate is:

$$\boldsymbol{y} = \boldsymbol{\tau}_y + \boldsymbol{\Gamma}_\mathbf{y} \cdot \boldsymbol{\eta} + \boldsymbol{\delta} \tag{9}$$

where $\boldsymbol{y}$ is a q-vector of observed variables, and $\boldsymbol{\eta}$ is a vector of latent factors assumed to underlie the observed variables. The $\boldsymbol{\Gamma}_\mathbf{y}$ is a matrix of factor loadings describing the relationship between the observed variables and the latent factors, $\boldsymbol{\tau}_y$ is the mean vector of $\boldsymbol{y}$, and $\boldsymbol{\delta}$ represents a vector of errors. If the latent factors are assumed to be uncorrelated and of unit variances, the individual factor loadings can be estimated by an analysis of the correlation and covariance matrix of $\boldsymbol{y}$ (e.g., Jöreskog & Sörbom, 1979; Kaplan, 2000). However, as can be seen in *Table 1,* the relevant observed variables related to sexual risk taking in CAPS are of ordinal scale. With ordinal variables, conventional correlation and covariance matrices cannot be used to estimate the model parameters. Hence, for EFA and

CFA of ordinal variables the *polychoric* correlation is used to estimate the system in equation (9). The polychoric correlation may be estimated by several procedures. The method used in LISREL is based on the "underlying response variable approach". This approach assumes that each observed ordinal variable has an underlying, normally distributed, continuous variable. The procedure estimates the probability of giving a response in a specific category and then estimates the correlation between the unobserved continuous response variables (e.g., Jöreskog & Moustaki 1994; a more detailed description of the estimation procedure of the polychoric correlations is given in appendix A3).

Our hypothesized model, described in equation (10), contains the observed variables; 1) relative number of sex partners to age group (*sexp*), 2) time before having sex (*timesex*), 3) relationship type (*rel type)*, and 4) presence of multiple sex partners (*multiple sexp*). With four observed variables the degrees of freedom are insufficient to test a model of more than one latent factor.[21] Hence, a CFA of four observed variables implies a structure of the following form (A full description of the variables can be found in the appendix):[22]

$$\begin{pmatrix} sexp \\ Timesex \\ rel\ type \\ multiple\ sexp \end{pmatrix} = \begin{pmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \end{pmatrix} \cdot \xi + \begin{pmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \end{pmatrix} \tag{10}$$

The latent factor scores are estimated in accordance with the approach outlined by Anderson & Rubin (1956) (see also, Jöreskog, 2000).

[21] A naive analysis of all variables related to sexual risk taking was also conducted. Variables associated with relatively high factor loadings (above 0.5) include: age at first sex, number of sex partners relative to the average in the young adult's age group, number of sex partners during the past 12 months, and whether or not the young adult had multiple sex partners at the same time. However, in combination these variables do not produce a statistically viable model. Indeed, age of first sex in general reduce model fit regardless of the other variables included in the analysis. Results are available from the authors upon request.

[22] The variables "multiple sex partners" take the value 0 if the young adult (or his or her partner) had no other sexual partners during the relationship and 1 if the young adult (or his or her partner) did have other partners. Finally, the "relationship type" variable takes the value 1 if the sexual partner was the young adult's spouse, 2 if the sexual partner was a loved girl or boy friend, 3 if the sexual partner was someone known but not loved and 4 if the sexual partner was someone that the young adult did not know well. Since it may be the case that a spouse became infected with HIV before marriage, even marital sex without condoms are measured as mildly risky. For individuals not yet sexually active, the "riskpartner" measure is always zero.

4.2.2 Expected health, expected income and uncertainty of future health

The main variables of interest for testing the health risk model relate to expected health, expected income and uncertainty of future health. The CAPS dataset contains several measures of the young adults' perception of current and expectation of future health. The variable perhaps most closely related to expected health is the young adult's life length expectancy. However, this variable is potentially endogenous to the young adult's present level and expectation of future sexual risk taking behavior. Hence, we would ideally like to find an instrument that affects life expectancy (or expected health) but is unrelated to sexual risk taking. In previous studies, malaria frequency has been used (Oster, 2007a). However, in the CAPS dataset, and for the Cape Town region, no such variables exist. In order to deal with the endogeneity of the life expectancy variable, we instead instrument this variable with the mean life expectancy in the community in which the young adult resides and with the life expectancy of the young adult's parent (Examples of constructing instruments using aggregate village level variables include Quigley & Raphael, 2005; D'Hombres *et al.*, 2010). It may be argued that the mean of life expectancy suffers from neighborhood effects (i.e. risky individuals may decide to reside in areas where other risky individuals live). However, since the sample used in the econometric analysis consists of young adults, dwelling location is likely to be determined not by the respondents themselves, but rather by the head of the household. Likewise, although there may be some links between the young adult's risk taking behavior and the parent's life expectancy (for example if the parent engages in risk and this affects the risk taking behavior of the young adult), this link is likely to be relatively weak.

The theoretical model described above predicts that *uncertainty* of future health reduces incentives to abstain from unsafe sex in the present. More specifically, *proposition 1a* in *section 3* above, suggests that the *spread* between potential future health outcomes matters for sexual behavior. We therefore estimated the variance

in subjective life expectancy in each enumeration area[23] and use this as a proxy for uncertainty of future health.

Finally, *proposition 1c* suggests a link between expectations of future income and current sexual risk taking behavior. Since risky sexual behavior may affect expectations of future income (via the effect of health on earnings), we use mean household per capita income as a direct proxy for measuring expected income. Since it is more likely that older adults and parents rather than the young adults themselves are breadwinners in the household, we treat this variable as exogenous in the regressions.

In order to control for HIV knowledge, we use information on how often the young adult talks about HIV with parents or step parents, a dummy for whether the young adult knows someone with HIV or someone that has died of AIDS, and a set of dummies for different methods stated by the young adult as effective methods to prevent an HIV infection.[24] In addition we include a dummy for whether the young adult had secondary education or higher in 2003.[25] The different measures of HIV knowledge is included in order to capture both formal HIV knowledge and more deeply rooted relational knowledge of the consequences of an HIV infection.

4.3 Econometric specification

To study whether a significant impact of the economic and health conditions on the decision to engage in risky sexual behavior exists, we start by presenting the econometric relationships between our measure of risky sexual behavior and its determinants. We then discuss the econometric issues involved in the

[23] Primary sampling units corresponded to enumeration areas within the 1996 census and are defined in terms of subplace and placename. In calculating the means and variance of subjective life expectancy at a neighborhood level, we used all observations within a subplace (excluding the individual's own data) if the total number of observations were greater or equal to 20. Alternatively we estimated the means and variances at a placename level, but in such cases restricted the sample by population group.

[24] Abstaining from sex, only having one sex partner, limiting the number of sex partners and using condoms

[25] A dichotomous variable measuring whether the young adult only has primary education or lower, or at least secondary education.

measurement of the dependent and independent variables and how we address them.

The main hypothesis is that the degree of riskiness of an individual's sexual behavior depends on the level and uncertainty of future prospects in terms of health and income. In estimating this relationship a number of important factors need to be considered. First, the sample consists of a relatively large share of individuals not yet sexually active. Merely estimating the relationship for the sexually active sample, or simply treating these individuals as "zero-risk" takers in the regression may lead to selection bias. First, since abstaining from sex may constitute a strategy to protect against HIV the non-sexually active sample may contain important information. However, estimating a Tobit where not sexually active young adults are treated as zeroes is problematic. First, the Tobit approach implies that we assume that the decision to not have sex is qualitatively the same as the decision related to the *degree* of risk taken. However, there may be important differences related to these decisions. Consider for example the effect of age: the older the young adult is, the more likely it is that he or she has had sex, simply due to biological reasons. However, concerning the *degree* of risk taken, age may have other implications such as experience or the desire to engage in more stable relationships. Second, sexually active individuals may differ from non-sexually active individuals with regards to unobserved characteristics such as risk aversion. In other words, treating the decision to abstain from sex as a corner solution may provide biased results due to a correlation of the error terms. Hence, studying the riskiness of sexual behavior needs to account for the presence of individuals who have no sexual experience at all and to correct for possible sample selection. In addition, individuals who are sexually active may choose to abstain from *risky* sexual behavior by choosing to use condoms consistently. As in the case of the choice to become sexually active, this decision *may* be distinct from the decision related to the degree of risk taken. This would for example be true for someone who does not use condoms, but engage in sex with only one partner consistently, while expecting their partner to be mutually

monogamous. One way of estimating the model is to consider a double selection framework. This approach suggests the following system of equations:

Selection model 1: The decision to become sexually active or not

$$y_{s,i} = \begin{cases} 1 & if \quad y_{s,i}^{*} = \boldsymbol{\alpha}'\boldsymbol{w_i} + \varepsilon_i > 0 \\ 0 & otherwise \end{cases} \tag{11}$$

where for an individual i , y_s is a dichotomous variable taking the value 1 if the young adult is sexually active and 0 otherwise, and $\boldsymbol{w}$ is a vector of variables that determine the individual's decision to engage in sex or not; $\boldsymbol{\alpha}$ represents the vector of coefficients to be estimated, and ε represents the error term.

Selection model 2: The decision to use condoms consistently or not, given that the young adult is sexually active

$$y_{c,i}|y_{s,i} = 1 \quad = \begin{cases} 1 & if \quad y_{c,i}^{*} = \boldsymbol{\vartheta}'\boldsymbol{z_i} + \varepsilon_i > 0 \\ 0 & otherwise \end{cases} \tag{12}$$

where for individual *i,* y_c is a dichotomous variable taking the value 1 if condoms were used consistently with the individual's last sex partner and 0 if condoms were used inconsistently and $\boldsymbol{z}$ is a vector of exogenous variables affecting the decision to use condoms consistently. Note that, since our main interest is to investigate sexual risk taking, and in order to avoid endogeneity in the selection equation, we exclude variables related to health and income in these equations.[26] The selectivity corrected outcome model for sexual behavior given inconsistent condom use is given by:

$$y_{sr,i}|\, y_{s,i}, y_{c,i} = 1 \quad = \boldsymbol{X_i}'\boldsymbol{\beta} + \sigma_1 \cdot \lambda_{1,i} + \sigma_2 \cdot \lambda_{2,i} + \upsilon_i \tag{13}$$

where for an individual i y_{sr} is the sexual risk index, and λ are the estimated inverse Mill's ratios emanating from selection equation (11) and (12) respectively. The $\boldsymbol{\beta}$, σ_1 and σ_2 are the corresponding coefficients to be estimated. The model can be estimated even if the variables included in the different regressions are

[26] A preliminary analysis shows that the coefficients on these variables are insignificant. Results are available from the authors upon request.

identical. However, if this is the case, the identification of the model relies on the nonlinearity of the inverse Mills ratios. Since this nonlinearity is often weak, the lack of exclusion restrictions is likely to cause a high correlation between the estimated inverse Mills ratio and the regressors in the outcome model (e.g. Wooldridge, 2002). This multicollinearity makes the estimated coefficients unreliable and may thus lead to erroneous conclusions about the significance levels of the estimated parameters.

In order to reduce multicollinearity we thus need to find a set of valid exclusion restrictions for each selection equation. For the first selection equation (the decision to become sexually active) two exclusion restrictions are available in the dataset: a dummy variable for whether or not the young adult expected to have a child in three years time in 2002, and whether or not the young adult stated abstinence as an effective measure to avoid an HIV infection. However, finding valid exclusion restrictions that separates the decision related to condom use from the decision related to the sexual risk index is difficult from both theoretical and data availability perspectives. Research in psychology and sociology suggests that perceived ability to prevent an HIV infection, social support for condom use and discussing HIV prevention with parents constitute important determinants for condom use (e.g., Adih & Alexander, 1999; Diclimente *et al.*, 1992; Miller *et al.*, 1998; Meekers and Klein, 2002). However, these factors may also affect the degree of sexual decision for individuals that use condoms inconsistently. In addition to making estimation difficult, the lack of theoretically viable exclusion restrictions also questions the adequacy of modeling the condom decision as a selection issue. A preliminary analysis of the double selection model show that, due to the strong correlation between the error terms of the condom equation and the sex risk equation in a finite sample, the selectivity corrected standard errors are in some instances negative (see Greene, 1981 for a discussion of this problem). We take this as an additional argument for treating the condom and sex

risk decision to be intrinsically the same,[27] and therefore consider a mildly different approach in terms of viewing the sexual behavior and condom decision as qualitatively the same.[28] Since it may be important to differentiate between the "zero-risk takers" that are not sexually active, from the "zero-risk takers" that are condom users, we maintain the selection model for the decision to become sexually active in the first step[29]. For the second step, we adjust the LISREL risk index for condom use in terms of multiplying the latent factor scores with 1 if condoms were used inconsistently, and 0 if condoms were used consistently. This produces a zero-inflated dependent variable. In order to adjust for the large stack of zeroes we therefore estimate the second step with a Tobit. This approach has previously been used by, for example, Czarnitzki & Kraft (2004) and Hallman *et al.* (2005) in other settings.

The selection model thus reduces to selection model 1 (equation 11), while the outcome equation now has the condom use adjusted LISREL index as the dependent variable:

$$y^*_{sr,i} \mid y_{s,i} = 1 \quad = \boldsymbol{X_i}'\boldsymbol{\beta} + u_i \tag{14}$$

$$y_{sr,i} = max\left(0, y^*_{sr,i}\right) \tag{15}$$

The log likelihood function for the Tobit model with selectivity is given by:

$$\begin{aligned} Log\ L = &\sum\nolimits_{y_s=0} log\Phi[-\alpha' w] + \sum\nolimits_{y_s=1, y_{sc}=0} log\Phi_2[-\beta_1' \boldsymbol{x}_{i1}, \alpha' w, -\rho] \\ &+ \sum\nolimits_{y_s=1, y_{sc}>0} -1/2\,[log2\pi + log\sigma + (u_i/\sigma)^2] \\ &+ log\Phi\left[(\alpha' w + \rho u_i/\sigma)/(1-\rho^2)^{\frac{1}{2}}\right] \end{aligned} \tag{16}$$

[27] Results for the double selection model are available from the authors upon request. The results are qualitatively the same as the Tobit model with selectivity

[28] Results for the double selection model are available from the authors upon request. The results are qualitatively the same.

[29] Naturally, using condoms does not guarantee full protections against HIV since condoms may break or come off during sexual intercourse. However, since, to our knowledge, there are no estimates on the degree of risk associated with condoms we disregard from this effect here.

where Φ_2 is the standard bivariate normal cumulative distribution function (CDF) and Φ is the univariate standard normal CDF. The ρ is the correlation between u and ε, and σ is the error variance (Greene, 2007, p. R17-69, E31-8).

The potential endogeneity issue is addressed using instrumental variables techniques. Due to the nonlinear characteristic of the outcome model, the instrumental variable approach involves two steps that are mildly different from the classical 2SLS procedure (e.g. Angrist and Pischke, 2009; Greene, 2007). In the first step, the endogenous variable is regressed on all exogenous variables in the outcome model in combination with a set of instruments for the selected sample:

$$\tilde{h}_{t+1,i} = \boldsymbol{X_i}'\boldsymbol{\beta_h} + \boldsymbol{V_i}'\boldsymbol{\kappa} + e_i \qquad (17)$$

where, for individual *i*, $\tilde{h}_{t+1}$ is the subjective life expectancy, $\boldsymbol{X}$ the vector of exogenous variables in equation (15), and $\boldsymbol{V}$ is a vector of instrumental variables corresponding to the endogenous variables. The $\boldsymbol{\beta_h}$ and $\boldsymbol{\kappa}$ are vectors of parameters to be estimated, and $\boldsymbol{e}$ is the error term. The predicted value from equation (17) is then used as an instrument in the outcome equation. Standard errors are corrected for the generated regressor problem (Greene, 2007, p. E30-26). The selection, outcome and instrumentation is carried out in one step with maximum likelihood in Limdep.

As mentioned above, our candidate instruments for the endogenous variable subjective life expectancy consists of the life expectancy of the young adult's parent and mean life expectancy at the sub-place level (net of the young adult's own life expectancy). Each of these instruments is a plausible instrumental variable whose validity depends on the degree to which it is correlated with subjective life expectancy only via its effect on life expectancy and not via any direct link to risky sexual behavior.

In order to test for over-identification, we perform an Amemiya-Lee-Newey test (Baum *et al.,* 2006). The test indicates that the specification shows no over-identification. As we fail to reject the null hypothesis of validity of mean of young

adults' and parents' life expectancy, these instruments are used in our model specifications. In order to test exogeneity, we perform a Wald test.[30] The results indicate insufficient evidence to reject exogeneity. This result may be interpreted in three ways: As subjective life expectancy not being endogenous to sexual risk taking, as subjective life expectancy not measuring expected health, or as the explanatory variables not being adequate as instruments. From a theoretical perspective, life expectancy is without doubt endogenous to the level of sexual risk taking as long as HIV implies a premature death. Hence, some caution is needed when we interpret the results presented below.

Heteroscedasticity may constitute a problem. This is especially so when the outcome equation is a Tobit, since the presence of heteroscedasticity makes Tobit coefficients both inefficient and inconsistent. In order to correct for possible heteroscedasticity, we first estimate a heteroscedastic Tobit model without correcting for endogeneity (see *Table A4* in the appendix). However, since the estimation does not reveal any severe heteroscedasticity, the results presented in the next section are for a Tobit selectivity model with robust standard errors and instrumentation for the variable life expectancy.

Finally, due to the relatively low reliability of the sexual risk index estimated by factor analysis, we also estimate a selection model that focus on the decision related to condom use. More specifically, we estimate a model where the dependent variable is a measure of how often the young adult used condoms with his or her last sexual partner. As was argued above, this approach is only adequate if we consider with *whom* the individual had sex. In order to do this, we include information about the type of relationship the young adult had with the individual that he or she had sex with. In order to use all information available, we use the condom variable of ordinal scale available in the CAPS dataset. This implies that we need to estimate an ordered probit with selection. This model is given by:

[30] The intuition behind endogeneity is that the error terms of the structural and reduced form equations are correlated. This is because the added explanatory power of the instrument would be reflected in the reduced form equation (Wooldridge, 2002). However, it should be noted that even an invalid instrument which has its own explanatory variable could pass the test for endogeneity, implying that the test for endogeneity is not a test for the validity of the instrument per se.

$$
\begin{aligned}
y^*_{c,i} &= \boldsymbol{\vartheta_c}'\boldsymbol{z_i} + \zeta_i, \quad E[\zeta_i] = 0 \\
y_{c,i} &= 1 \quad if \quad y_{c,i} > \mu_0, \\
y_{c,i} &= 2 \quad if \quad y_{c,i} > \mu_1, \\
y_{c,i} &= 3 \quad if \quad y_{c,i} > \mu_2, \\
y_{c,i} &= 4 \quad if \quad y_{c,i} > \mu_4
\end{aligned}
\tag{18}
$$

where $\boldsymbol{z_i}$ now also contains the explanatory variable relation to last sex partner (rel_type). As in the above, $y_{c,i}$ is only observed if $y_{s,i} = 1$. As in the Tobit model with selectivity, subjective life expectancy is instrumented with mean life expectancy and parent life expectancy. The log likelihood function for the model with sample selection is:

$$
\begin{aligned}
Log\ L = \sum_{y_s=0} & log\Phi[-\alpha'\boldsymbol{z}] \\
& + \sum_{j,y_s=1} log\{\Phi_2[\mu_j - \boldsymbol{\vartheta_c}'\boldsymbol{z_i}, \alpha' w, \rho] \\
& - \Phi_2[\mu_{j-1} - \boldsymbol{\vartheta_c}'\boldsymbol{z_i}, \alpha' w, \rho]\}
\end{aligned}
\tag{19}
$$

where μ_j are the thresholds (Greene, 2007).

5. Empirical results

In this section we present the results of the empirical analysis. We start presenting the results of the CFA for the sexual risk index in section 5.1 and then proceed with the main results of the empirical analysis in section 5.2.

5.1 The sexual risk index

A CFA in LISREL 8.80 of the equation system in equation (10) produces a model with the relationships presented in *Figure 1* below.

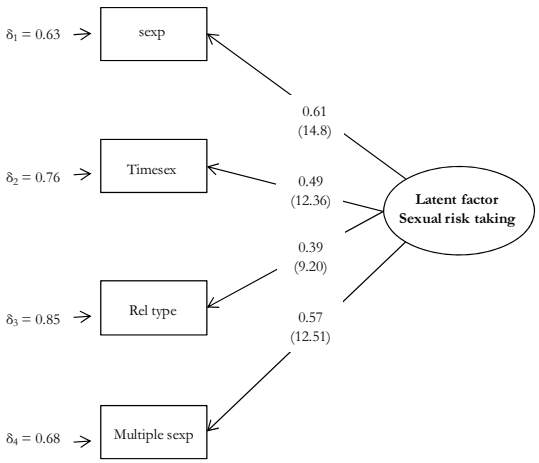


Figure 1: Path diagram for sexual risk taking

Observed variables represented by rectangular boxes and latent factors by elliptic boxes. Factor loadings are presented on each path from the latent factor to the observed variable with *t-values* in parenthesis. Fit statistics: Satorra-Bentler Scaled Chi-Square = 0.99 (P = 0.61), Root Mean Square Error of Approximation (RMSEA) = 0.0, Goodness of Fit Index (GFI) = 1.00 , Adjusted Goodness of Fit Index (AGFI) = 1.00, Parsimony Goodness of fit index (PGFI) = 0.20.

The path diagram in *Figure 1* describes the relationship between the set of observed variables and the hypothesized latent factor sexual risk taking. The *factor loading* for each variable describes how much of the variance of a variable that is explained by the latent factor. As can be seen in *Figure 1* all manifest variables are associated with positive loadings on the latent factor, thus suggesting that a higher degree of sexual risk taking is associated with more sexual partners, more casual partners, shorter time before having sex and the presence of simultaneous sex partners. However, as can also be seen in the figure, the estimated factor loadings are relatively small. This implies that the construct reliability and total extracted variance[31] are relatively low (0.59 and 0.27, respectively).[32] However, the overall model fit is satisfactory with a Santorra-Bentler scaled Chi-square equal to 0.99 (*p*

[31] $Construct\ reliability = \frac{(\sum_{i=1}^{p} \lambda_i)^2}{(\sum_{i=1}^{p} \lambda_i)^2 + \sum_{i=1}^{p} e_i}$, $extracted\ variance = \frac{\sum_{i=1}^{p} (\lambda_i)^2}{\sum_{i=1}^{p} (\lambda_i)^2 + \sum_{i=1}^{p} e_i}$

[32] Ideally, construct reliability should be above 0.7 and extracted variance above 0.5

= 0.61) and a root square mean error corresponding to 0.0. The parsimony goodness of fit index suggests that the model contains too many indicators. Since the model becomes saturated with less than four indicators, it is not possible to improve the parsimony by dropping an indicator. Given the above results, it is clear that our measure of sexual risk taking is not 'perfect'. However, in comparison with alternative measures, this measure has been estimated and tested with suitable statistical methods and the individual weights of the indicator variables are in all cases highly significant. We therefore argue that the estimated sex risk index is a more adequate measure of sexual risk taking than using individual variables like, say age of first sex.[33]

5.2 Main results

Let us now turn to the empirical findings. As can be seen in *Table* 2, the results only give weak support for the propositions derived from the theoretical model in *section 3*. *Proposition 1b* suggests that expectations of good health in the future increases incentives to abstain from sexual risk taking in the present. However, as is depicted in *Table 2*, although the coefficient on life expectancy has the expected sign, it is not statistically significant. Indeed, this result persists even if we do not use instrumental variables. Hence, if subjective life expectancy is a valid measure of expected health we cannot reject the null hypothesis that expectations of the level of future health is unrelated to sexual risk taking in the present.

Proposition 1a suggests that a high degree of uncertainty of future health reduces the expected utility of safe sexual practices. The positive and significant coefficient on variance in life expectancy lends support to this hypothesis. The result suggests that individuals living in communities with a greater variability in life length scores significantly higher on the sexual risk index.

[33] In a forthcoming paper, the differences between different measures of sexual risk are discussed further.

Table 2: *Tobit selectivity model: Determinants of the degree of sexual riskt aking by young adult*

	B	std.err	z	P[|Z|>z]
Direct effects in the regression				
Constant	0.761	0.684	1.111	0.266
Black	-0.377	0.379	-0.995	0.32
Colored	0.3	0.345	0.869	0.385
Female	**1.086**	0.193	5.629	0.000
Education	**-0.476**	0.225	-2.12	0.034
infHIV	**-0.199**	0.069	-2.901	0.004
HIVknow	0.046	0.177	0.259	0.795
LifeEXP	-0.007	0.046	-0.147	0.884
Variance lifeEXP	**0.026**	0.007	3.492	0.001
Income	**-0.07**	0.03	-2.356	0.019
HIVprotct_limit	**0.729**	0.263	2.771	0.006
HIVprotct_condom	-0.239	0.253	-0.944	0.345
Indirect effects in Lambda (mean are for all observations)				
Constant	**-8.084**	2.203	-3.67	0.000
Black	**0.515**	0.135	3.81	0.000
Colored	-0.023	0.063	-0.358	0.72
Female	-0.055	0.048	-1.136	0.256
infHIV	-0.024	0.026	-0.946	0.344
HIVknow	**0.159**	0.067	2.371	0.018
Age	**0.824**	0.237	3.482	0.001
Age^2	**-1.922**	0.607	-3.169	0.002
HIVprotct_abstain	**-0.413**	0.105	-3.946	0.000
ChildEXP_2002	**0.236**	0.119	1.99	0.047
Total effects of variables in both parts				
Black	0.138	0.402	0.345	0.73
Colored	0.276	0.351	0.79	0.43
Female	**1.031**	0.199	5.188	0.000
infHIV	**-0.224**	0.073	-3.048	0.002
HIVknow	0.205	0.189	1.081	0.28
SIGMA(1)	**2.373**	0.15	15.767	0.000
RHO(1,2)	**-0.473**	0.087	-5.436	0.000
N	1838			
Log L	-2619.331			
Finite sample AIC	2.877			

Finally, *Proposition 1c* suggests that expectations of future income may both increase and decrease incentives to engage in unsafe sex practices in the present. The empirical results suggest that a high household income is associated with a lower degree of sexual risk taking. Given the assumption that a young adult's expectations of own future income is a function of their parents' income level, this suggests that future income levels have a dampening effect on sexual risk taking.

For most of the covariates, the results are relatively unsurprising. In accordance with the UNAIDS (2009) report on the AIDS epidemic, women score significantly higher than men on the sexual risk index. Similarly, young

adults with only primary education or lower, and individuals that do not discuss HIV with their parents are more exposed to risk, than young adults with secondary school education and young adults from families that talk about HIV.

Knowing someone with HIV is not significantly associated with sexual risk taking behavior. However, it is interesting to note that the indirect effect is significant at the 5 percent level and *positive*. This result suggests that knowing someone with HIV/AIDS may be associated with more sexual risk taking behavior.[34] Naturally, if the young adult lives in an environment where sexual risk taking is fairly common, we may expect that he or she knows someone with HIV/AIDS and that the social norms related to sexual behavior affects the young adult's own sexual habits. However, it is surprising that young adults that consider limiting the number of sex partners (HIVprotect_limit) to be an effective method to protect against HIV/AIDS have higher scores on the sexual risk index than young adults not supporting this view. Finally, it is relatively unsurprising that older young adults are more likely to be sexually active and that this relationship is non-linear.[35]

The ordered probit for condom use alone (corrected for selection) shows similar results as the results of the Tobit selectivity model. The results differ with respect to one interesting aspect; as can be seen in *Table 3*, life expectancy is *significantly* associated with the frequency of condom use with the young adult's most recent sexual partner. The results suggest that the higher the life expectancy is, the more likely it is that condoms are used to a relatively higher extent. Variance of life expectancy is, as in the above associated with a lower degree of protective measures in terms of condom use and a higher income is significantly associated with a higher rate of condom use. Some caution is needed when we

[34] We have naturally not included individuals who are HIV positive themselves. Unfortunately we cannot control for whether the person is the young adult's sex partner since this information is not available in the dataset.

[35] Since age is already included in one of the measures included in the sexual risk index, we do not include age as a covariate for the sexual risk index.

interpret these results as the variance explained in the condom use regression is very low (*MacFadden's Pseudo R-square* is 0.001).

Table 3: *Ordered Probit: Determinants of Condom use*

	B	std.err	z	P[|Z|>z]
Index function for probability				
Constant	-0.052	0.525	-0.099	0.922
Black	**-0.31**	0.174	-1.786	0.074
Colored	0.102	0.16	0.64	0.522
Female	**0.48**	0.065	7.422	0.000
Education	**-0.283**	0.092	-3.079	0.002
infHIV	**-0.094**	0.028	-3.368	0.001
HIVknow	-0.002	0.074	-0.023	0.982
LifeEXP	**-0.045**	0.018	-2.483	0.013
Variance lifeEXP	**0.01**	0.003	3.361	0.001
Age	**0.062**	0.021	2.984	0.003
Income	**-0.057**	0.013	-4.213	0.000
HIVprotct_condom	**-0.291**	0.098	-2.968	0.003
Rel_type	**-0.134**	0.048	-2.8	0.005
Threshold parameters for index				
Mu(1)	**0.184**	0.019	9.811	0,000
Mu(2)	**0.932**	0.042	22.256	0,000
Selection equation				
Constant	**-14.112**	1.997	-7.068	0.000
Black	**0.962**	0.121	7.963	0.000
Colored	0.004	0.107	0.038	0.97
Female	**-0.145**	0.067	-2.15	0.032
infHIV	-0.037	0.03	-1.252	0.211
HIVknow	**0.287**	0.084	3.436	0.001
Age	**1.452**	0.231	6.278	0.000
Age^2	**-3.397**	0.663	-5.12	0.000
HIVprotct_abstain	**-0.756**	0.068	-11.119	0.000
ChildEXP_2002	**0.422**	0.155	2.712	0.007
Cor[u(probit),e(ordered probit)]				
Rho(u,e) |	**-0.253**	0.151	-1.675	0.094
N	2080	Psuedo Rsqr(Mcfadden)		0.001
Log L	-2507.335	Chi squared (prob)		7.401 (0.007)
Finite Sample AIC	2.436			

5. Conclusions and Discussion

The main focus of this paper is to empirically test the link between expectations of future health and income and sexual risk taking. The main findings indicate that uncertainty of future health is a significant determinant of current patterns of sexual risk taking. Similarly, risky sexual behavior tends to be associated with low current income. The association between household income

and sexual risk taking suggests that an expectation of a prosperous future may well reduce the incentives to engage in sexual risk taking in the present. The relatively weak impact of future income could be explained by its multidirectional impact. A higher future income may increase the expected utility of surviving to old age and may also reduce the need for saving. Since the CAPS dataset does not contain information about savings or monetary costs related to sexual behavior, we cannot disentangle the two effects from each other.

The results for expected health are mixed. Although the empirical analysis lends support for a relationship between low life length expectations and a high degree of sexual risk taking in terms of condom use, the low degree of variance explained in the regression indicates that the evidence for a link between subjective life expectancy and condom use is relatively weak.

The weak relationship between life expectancy and sexual risk taking raises interesting questions about human rationality and the validity of life expectancy as a measure of expected health. If subjective life expectancy is indeed an adequate measure of expected health, the empirical analysis only lends limited support for the hypothesis derived from the theoretical model in *section 3*. However, as described in the discussion of the instrumental variable tests, the exogeneity of life expectancy cannot be rejected. Hence, since future health is likely to be a function of sexual risk taking, the empirical results implies that life expectancy may not correctly measure subjective expected health. In addition, it should be noted that the young adults' subjective expectations related to health may be biased. Indeed, research in psychology suggests that individuals tend to overestimate the per-coital risk of an HIV infection, but to underestimate their *personal* risk of acquiring the virus. This phenomenon has been labeled *optimistic bias* (e.g., van der Pligt *et al.*, 1993). Hence, if individuals fail to fully acknowledge their personal risk, subjective life expectancy may not be endogenous to the degree of sexual risk taking. However, if it is the case that individuals rationalize their behavior, in terms of (potentially falsely) convincing themselves that their protective measures are adequate, then expected health should not be expected to

affect incentives related to sexual risk taking. If this is the case, traditional economic models of expected utility needs revision in order to catch the complex nature of risk perception and risk taking behavior (the mechanisms and consequences of optimistic bias and rationalizing behavior are discussed in Mannberg, 2010).

The results of the empirical analysis also provide interesting suggestions regarding the other determinants of sexual risk taking. The results in general suggest that females are exposed to HIV risk to a higher degree than men. Even though women are less likely to be sexually active, they are also less likely to use condoms frequently. This result may suggest that women dislike condoms more than men or that they are more prone to risk taking in general. A perhaps more likely explanation relates to social taboos concerning women's use of condoms and a general lack of sexual bargaining power for women. It is also interesting to note that information and knowledge of HIV in terms of discussing HIV with relatives and being educated is associated with a lower degree of sexual risk taking. Although previous research (Macintyre *et al.* 2001) has found that knowing someone with HIV reduces the degree of sexual risk taking, our analysis suggests that a personal experience of HIV actually *increases* the degree of sexual risk taking.

The major finding of the study is that poor economic circumstances and, more importantly, lack of bright economic and health prospects, explain the anomalies regarding high levels of sexual risk taking in a risky sexual environment. These findings may also hold important information from policy perspective. Since, as per the finding of this study, sexual behavior is closely tied to economic circumstances, the effectiveness of preventive mechanisms in the HIV epidemic requires addressing poverty and social insurance issues. In addition, the importance of HIV information and inter-gender imbalances in bargaining power call for more research on these issues.

While the study makes an important methodological step in combining sexual risk measures into an index, future research that analyzes the relative information

contents of alternative sexual risk measures would form the basis for studies on sexual behavior. Further, studies about the impacts of reducing the taboo related to talking about HIV, and the relatively low degree of condom use of women would also illuminate our understanding of preventive measures.

Appendix A1

In this section, the proof of proposition 1 is given. First, let us totally differentiate the first order conditions (5) and (7) with respect to the parameters, $\gamma, \tilde{h}_2, Y_2$ and φ. This gives us the system:

$$\begin{pmatrix} U_{x_{us}x_{us}} & U_{x_{us}x_s} & U_{x_{us}S} \\ U_{x_sx_{us}} & U_{x_sx_s} & U_{x_sS} \\ U_{Sx_{us}} & U_{Sx_s} & U_{SS} \end{pmatrix} \cdot \begin{pmatrix} dx_{us} \\ dx_s \\ dS \end{pmatrix} = \begin{pmatrix} -U_{x_{us}\gamma} & -U_{x_{us}\tilde{h}_2^-} & -U_{x_{us}\delta} & -U_{x_{us}\theta} & -U_{x_{us}\varphi} \\ -U_{x_s\gamma} & -U_{x_s\tilde{h}_2^-} & -U_{x_s\delta} & -U_{x_s\theta} & -U_{x_s\varphi} \\ -U_{x_s\gamma} & -U_{x_s\tilde{h}_2^-} & -U_{x_s\delta} & -U_{x_s\theta} & -U_{x_s\varphi} \end{pmatrix} \cdot \begin{pmatrix} d\gamma \\ d\tilde{h}_2 \\ d\varphi \end{pmatrix} \tag{A1.1}$$

where the individual derivatives are given in equations A1.2-A1.16, below.

$$U_{x_{us}x_s} = pq \cdot u_{c_1c_1} < 0 \tag{A1.2}$$

$$U_{x_{us}S} = q \cdot u_{c_1c_1} + \beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \left[\rho \cdot u_{c_2}(c_2, h_{high}) + (1-\rho) \cdot u_{c_2}(c_2, h_{low})\right] < 0 \tag{A1.3}$$

$$U_{x_sS} = p \cdot u_{c_1c_1} < 0 \tag{A1.4}$$

$$U_{x_{us}\gamma} = \rho \cdot (1-\rho) \cdot \beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \left[u_h(c_2, h_{high}) - u_h(c_2, h_{low})\right] > 0 \tag{A1.5}$$

Note that, by the second order condition for a maximum, $U_{x_{us}x_{us}}, U_{x_sx_s}, U_{SS} < 0$.

$$U_{x_s\gamma} = 0 \tag{A1.6}$$

$$U_{S\gamma} = \rho \cdot (1-\rho)\beta\varphi^{x_{us}}\left[u_{c_2h}(c_2, h_{high}) - u_{c_2h}(c_2, h_{low})\right] > 0 \tag{A1.7}$$

$$U_{x_{us}\tilde{h}_2} = \beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \left[\rho \cdot u_h(c_2, h_{high}) + (1-\rho) \cdot u_h(c_2, h_{low})\right] < 0 \tag{A1.8}$$

$$U_{x_s\tilde{h}_2} = 0 \tag{A1.9}$$

$$U_{S\tilde{h}_2} = \beta\varphi^{x_{us}}\left[\rho \cdot u_{c_2h}(c_2, h_{high}) + (1-\rho) \cdot u_{c_2h}(c_2, h_{low})\right] > 0 \tag{A1.10}$$

$$U_{x_{us}\rho} = \beta\ln(\varphi)\varphi^{x_{us}}\left[u(c_2, h_{high}) - u(c_2, h_{low})\right] < 0 \tag{A1.11}$$

$$U_{x_s\rho} = 0 \tag{A1.12}$$

$$U_{S\rho} = \beta\varphi^{x_{us}}\left[u_{c_2}(c_2, h_{high}) - u_{c_2}(c_2, h_{low})\right] > 0 \text{ [36]} \tag{A1.13}$$

$$U_{x_{us}Y_2} = \beta\ln(\varphi)\varphi^{x_{us}}\left[\rho \cdot u_{c_2}(c_2, h_{high}) + (1-\rho) \cdot u_{c_2}(c_2, h_{low})\right] < 0 \tag{A1.14}$$

$$U_{x_sY_2} = 0 \tag{A1.15}$$

$$U_{SY_2} = \beta\varphi^{x_{us}}\left[\rho \cdot u_{c_2c_2}(c_2, h_{high}) + (1-\rho) \cdot u_{c_2c_2}(c_2, h_{low})\right] < 0 \tag{A1.16}$$

$$U_{x_{us}\varphi} = \beta \cdot \varphi^{x_{us}-1} \cdot \left[\rho \cdot u(c_2, h_{high}) + (1-\rho) \cdot u_c(c_2, h_{low})\right] \cdot [1 + x_{us} \cdot \ln(\varphi)] \tag{A1.17}$$

$$U_{x_s\varphi} = 0 \tag{A1.18}$$

$$U_{S\varphi} = x_{us} \cdot \beta \cdot \varphi^{x_{us}-1} \cdot \left[\rho \cdot u_{c_2}(c_2, h_{high}) + (1-\rho) \cdot u_{c_2}(c_2, h_{low})\right] > 0 \tag{A1.19}$$

[36] Since $u_{c_2h_2} > 0$

Further, let us define:

$$\left[U_{x_s x_s} \cdot U_{SS} - \left(U_{x_s S}\right)^2\right] = D_{x_{us}} > 0 \text{ [37]} \tag{A1.20}$$

$$\begin{aligned}\left[U_{x_{us}x_s} U_{x_s S} - U_{x_s x_s} U_{x_{us} S}\right] &= D_S \\ &= -\beta \cdot \ln(\varphi) \cdot \varphi^{x_{us}} \cdot \frac{\partial E[u(c_2, h_2)]}{\partial S} \\ &\cdot \left(q^2 u_{cc} + \alpha^2 \cdot g_{x_s x_s}\right) < 0\end{aligned} \tag{A1.21}$$

The derivatives in *proposition 1a-1e* are given by:

$$\frac{\partial x_{us}}{\partial \gamma} = \frac{-U_{x_{us}\gamma} \cdot D_{x_{us}} - U_{S\gamma} \cdot D_S}{D} > 0 \tag{A1.22}$$

$$\frac{\partial x_{us}}{\partial \tilde{h}_2} = \frac{-U_{x_{us}\tilde{h}_2} \cdot D_{x_{us}} - U_{S\tilde{h}_2} \cdot D_S}{D} < 0 \tag{A1.23}$$

$$\frac{\partial x_{us}}{\partial \rho} = \frac{-U_{x_{us}\rho} \cdot D_{x_{us}} - U_{S\rho} \cdot D_S}{D} < 0 \tag{A1.24}$$

$$\frac{\partial x_{us}}{\partial Y_2} = \frac{-U_{x_{us}Y_2} \cdot D_{x_{us}} - U_{SY_2} \cdot D_S}{D} \lessgtr 0 \tag{A1.25}$$

$$\frac{\partial x_{us}}{\partial \varphi} = \frac{-U_{x_{us}\varphi} \cdot D_{x_{us}} - U_{S\varphi} \cdot D_S}{D} \lessgtr 0 \tag{A1.26}$$

The signs of equation (A1.22) to equation (A1.26) follow from equation (A1.2) – (A1.21)

[37] By the second order condition for a maximum

Appendix A2

Variables related to sexual risk taking	
rel_type	Type of relationship to last sex partner (1; spouse/married, 2; Someone loved but not married to, 3; Someone known well but not loved, 4; Someone not known well)
timesex	Time before sexual intercourse with last sex partner (1; More than a year, 2; Less than a year but more than 1 month, 3; less than a month but more than 2 days, 4; less than 2 days)
multisex	Whether or not young adult had other sex partners during last sexual relationship: (1; definitely no, 2; unsure, 3; definitely yes)
sexp12	Number of sex partners last 12 months
Sexp_life	Number of sex partners in life
sexp_rel_age	Number of sex partners relative to age group (sexp_life/average sexp_life in age group *j*), categorical variable where each group represent a quartile of the sample
Condom use	Ordinal variable for condom use with most recent sex partner (1; always, 2; usually, 3; sometimes, 4; rarely)
Condom_dic	Dichotomous variable for condom use with most recent sex partner (0; always, 1; less than always)
Independent variables	
lifeEXP	Life expectancy of young adult (30, 40, 50, 60, 70, 80)
Variance in lifeEXP	Variance in subjective life expectancy at sub-place level
Mean lifeEXP	Mean of subjective life expectancy at sub-place level
Parent lifeEXP	Parent subjective life expectancy
Age	Age in wave 1 (2002)
Age^2	Age in wave 1 squared
Education	Educational level (1; primary, 2; secondary or higher)
HIVknow	Dummy variable for relationship to an individual infected by or died of HIV/AIDS
pcinc	Household per capita income
infHIV	How often young adult discuss HIV with parent or step parent (1=never, 2=rarely, 3= sometimes, 4=often)
childEXP	Dummy variable for whether the young adult expected to have a child in three years time in 2002 (wave 3 took place in 2005)
HIVprotct_abstain	Dummy variable for whether young adult mentioned abstaining from sex as a method for preventing an HIV infection
HIVprotct_limit	Dummy variable for whether young adult mentioned limiting number of sex partners as a method for preventing an HIV infection
HIVprotct_condom	Dummy variable for whether young adult mentioned using condoms as a method for preventing an HIV infection

Appendix A3

The description in this section is to a large extent based on Jöreskog (2005), and Jöreskog and Moustaki (2001) (see also: e.g. Jöreskog, 1994). The CFA for ordinal variables described in section 4.2.1 was conducted as follows. In our dataset, we have extracted a set of manifest variables related to sexual behavior. Let us call these variables y_1, y_2, y_3 and y_4. Our hypothesis is that these variables are related to a latent variable; ξ, in terms of sexual risk taking. The latent variable is assumed to account for the dependencies between the manifest variables, such that if the latent variable was to be held fixed, the manifest variables would be independent. The basic model that we want to estimate can be represented by a *path diagram*, as depicted in *Figure A1*:

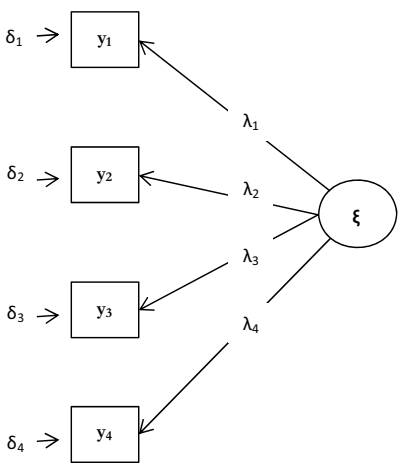


Figure A1: Path diagram

Observed variables represented by rectangular boxes and latent factors by elliptic boxes.

Classic factor analysis is based on the assumption that both manifest and latent variables are continuous and normally distributed with zero mean and unit variance, and suggests the following model for *k* latent factors:

$$E[y_i|\xi_1, \xi_2, \dots, \xi_k] = \lambda_{i1} \cdot \xi_1 + \lambda_{i2} \cdot \xi_2 + \cdots + \lambda_{ik} \cdot \xi_k \quad \text{(A3.1)}$$

$$E[y_i y_j|\xi_1, \xi_2, \dots, \xi_k] = 0 \quad i \neq j \quad \text{(A3.2)}$$

Assuming independence between the latent factors, the above model implies that the correlations between the observed variables are given by:

$$\rho_{ij} = \sum_{l=1}^{k} \lambda_{il} \cdot \lambda_{jl} \quad \text{(A3.3)}$$

However, in our case the observed variables are of ordinal scale. Since ordinal variables do not have metric properties, the correlations and covariance of ordinal variables lacks meaning. In contrast to classical factor analysis, ordinal factor analysis is based on the *polychoric* correlation between the observed variables. This correlation is obtained by assuming that each observed ordinal variable has an underlying normally distributed continuous variable y_i^* with range $-\infty$ to $+\infty$. The underlying variable y_i^* assigns a metric to the ordinal variable and can be used for CFA. For an ordinal variable with *m* categories, the relationship between y_i and y_i^* is

$$y_i = i \quad \Rightarrow \quad \tau_{i-1} < y_i^* < \tau_i, \qquad i = 1,2, \dots, m \quad \text{(A3.4)}$$

where

$$-\infty = \tau_0 < \tau_1 < \tau_2 < \cdots < \tau_{m-1} < \tau_m = +\infty \quad \text{(A3.5)}$$

are the thresholds. The underlying variables are assumed to have a standard normal distribution $\phi(u)$ and a distribution function $\Phi(u)$.[38] The probability of an answer in category i is:

[38] Although the univariate marginal normality of the underlying variables is not testable, the bivariate normality of two underlying variables can be tested in LISREL.

$$\pi_i = Pr[y = i] = Pr[\tau_{i-1} < y^* < \tau_i\ ] = \int_{\tau_{i-1}}^{\tau_i} \phi(u)du \\ = \Phi(\tau_i) - \Phi(\tau_{i-1}) \tag{A3.6}$$

This implies that $\tau_i = \Phi^{-1}(\pi_1 + \pi_2 + \cdots + \pi_i)$, where Φ^{-1} is the inverse of the standard normal distribution function, and the quantity $(\pi_1 + \pi_2 + \cdots + \pi_i)$ is the probability of an answer in category i or lower. π_i can be consistently estimated by the percentage of answers in category i,

$$\hat{\tau}_i = \Phi^{-1}(p_1 + p_2 + \cdots + p_i) \quad i = 1, 2, .., m-1 \tag{A3.7}$$

where the quantity $(p_1 + p_2 + \cdots + p_i)$ is the proportion of cases in the sample with answers in category i or less. The polychoric correlation is estimated by assuming that the underlying variables are standard bivariate normal with a correlation ρ. The polychoric correlation is thus the correlation of the underlying variables. For two ordinal variables, the polychoric correlation can be estimated by maximizing the log likelihood of the multinominal distribution,

$$\ln L = \sum_{i=1}^{m_1}\sum_{j=1}^{m_2} n_{ij} \cdot \log\left(\pi_{ij}(\boldsymbol{\theta})\right) \tag{A3.8}$$

where n_{ij} is the number of cases in category *i* on variable 1 and in category *j* on variable 2, and where

$$\pi_{ij}(\boldsymbol{\theta}) = Pr[y_1 = i, y_2 = j] = \int_{\tau_{i-1}^{(1)}}^{\tau_i^{(1)}} \int_{\tau_{j-1}^{(2)}}^{\tau_j^{(2)}} \phi_2(u, v)dudv \tag{A3.9}$$

Finally, $\phi_2(u, v) = \frac{1}{2\pi\sqrt{(1-\rho^2)}} \cdot e^{-\frac{1}{2(1-\rho^2)}\cdot(u^2 - 2\rho uv + v^2)}$ is the standard bivariate normal density with correlation ρ and $\boldsymbol{\theta} = \left(\tau_1^{(1)}\tau_2^{(1)}, \ldots, \tau_{m_1-1}^{(1)}, \tau_1^{(2)}\tau_2^{(2)}, \ldots, \tau_{m_2-1}^{(2)}, \rho\right)$. Maximizing $\ln L$ is the same as minimizing the function,

$$F(\boldsymbol{\theta}) = \sum_{i=1}^{m_1}\sum_{j=1}^{m_2} p_{ij} \cdot \left(\ln\left(p_{ij}\right) - \ln\left(\pi_{ij}(\boldsymbol{\theta})\right)\right) \tag{A3.10}$$

where p_{ij} are the sample proportions. The PRELIS program in LISREL estimates the threshold values from the univariate marginal distributions, $\hat{\tau}_i = \Phi^{-1}(p_1 + p_2 + \cdots + p_i)$ and then estimates the polychoric correlations and their asymptotic covariance matrix from the bivariate marginal distributions by minimizing $F(\boldsymbol{\theta})$. The hypothesis that the observed variables are indicators of a one-dimensional variable is tested by estimating the model with maximum likelihood with robust standard errors and chi-square corrected for non-normality using the asymptotic covariance matrix of the polychoric correlations (Jöreskog, 2005).

If the model fit is adequate, the estimation procedure in LISREL provides us with consistent estimates of the factor loading associated with each variable in combination with each variable's unique variation.

Appendix A4

Table A4 *Heteroscedasticity corrected Tobit without selection*

	B	std.err	z	P[|Z|>z]
Constant	-3.273	1.227	-2.667	0.008
Black	1.023	1.004	1.019	0.308
Colored	0.844	0.975	0.865	0.387
Female	1.563	0.317	4.926	0.000
Education	0.24	0.282	0.853	0.394
infHIV	-0.431	0.097	-4.457	0.000
HIVknow	0.428	0.216	1.986	0.047
LifeEXP	-0.001	0.05	-0.022	0.982
Variance lifeEXP	0.016	0.009	1.717	0.086
Income	-0.534	0.172	-3.1	0.002
HIVprotct_limit	0.917	0.315	2.91	0.004
HIVprotct_condom	1.209	0.426	2.836	0.005
Heteroscedasticity term				
Black	-0.016	0.334	-0.049	0.961
Colored	-0.155	0.313	-0.496	0.62
Female	-0.328	0.142	-2.308	0.021
Education	-0.006	0.172	-0.033	0.974
infHIV	0.053	0.049	1.081	0.28
HIVknow	0.015	0.131	0.117	0.907
LifeEXP	0.011	0.03	0.377	0.706
Variance lifeEXP	0.666D-05	0.005	0.001	0.999
Income	0.055	0.042	1.332	0.183
HIVprotct_limit	0.009	0.158	0.059	0.953
HIVprotct_condom	-0.064	0.188	-0.341	0.733
Disturbance standard deviation				
Sigma	3.251	1.55	2.097	0.036

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III

Risk and Rationalization

– The role of affect and cognitive dissonance for sexual risk taking*

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Abstract

This paper analyzes the mechanisms underlying excessive sexual risk taking in the presence of HIV. Drawing ideas from psychology on decision-making processes and risk evaluation, a theoretical model interacting affect-induced myopia and cognitive dissonance is developed and analyzed. The results of the theoretical analysis suggest that the effect of rationalization of personal risk depends on the risk of being HIV positive. Although rationalization causes excessive risk taking behavior for individuals with a relatively low lifetime risk, it may prevent fatalism among individuals whose lifetime risk of HIV is perceived as overwhelming.

Keywords: HIV/AIDS, Self-control, Time inconsistency, Dissonance theory, Regret

JEL-Classification: D81, D84, D91, I12

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1. Introduction

The purpose of this paper relates to the question of why people tend to engage in sexual behavior that is later regretted, and to how this tendency affects perceptions of personal risk and incentives to abstain from sexual risk taking in the future. More specifically, an inter-temporal model is developed in order to analyze the consequences of myopia and remorse on sexual behavior in the presence of HIV/AIDS. The model merges ideas from psychology regarding cognitive limitations of the human mind with economic theory of utility maximization, and is loosely based on previous work by Akerlof & Dickens (1982), O'Donoghue & Rabin (2000), Loewenstein & O'Donoghue (2007), Bénabou a& Tirole (2002; 2004). The results of the theoretical analysis suggest that defensive denial of personal risk contribute to excessive risk taking behavior for individuals with a relatively low lifetime risk, but may prevent fatalism among individuals whose lifetime risk of HIV is perceived as overwhelming. In addition, and consistent with research in psychology,[3] the theoretical analysis further suggests that focusing attention on anticipated regret may prove beneficial for increasing intentions to adopt safer sex practices.

The Human Immunodeficiency Virus (HIV) has harvested human deaths for nearly three decades.[4] Although educational campaigns have resulted in increased levels of HIV awareness and some signs of safer sexual practices, unprotected casual sex is still practiced in HIV susceptible groups.[5] Admittedly, the persistence of sexual risk taking may in part be explained by the increased availability and efficiency of antiretroviral (ARV) therapy or by risk loving preferences. However, for a large share of the HIV susceptible population, AIDS is still associated with

[3] See van der Pligt (1996) for an excellent review.
[4] UNAIDS (2009)
[5] Indeed, studies in sociology suggest that individuals with adequate HIV knowledge engage in recurrent sexual risk taking. See e.g. Campbell, (1997); Varga (1997b); Pettifor *et al.* (2000); MacPhail & Campbell (2001); Anderson & Beutel (2007)

premature death as well as social stigmatization.[6] Similarly, risk loving preferences cannot alone explain sexual risk taking behavior. Research in psychology show that engagement in risky sex is often associated with posterior regret, thus suggesting a presence of time-inconsistent preferences. [7]

Quasi-hyperbolic time preferences are today relatively standard procedure in economic models for intertemporal choice.[8] However, the mechanisms underlying the excess weight on present utility has not, until recently, received much attention.

Loewenstein (1996) offers a potential explanation to time-inconsistent preferences by incorporating insights from neuroscience on how our decision-making capacity is affected during states of heightened physical arousal. According to Loewenstein, human decision making is governed by two basic systems in the brain; a cognitive (rational), and an emotional (impulsive). Both systems are of importance for making adequate and efficient decisions in a given situation. The cognitive system enables probability calculations related to the potential outcomes of a decision, while emotions give the individual a quick reference concerning how he/she "feels" about the alternatives. However, *visceral factors*, such as hunger or sexual desire, tend to crowd out the cognitive system and may therefore hamper the ability to make decisions consistent with long term rationality. In line with this theory, Loewenstein *et al.,* (2001), present empirical evidence indicating that both the mood experienced at the time of the decision and the time interval between decision and outcome has important implications for risk perception. More specifically, happy moods and a long time interval between tend to make people to react with a relatively low degree of fear to certain types of objectively dangerous situations.[9] In accordance with this theory, Alhakami & Slovic (1994) find an inverse relationship between perceived risk and

[6] In 2008 alone, 2 million individuals died of AIDS related diseases. See Lakdawalla *et al.* (2006); Rao *et al.* (2006); Mechoulan (2007); UNAIDS (2009)
[7] See e.g. Richard, *et al.* (1996); Nordgren *et al.,* (2007)
[8] See e.g. Strotz (1955-1956); Thaler & Shefrin (1981); Loewenstein & Prelec (1992); Laibson (1997); O'Donoghue & Rabin (1999; 2001)
[9] See also Slovic (2001)

perceived benefit of an activity, and that the strength of the correlation is related to the intensity of positive or negative affect associated with that activity; if an individual *likes* an activity, the risk associated with that activity is judged as relatively lower and benefits as relatively higher than activities disliked. Similarly, Ariely and Loewenstein (2006), show that experimentally induced sexual arousal creates an acceptance of norm-violating and risky behaviors that increase the likelihood of having sex.[10] The ideas developed by Loewenstein concerning affect-induced myopia have been incorporated in economic models by, for example, O'Donoghue & Rabin (2000), Loewenstein *et al.* (2003) and Lowenstein & O'Donoghue (2007).[11]

Now, the presence of visceral cues may explain why time-inconsistent behavior arises. However, we are still left with the question of what consequences these inconsistencies have for future preferences and behavior. According to Ainslie (1974; 1975; 2001), the failure to exert self-control may have long lasting effects on both behavior and preferences. Ainslie argues that an individual can be depicted as a patchwork of interests that differ with regard to the time-horizon of need-fulfillment. The relative bargaining power of each interest depends on the proximity of need-fulfillment, how costs and benefits are bundled, and on contextual cues. Visceral factors, such as sexual desire, activate and increase the bargaining power of the short term interest to satisfy this desire. If such behavior is in conflict with a long term interest a rational individual may have incentives to act strategically in terms of the formation of *personal rules*. According to Ainslie, personal rules are "commitments made in the mind where the stake is nothing but the credibility of the individual to himself" (Ainslie, 2001, p.94). Most

[10] See also e.g., Ditto *et al., (2006)*
[11] See also; Thaler & Shefrin (1981); Laibson (1998; 2001); Bénabou & Pycia (2002); Loewenstein, O'Donoghue, & Rabin (2003); Benabib & Bisin (2004); Bernheim & Rangel (2004); Battaglini *et al.* (2005); Broccas & Carillo 2008).

commonly, personal rules bundle rewards so that the present temptation is not only weighed against one reward in the future, but rather to a set of rewards.[12]

During the last decade, Ainslie's ideas have been explicitly incorporated in economic models for time-inconsistent behavior. The perhaps most comprehensive work has been done by Bénabou and Tirole (2002; 2004).[13] Bénabou and Tirole argue that individuals have incomplete information regarding their ability to resist short term temptations and therefore rely on past actions as indicators of character. In their 2002 paper, Bénabou and Tirole show that the presence of hyperbolic discounting may create incentives for an individual to engage in strategic behavior in terms of sending potentially self-deceiving signals to future selves concerning their ability to resist temptations. Bénabou and Tirole (2004) focus on the intrinsic motivation for rule based behavior. In addition to the incomplete information regarding ability, Bénabou and Tirole (2004) assume that individuals have imperfect recall concerning relapses and situational factors affecting the cost to abstain from indulgence in short term temptations. Failure to persevere signals a character of low ability to future selves and may thereby contribute to continuing impulsive behavior. However, incomplete information of situational factors related to the cost of abstaining enables an attribution of the failure to persevere to external circumstances, and thus allows future selves to rationalize past behavior.

The rationale for both signaling high ability to future selves and for rationalizing past behavior in Bénabou and Tirole (2002; 2004) in part stems from the assumption that individuals derive utility from having a positive self-image. In a series of psychological experiments, Festinger (1957) and Aronson (1968) showed that participants who voluntarily engaged in behavior inconsistent with their self-image afterwards rationalized their behavior in order to maintain a consistent self-concept. According to *cognitive dissonance theory* (Festinger, 1957;

[12] The violation of a personal rule reduces the credibility of that rule and thus sends a signal to the individual that he is unlikely to follow the rule in the future. Hence, giving in to a temptation is thus associated with a greater cost than if only the particular situation at hand is considered (Ainslie, 2001).
[13] See also e.g., Broccas and Carrillo (2008); Fudenberg & Levine (2006); Gul & Pesendorfer (2001)

Aronson, 1968; 1992), inconsistent behavior has a tendency to create a negative physical arousal (cognitive dissonance), and therefore to create incentives to either change behavior, preferences or to change the evaluation of the behavior that caused the arousal.[14] Aronson (1992) suggests that most individuals strive for 3 things: 1) to preserve a consistent and predictable sense of self, 2) to preserve a competent sense of self, and 3) to preserve a morally good sense of self. Hence, an individual that engages in behavior that either questions his/her intelligence or that induces feelings of guilt will experience incentives to perform dissonance reducing behavior.[15] Accordingly, dissonance theory predicts that people will in general use all available information *before* making a decision. However, *after* the decision has been made they will tend to seek reassurance that they did the right thing.[16]

States of physiological arousal have a potentially important role for rationalization tendencies since high levels of arousal severely diminish the ability to judge future consequences of current behavior.[17] Engagement in risky behavior threatens our self-image as competent individuals and may therefore give rise to anxiety.[18] Indeed, a number of studies in psychology suggest that individuals that engage in high risk behavior tend to underestimate their personal risk in comparison to similar others, and that some individuals displays maladaptive coping strategies such as a defensive denial of risk.[19] Hence, in order to fully understand persistent sexual risk taking it may be important to include self-image maintenance in the analysis.

In their seminal paper from 1982, Akerlof & Dickens use ideas from cognitive dissonance theory in order to analyze the economic consequences of risk taking behavior at the work place. In accordance with Aronson (1968; 1992), Akerlof

[14] See also Aronson (1968; 1992),
[15] Aronson (1992)
[16] Aronson (1989)
[17] See e.g. Tiedens and Linton (2001); Loewenstein & Lerner (2003)
[18] See e.g. Weinstein (1984); van der Pligt *et al.* (1993); van der Pligt (1996)
[19] See e.g. Offir, *et al.* (1993); van der Pligt *et al.* (1993); Abdool Karim *et al.* (1995); van der Pligt (1996); Varga (1997a; 2001); Blanton & Gerrard (1997) ; Gerrard, *et al.* (2000); Harré, (2000); Ariely & Loewenstein (2006)

and Dickens argue that accepting an exposure to risk questions the individual's intelligence, and thereby creates incentives to rationalize past behavior. In the setting of their theoretical model, rationalization is modeled as understating the risk taken. Applied on worker safety, Akerlof & Dicken's theoretical results suggest that insufficient supply of safety insurance in one period may induce underestimation of risk, and thus insufficient demand for insurance, in proceeding periods.

The model developed in this paper builds on the ideas as developed by Akerlof and Dickens (1982), O'Donoghue & Rabin (2000), Loewenstein & O'Donoghue (2007) and Bénabou & Tirole (2002; 2004). However, whereas Akerlof and Dickens model the exposure to health risk as exogenously given (i.e. insurance is only available in time period 2) the model presented in this paper assumes that the individual himself chooses the amount of risk to be exposed to (in terms of the decision to use condoms or not). Endogenous exposure to risk is implicitly incorporated in O'Donoghue & Rabin (2000), Loewenstein & O'Donoghue (2007) and Bénabou and Tirole (2002; 2004). However, the O'Donoghue & Rabin (2000), and Loewenstein & O'Donoghue (2007) papers end with the analysis of how affect may give rise to excessive sexual risk taking. In contrast, the model presented in this paper continues with an analysis of how myopic behavior affects incentives in future time periods. The Bénabou and Tirole (2002; 2004) papers provide an exquisite analysis of the development of behavior over time. The approach taken in this paper differs from Bénabou and Tirole in terms of an explicit incorporation of the role of cognitive dissonance and rationalizing behavior and in terms of the assumption of full information about preferences and past behavior. To my knowledge, no one has to date linked theories of myopic behavior with those of rationalizing behavior in relation to sexual risk taking behavior. The model presented in this paper tries to fill this gap.

The remaining part of the paper is outlined as follows: In order to build up a basic understanding of the model mechanisms, I first develop a basic model for strategic interaction between short-term and long-term interests concerning

sexual choices under affect. I then introduce the opportunity to rationalize past behavior and analyze how the presence of cognitive dissonance affects sexual behavior, subjective risk evaluation and incentives to invest in self-control.

2. Theoretical approach

2.1 A basic model for sexual behavior

Consider an individual (for simplicity treated as a "he") that lives during 3 time periods. The rationale for using the non-standard framework of 3 time-periods is that this approach enables us to analyze both incentives to and effects of rationalizing behavior. Although the assumption of 3 time-periods is not strictly needed for the first part of the analysis, the assumption is maintained in order to give an overview of the full model. In order to keep the analysis as simple as possible I assume a separable lifetime utility function. This assumption enables an analysis focused on sexual behavior.

In each time period, the individual is assumed to face an exogenous supply of attractive sexual opportunities.[20] The individual's choice set is thus constituted by whether sexual experiences are to be safe or unsafe. Safe sex is defined as sex with a condom, where condoms are assumed to provide a 100 percent protection against sexually transmitted infections such as HIV, but also to insert a cost in terms of reducing pleasure of sexual consumption.[21] Finally, in order to enable the analysis of cognitive dissonance in the augmented version of the model I

[20] Naturally, to be correct sexual decisions should be modeled as a bargaining process between two parties. The model presented in this paper treats "sexual opportunities" as exogenous. In other words, the individual is assumed to meet an exogenous number of sexually attractive, and willing, individuals.

[21] Condoms naturally also have monetary costs. However, in order to keep the analysis as simple as possible, and since the analysis does not consider budget constraints other than the constraint related to health, monetary costs of condom use are neglected in the analysis below. Non-monetary costs related to condom use are, for example, physical reduction in sensation and social stigma. Social norms prescribe behaviors considered consistent with being a member of a particular social group. Consequently, if condoms are associated with promiscuity for women, lack of masculinity for men, and lack of trust or as a symptom of STI:s within a certain community, using condoms may imply cost in terms of social stigma and lowered self-esteem. Finally, the cost of condoms is also related to availability, as having a condom readily available in the heat of the moment in the pocket constitutes a lower cost than having to run to the store in order to buy one.

assume that, if the individual contracts HIV in time period 1 or 2, he dies at the end of time period 2.[22] This assumption reflects the relatively long incubation time of AIDS. The simplifying assumption that an HIV infected individual dies at the end of time period 2 regardless of whether HIV is contracted in time period 1 or 2 is relatively strong and does have implications for the analysis since it implies that the marginal disutility of contracting HIV in the second period is lower than contracting HIV in the first period. However, the assumption enables analytical results and may be justified if older individuals in general are more vulnerable to infections such as influenza and pneumonia. Following O'Donoghue & Rabin (2000) and Loewenstein & O'Donoghue (2007), I assume that a rational individual does not discount the future.[23] The individual's preferences in period $\boldsymbol{t}$ are described by the lifetime utility function,

$$U(\boldsymbol{n}, \overline{\boldsymbol{x}}, \varphi) = u(\bar{x}_1) - C^n(n_1, \bar{x}_1) + u(\bar{x}_2) - C^n(n_2, \bar{x}_2) + \varphi^{(1-n_1)\bar{x}_1+(1-n_2)\bar{x}_2} \cdot \left(u(\bar{x}_3) - C^n(n_3, \bar{x}_3)\right) \quad (1)$$

where $\overline{\boldsymbol{x}} = \bar{x}_1, \bar{x}_2, \bar{x}_3$ represents the exogenous supply of sexual encounters in each time-period, and $\boldsymbol{n} = n_1, n_2, n_3$ is the endogenous share of sexual acts in which condoms are used in each time period. $\varphi = (1 - \Pr(HIV))$, represents the per-coital probability of staying HIV negative, where $\Pr(HIV)$ is the probability of acquiring HIV through one unprotected sexual act.[24] Since the supply of attractive sexual opportunities is assumed exogenous in the model, $u(\bar{x}_t)$, a constant, represents the maximal pleasure derived from sexual opportunities. The individual's decision alternatives are constituted by whether or not to use a

[22] Without treatment, HIV progresses into AIDS in approximately 10 years. Now, assuming that the individual does not use treatment is clearly a stark simplification. However, even if antiretroviral (ARV) treatment is used, HIV is associated with a shortened life span (e.g.Lakdawalla *et al.* (2006); Mechoulan (2007); UNAIDS (2009); Rao *et al.* (2006). In addition, in many poor countries, many individuals do not know their HIV status until they develop AIDS, and ARV's are nowhere nearly available for all.

[23] O'Donoghue & Rabin (2000) argue that discounting the future should relate to the uncertainty of the future occurring. Hence, if the future is certain discounting of the future should not take place. Although the future is always to some extent uncertain, including discounting in the model presented in this paper would not add to the analysis.

[24] Pr(*HIV*) in turn is the product of two probabilities; the probability that the sexual partner has HIV, and the probability of HIV transmission given that the partner has HIV.

condom during the sexual intercourse. As mentioned above, condoms are likely to reduce sexual pleasure in terms of interrupted foreplay, reduced sensitivity and perhaps a sense of awkwardness. In equation (1), $C^n(\cdot)$ represents the subjective cost of using condoms. Consider the following functional form for $C^n(\cdot)$,

$$C^n(n_t, \bar{x}_t) = \frac{{n_t}^2 \cdot \bar{x}_t}{2} \tag{2}$$

This functional form suggests that condom related costs increase with the level of condom use, i.e., $C_n^n(\cdot) > 0, C_{nn}^n(\cdot) > 0$. Note that $C^n(\cdot)|_{n_t=0} = 0$. $u(\bar{x}_t) - C^n(n_t, \bar{x}_t)$, is thus the net pleasure of sex. Hence, as implied by equation (1) and (2), the individual's maximization problem is constituted by weighing the cost of using condoms, in terms of the reduction in sexual pleasure, to the benefit of protecting against health hazards such as HIV.

Before we analyze the effect of sexual arousal on risk-taking behavior, let us first define the solution for a rational individual without myopic tendencies. This solution is labeled *First Best* (FB) below, as it does not contain any preference reversal. Defining $(1 - n_1)\bar{x}_1 + (1 - n_2)\bar{x}_2 = x_{us}$ as the total amount of unprotected sex consumed and maximizing equation (1) with respect to n_1, n_2 and n_3 produces the following first order conditions

$$\frac{\partial U_1^{FB}}{\partial n_1} = -\frac{\partial C^n(n_1, \bar{x}_1)}{\partial n_1} - \bar{x}_1 \cdot \left(u(\bar{x}_3) - C^n(n_3, \bar{x}_3)\right) \cdot \ln(\varphi)\, \varphi^{x_{us}} = 0 \tag{3}$$

$$\frac{\partial U_1^{FB}}{\partial n_2} = -\frac{\partial C^n(n_2, \bar{x}_1)}{\partial n_2} - \bar{x}_2 \cdot \left(u(\bar{x}_3) - C^n(n_3, \bar{x}_3)\right) \cdot \ln(\varphi)\, \varphi^{x_{us}} = 0 \tag{4}$$

$$\frac{\partial U_1^{FB}}{\partial n_3} = -\varphi^{x_{us}} \cdot \frac{\partial C^n(n_3, \bar{x}_3)}{\partial n_3} \leq 0 \tag{5}$$

Equation (3)-(5), implicitly defines the optimal levels of condom use in each time period as functions of the risk of acquiring HIV. Let us define the optimal level of condom use in the first best scenario, ${n_t}^{*FB}(\bar{x}_1, \bar{x}_2, \bar{x}_3, \varphi)$. As can be seen in the equations (3)-(5), a rational individual without myopic tendencies

maximizes lifetime utility by equating the marginal cost of using condoms, as depicted by the first terms on the left hand side of the equations, to the marginal benefit in terms of a reduction in the risk of dying prematurely. Note that a rational individual optimally sets $n_3{}^{*FB} = 0$, since there is no risk associated with unprotected sex in time period 3.

Now, as suggested by Loewenstein (1996) and Ainslie (2001), the long term interest to maximize lifetime utility may differ from the short term interest to maximize sexual pleasure. Accordingly, let us assume that the individual consist of a sequence of different selves (or interests) whose individual objective functions may differ in the evaluation of long term costs.

Let us start by assuming that the individual can be divided into two different selves in each time period; one long term interest, represented by a forward looking and rational self striving to maximize lifetime utility, and one short term interest, represented by a sexually aroused self. Let us denote the long term interest LR_t, and the short term interest in each time period SR_t, where LR reflects Long Run preferences, and SR reflects Short Run preferences.

In each time period, the individual is assumed to be exposed to exogenous shocks in terms of affective stimuli (such as the opportunity to engage in sexual activities). During states of affect, the short-term interest is assumed to have the executive power. The timing of the sex model is depicted in *Figure 1*, below.

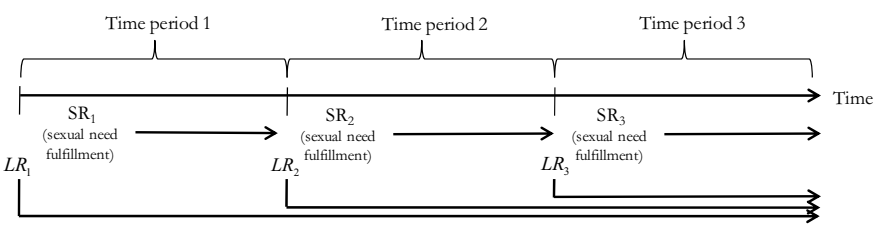


Figure 1: Timing of sexual decisions

At the onset of each time period, LR_t is assumed to use all available information to him at that point in time to maximize lifetime utility. However, LR_t is not in actual charge of future sexual decisions. The exposure to affective stimuli, in terms attractive sexual opportunities, gives rise to sexual arousal which is assumed to transfer the executive power to a more short sighted self (SR_t).[25] As the sexual arousal subsides, the individual is assumed to enter time-period 2 and the preferences of farsighted interests once again surmount. At the onset of time period 2 the long term interest (LR_2) is thus assumed to act in order to maximize the remaining lifetime utility. As in period 1, the individual in period 2 is assumed to get exposed to exogenous affective stimuli that transfer decision power to a shortsighted interest. If sexual risk taking in period 1 or 2 results in an HIV infection, the individual is assumed to die before reaching time period 3. If the individual does *not* catch HIV, long and short run selves in period three once again chooses optimal amounts of risky sex. After time period 3, the individual is assumed to die. Consequently, as unprotected casual sex in period 3 does not affect future utility, both long run and short run selves chooses unprotected sex consumption such that present utility is maximized (see equation (5)). In order to set the stage correctly, let us look closer at the behavior and objective functions of the affective selves.

2.1.1 Sexual short term interests

The true cost of engaging in unprotected sex in time period 1 is given by the risk of acquiring HIV times the utility loss; $\left(1-\varphi^{(1-n_1)\cdot\bar{x}_1}\right)\cdot u(\bar{x}_3)$. However, as mentioned in the introduction, strong physical arousal has a tendency to hamper rational decision making in terms of making the present more salient and reducing the ability to judge the future consequences of current behavior.[26] Hence, the sexually aroused selves should intuitively display myopic tendencies

[25] The intuition behind this assumption is that actual the decision of whether to use a condom or not is taken in the heat of the moment

[26] Immediate emotions affect the decision maker's expectations about both the probability and the desirability of the future consequences. For example, good moods generally make people more optimistic about the probability of positive outcomes, and of their future experience of the outcomes of a certain behavior (e.g., Loewenstein *et al.,* 2001; Loewenstein and Lerner, 2003).

and base their decisions on a heuristic decision rule rather than on complex probability calculations. Consequently, it may be reasonable to assume that sexually aroused individuals base their risk evaluation on a linear probability function such as $\widetilde{\Pr}(HIV) \cdot (1 - n_1) \cdot \bar{x}_1$, [27] where, $\widetilde{\Pr}(HIV)$ represents the individual's perception of the risk of acquiring HIV. In addition, Loewenstein and Lerner (2003) argue that *expected* emotions differ from *immediate* emotions.[28] This implies that the *expected* experience of an outcome is likely to differ from the actual, or *immediate*, experience of that outcome. In other words, an individual under affect should not be able to correctly judge the loss associated with dying prematurely. Taken together, this implies that the shortsighted self would base his sexual decisions on the following cost function:

$$\beta \cdot \left(1 - \widetilde{\Pr}(HIV) \cdot (1 - n_1) \cdot \bar{x}_1\right) \cdot \widetilde{U}(\bar{x}_3) \tag{6}$$

where $\beta; 0 \leq \beta \leq 1$, is a discount factor. If we disregard the first constant term ($\beta \cdot \widetilde{U}(\bar{x}_3)$) and denote the product, $\beta \cdot \widetilde{\Pr}(HIV) \cdot \widetilde{U}(\bar{x}_3) = \omega$, equation (6') transforms into:

$$-\omega \cdot (1 - n_t) \cdot \bar{x}_t = -C^w(\omega, n_t, \bar{x}_t) \tag{6'}$$

The parameter ω thus represents a sense of "worry", or gut feeling, of taking a sexual risk. Now, the part of ω that represents the risk of HIV could (or perhaps should) naturally to some extent be based on the true risk of an HIV infection (for example a weighted mean of some upper and lower bound of $\Pr(HIV)$). However, including a mechanism displaying how ω depends on $\Pr(HIV)$ would prevent us from deriving analytically tractable results. I therefore assume that sexual arousal creates a non-transparent "veil of ignorance" that keeps the individual from estimating the true probability of acquiring HIV through

[27] See, e.g. Griffin *et al.* (1999)
[28] See also, e.g., Loewenstein *et al.,* (2003)

engagement in unprotected casual sex.[29] Consider the objective function and first order condition for the sexually aroused self in time period 1:

$$U_1^{SR}(n_t, \bar{x}_t, \omega) = u(\bar{x}_t) - C^n(n_t, \bar{x}_t) - C^w(\omega, n_t, \bar{x}_t) \tag{7}$$

$$\frac{\partial U_1^{SR}}{\partial n_t} = -\left(\frac{\partial C^n(n_t, \bar{x}_t)}{\partial n_t} + \frac{\partial C^w(\omega, n_t, \bar{x}_t)}{\partial n_t}\right) = 0 \tag{8}$$

Equation (8) defines the optimal level of condom use as seen by the myopic self in period 1. Let us denote the short term optimal level of condom use ${n_t}^{m*} = {n_t}^{m*}(\omega)$. From equation (2), (6') and (7) it is easily seen that ${n_t}^{m*}$ is given by:

$${n_t}^{m*} = \omega \tag{9}$$

In order to evaluate the effect of myopic preferences, let us compare the optimal level of condom use as defined by equation (9) to the level of condom use implicitly defined by equations (3)-(5). Remember that, since sexual activities in time period 3 are "risk free", condom use in time period three is optimally set equal to zero. Hence, $C^n(0, \bar{x}_3) = 0$. Consider the following proposition:

Proposition 1: *If sexual arousal disables consequence analysis and if* $\omega \neq -u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}$ *then* $n_1^{*m} \neq n_1^{*FB}$. *More specifically:*

a) If the risk, or the potential utility loss, associated with unprotected sex is underestimated, condom use by sexually aroused agents will be lower than in the first best scenario, i.e., if $\omega < -u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}$ *then* $n_1^{*m} < n_1^{*FB}$.

b) If the risk, or the potential utility loss, associated with unprotected sex is overestimated, condom use by sexually aroused agents will be higher than in the first best scenario, i.e., if $\omega > -u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}$ *then* $n_1^{*m} > n_1^{*FB}$.

Proof. See the appendix

[29] This assumption may be justified by the energy consumption of the short term interest of getting laid; there is just too little energy left for that part of the brain engaged in calculating risk.

The intuition behind *proposition 1* is relatively straight forward. If affect disables the ability to correctly evaluate future consequences of current behavior, sexually aroused individuals are forced to base decisions on a more or less vague sense of the danger involved in unprotected sex.[30] In addition, the presence of the discounting factor β always makes the individual to underestimate the future cost of current risk taking. Consequently, if the marginal risk of acquiring HIV, based on the linear probability function in equation (6') is smaller or equal to the true probability of an HIV infection, then sexually aroused individuals will always over consume risky sex. However, there may be instances when a risk perception based on the linear probability function actually underestimates the true risk of acquiring HIV. In addition, although the scenario is not very likely, some individuals may also overestimate the experienced cost of an HIV infection. If the overestimation of the marginal risk of acquiring HIV or the expected utility loss from an HIV infection is sufficiently large, there may actually exist instances where sexually aroused individuals consumes *less* unsafe sex than in the first best scenario. In both cases the inability to correctly judge the risk associated with unprotected casual sex, will give rise to a behavior that is inconsistent with the individual's long term interests.

The scenario described by *proposition 1* is somewhat unrealistic. Although some of us admittedly feel completely unable to control affective urges, most individuals do exert some control even during states of affect. Let us therefore analyze how access to self controlling measures affect behavior in the presence of affect induced myopia.

2.1.2 Self control

As mentioned in the introduction, Ainslie (2001) argues that farsighted interest may act strategically in terms of forming personal rules in order to prevent short term indulgence in destructive behavior. Accordingly, let us assume

[30] In the model presented in this paper, ω represents this sense of risk. ω is treated as an exogenous parameter and is thus assumed to be completely detached from the true probability distribution for φ. In reality, ω should, although distorted, naturally have some base in φ.

that forward looking selves can invest in measures that provide future selves with incentives to abstain from excessive risk taking. More specifically, let us assume that LR_1 and LR_2 have access to instruments that reduces the cost of using condoms for the sexually aroused self. Now, it should be noted that these investments cannot be seen as personal rules in a strict sense. Personal rules should be related to an intrinsic cost of violating the rule in terms of sending a signal of failure to the individual. In addition, a violation of the personal rule should reduce the credibility of the rule for future decisions.[31] These mechanisms are not included in the model presented in this paper. Instead, the self-control measures suggested here relates to a reduction in the cost of condom use, for example in terms of buying condoms beforehand or by investing time and effort to reduce the actual cost of *using* condoms.

I introduce instruments available to the long run interests as investments conducted by the long run selves in each time period respectively. Let $z_t; 0 \leq z_t \leq 1$ for $t = 1,2$ represent the instrument available to the long run self in each time period. The lower z_t is, the lower is the subjective cost of using a condom by sexually aroused selves assumed to be. The self control augmented subjective cost of using condoms is given by:

$$C^n(n_t, z_t, \bar{x}_t) = z_t \cdot \frac{{n_t}^2 \cdot \bar{x}_t}{2} \qquad (2')$$

The functional form specified in equation (2') implies that, $C^n_{z_t}(n_t, z_t, \bar{x}_t) > 0$, and $C^n_{z_t z_t}(n_t, z_t, \bar{x}_t) = 0$. Further if $z_t = 0$, $C^n(n_t, 0, \bar{x}_t) = 0$. However, setting z_t low cannot be done without effort; making sure that condoms are available, practicing, or talking to a potential sexual partner about using condoms

[31] The idea of a personal rule is to bundle costs and rewards such that short term interests are persuaded to act in accordance with long term goals. In other words, giving in today sends a signal to the individual that he will always give in is thus associated with a greater cost than if only the particular situation at hand is considered (see Ainslie, 2001).

beforehand may take both time and energy. Let us therefore define the cost of investing in z_t in terms of an effort function:[32]

$$C^z(z_t, \bar{x}_t) = \frac{(1 - z_t)}{z_t} \cdot \bar{x}_t \tag{10}$$

The functional form of equation (10) suggests that the lower the individual wants to set z_t, the more it is going to cost him in terms of effort ($C^z_{z_t} < 0$, and $C^z_{z_t z_t} > 0$), Note that, if $z_t = 1$, then $C^z(1, \bar{x}_t) = 0$. The introduction of potential investments in self control implies that the life time utility function in equation (1) is now given by:

$$\begin{aligned} \mathrm{U}(\boldsymbol{z}, \boldsymbol{n}, \bar{\boldsymbol{x}}, \varphi) = & -C^z(z_1, \bar{x}_1) + u(\bar{x}_1) \\ & - C^n(n_1, \bar{x}_1, z_1) - C^z(z_2, \bar{x}_2) + u(\bar{x}_2) \\ & - C^n(n_2 \bar{x}_2, z_2) + \varphi^{x_{us}} \cdot u(\bar{x}_3) \end{aligned} \tag{1'}$$

where $\boldsymbol{z} = z_1, z_2$. Perfect foresight implies that LR_1 knows that SR_1 will treat z_1 as exogenously given when choosing ${n_1}^{m*}$. The first order condition for SR_1 thus defines ${n_1}^{m*} = {n_1}^{m*}(z_1, \omega, \bar{x}_1)$ as a function of the investment made by LR_1 in the previous time-period. The first order condition for a forward looking self with access to self-control is thus given by:

$$\begin{aligned} \frac{\partial U_t^{LR}}{\partial z_t} = & -\frac{\partial C^z(z_t, \bar{x}_t)}{\partial z_t} - \frac{\partial C^n(n_t^{*m}(z_t), \bar{x}_t, z_t)}{\partial z_t} \\ & - \left[\frac{\partial C^n(n_t^{*m}(z_t), \bar{x}_t, z_t)}{\partial n_t^{*m}} + \bar{x}_t \cdot u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}} \right] \cdot \frac{\partial n_t^{*m}}{\partial z_t} = 0 \end{aligned} \tag{11}$$

for $t = 1,2$ since ${n_t}^{m*} = {n_t}^{m*}(z_t, \omega, \bar{x}_t)$ is now given by $n_1^{*m} = (\omega / z_1)$. Equation (11) defines the optimal level of self-control investments in each time period. Let us define this level of investment; ${z_t}^{*SC} = {z_t}^{*SC}(\bar{\boldsymbol{x}}, \omega, \varphi)$, where SC stands for *Self-Control*. The first order condition in equation (11) suggests that a forward looking

[32] As is clear from equation (10), for $z_t = 0$ the function is undefined. Hence to be strict $z_t; 0 < z_t \leq 1$. However, as z_t approaches zero, the cost of investments in self-control approaches infinity, thus implying that the individual will never find it optimal to set $z_t = 0$.

self maximizes utility by equating the marginal cost of investing in self-control to the marginal benefit. As can be seen in equation (11), the marginal cost of investments in self-control is constituted by both the direct investment cost and by a cost related to the increase in condom use. The marginal benefit of investments in self-control relates to the reduction in condom cost at a given level of condom use, and by the increased probability of surviving to old age. Let us now analyze how the availability of investments in self control affects sexual choices in the sex model. Consider the following proposition:

Proposition 2: *In the absence of myopic tendencies, a forward looking individual does not invest in self control, i.e.,* $z_t^{*FB} = 1$. *However, if the individual has myopic tendencies, and if* $\omega < -u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}$, *we can no longer rule out an interior solution for investments in self control, i.e.,* $z_t^{*SC} \leq 1$.

Proof. See the appendix

The intuition behind *proposition* 2 is relatively straight forward. If long run interests do not have executive power over behavior in aroused states, they are forced to act strategically in order to constrain the decisions of future short-sighted interests. In other words, the knowledge that we, in the heat of the moment, tend to do things that we later regret creates incentives to bolster our ability to refrain from these foolish decisions. Hence, if practicing to put on a condom, or talking to potential sexual partners about condom use, relieves the tension of using condoms, this may constitute a way of reaching closer to our long term goals.

Until now, we have limited our analysis to a somewhat trivial model of investments in self-control in the presence of sexual myopia. This analysis was carried out to set the stage for the main topic of this paper; the presence of cognitive dissonance and its effect on sexual behavior. Let us therefore briefly discuss how the presence of cognitive dissonance changes the timing of the model, and the choice set of the long run selves in time period 1 and 2.

2.2 A Model for sexual rationalization

As mentioned in the introduction, cognitive science suggests that individual well-being is dependent on having a coherent and positive self-concept. Hence, if myopic tendencies induces excessive risk taking, then future interests to minimize suffering may well give rise to rationalization tendencies. Let us therefore extend the previous analysis and assume that the individual has an additional short-term self whose main interest is to reduce anxiety and maintain a positive self-image. The new timing of the model is depicted in *Figure 2*, below:

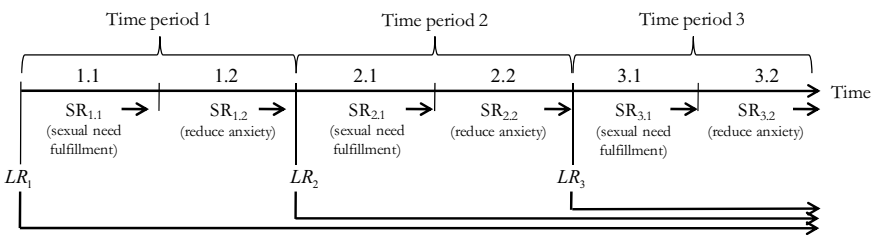


Figure 2: Timing of decisions related to sexual behavior and rationalization

As before, LR_1 is assumed to use all available information in order to maximize lifetime utility, but not to be in charge of the actual decision making during states of sexual affect. However, the introduction of cognitive dissonance implies that, if the individual engages in excessive risk taking in time period t.1, he will now experience negative physical arousal in terms of anxiety in time period t.2. Hence, if decisions in previous periods have resulted in excessive risk taking, a new short run self with the interest to minimize HIV related anxiety will surmount as the individual enters time period 1.2. This short sighted self ($SR_{1.2}$) myopically strives to maintain a positive self-image in terms of rationalizing past behavior. Rationalization is modeled as a subjective evaluation of personal risk of acquiring HIV during an unprotected sex act. As in the above, the true per-coital probability of remaining HIV negative is given by, φ. Let us define the subjective per-coital probability or remaining HIV negative, as chosen by $SR_{1.2}$, $\widetilde{\varphi}$.

After tackling the aftermath of the sexual activity, the individual is assumed to enter time period 2 were the long term interest (LR_2) maximizes the remaining lifetime utility. However, if $SR_{1.2}$ has rationalized past behavior, in terms of choosing $\widetilde{\varphi} \neq \varphi$, LR_2's decisions will not be based on the true risk of acquiring HIV from an unprotected sexual act but rather on $\widetilde{\varphi}$. As in period 1, the individual in period 2 is assumed to get exposed to exogenous affective stimuli that create myopic behavior in period 2.1, and potentially rationalizing behavior in time period 2.2.

Since the individual is assumed to die after time period 3, rationalization in period 2 has no effect on sexual behavior in time period 3. Consequently, since rationalization in period 2 has no future costs this aspect is ignored in the analysis below. Before we turn to the analysis of the effect of rationalization opportunities on sexual behavior and investments in self control, let us briefly discuss the cognitive dissonance function. This is done in the next section.

2.2.1 Rationalizing short term interests

Voluntary involvement in unsafe sexual activities implies that the individual exposes himself to the risk of dying prematurely.[33] Hence, in accordance with the ideas of Aronson (1968), this type of behavior questions may question the individual's self-image as an intelligent and responsible individual (and induce fear of premature death). In our model this implies that, if $\varphi < 1$, and if ${n_t}^{m*} < 1$, the individual experiences a sense of anxiety and an urge to restore the consistency of his self-concept in terms of seeking information affirming that the decision taken was the right one. This may for example imply that the individual downplay his sexual partner's relative riskiness. Hence, in the analysis below, the restoration of a positive self-image is assumed to be carried out in terms of rationalizing past behavior.

Naturally, the restoration of a positive and coherent self-image does not come without costs. Rationalization implies that the individual needs to use effort to

[33] The anxiety could naturally also be related to the social stigma associated with being HIV positive. However, the analysis of social stigma is beyond the scope of this paper

convince himself that his preferred perception of his behavior is the correct one. However, for simplicity this aspect of rationalization costs will be disregarded here. More importantly, rationalization of personal risk distorts the information set of future selves. Since the individual's perception of the riskiness of past behavior is likely to be based on the risk of acquiring HIV, rationalization implies changing his perception of the per-coital survival probability.

Before we define the cognitive dissonance function, let us define the main characteristics that should be included in this function to make it consistent with cognitive dissonance theory. Define $\tilde{\varphi}^*$ as the optimal level of subjective personal survival probability from the perspective of $SR_{1.2}$. The cognitive dissonance function should then have the following characteristics:

1) If there is no risk involved in a certain behavior, there will be no need to rationalize behavior, i.e.,

$$if\ \varphi = 1\ \ then\ \ \tilde{\varphi}^* = 1\ \forall\ n_1 \tag{12}$$

2) If an individual has not engaged in any risk taking in previous time periods there should not be any need to rationalize behavior, i.e.

$$if\ n_1 = 1\ \ then\ \ \tilde{\varphi}^* = \varphi\ \ \forall\ \varphi \tag{13}$$

A cognitive dissonance function which meets these requirements is given by:

$$CD\left(\tilde{\varphi}, n_1, c_f\right) = \frac{1}{2} \cdot c_f \cdot (1 - n_1) \cdot \bar{x}_1 \cdot (1 - \tilde{\varphi})^2 \tag{14}$$

where $c_f \geq 1$ is a scale parameter measuring the negative arousal caused by having an inconsistent self-concept (or the fear of premature death). In other words, as long as the individual does not engage in sexual risk taking ($n_1 = 1$ or $\varphi = 1$), cognitive dissonance will never arise.[34] However, if past behavior involves sexual

[34] To be correct, cognitive dissonance should be a function of the deviation between actual behavior and the individual's self-image as an intelligent and competent person. It is naturally possible that the individual has a self-image that is consistent with some degree of risk taking behavior. This specification implies that $(1 - n_1)$ is replaced with $(\bar{n}_1 - n_1)$ in equation (14), where $\bar{n}_1^i$ is the level of

risk, the individual will experience a threat towards his self-image and enter into a state of negative physical arousal. As in the case of sexual arousal, affect due to cognitive dissonance is assumed to hamper the individual's ability to judge the future consequences of current behavior. Remember that the true consequences of choosing a *personal* risk of HIV ($\tilde{\varphi}$) that diverge from the true level of HIV risk (φ) is that future selves may underestimate the risk of an HIV infection. In other words, the cost of rationalization is the increased risk of premature death, as given by:

$$u(\bar{x}_3) \cdot \varphi^{(1-n_1)\bar{x}_1} \cdot \left[\varphi^{(1-n_2(\varphi))\bar{x}_2} - \varphi^{(1-n_2(\tilde{\varphi}))\bar{x}_2}\right] \tag{15}$$

As in the case of sexual arousal, the heightened arousal associated with anxiety is likely to affect the cognitive capacity to evaluate the future consequences of a given decision. Psychological research suggest that while positive moods are associated with heuristic information processing, negative moods are associated with a more systematic information processing. However, extremely negative states of affect, such as fear, also seem to be associated with a heuristic information processing or avoidance.[35] Since an HIV infection is still associated with premature death in most instances, it may be reasonable to assume that a potential HIV infection causes the individual to experience fear. Consequently, an individual that suspects that his previous behavior has exposed him to HIV is unlikely to engage in complex probability calculations, but rather to rely on heuristics. In addition, since affect reduces the ability to judge future consequences of current behavior, an individual experiencing fear should not consider the behavioral consequences of rationalization (i.e. the effect of rationalization on future condom use). Instead, the individual is once again assumed to rely on a heuristic approach to evaluate the future cost of current behavior in terms of the function:

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condom use that is consistent with the individuals self-image as an intelligent person. However, using this specification we cannot guarantee that $0 \leq \tilde{\varphi} \leq 1$ for $n_1 > \bar{n}_1$. For simplicity I therefore treat the personal norm as not engaging in sexual risk taking at all.

[35] See, e.g. Griffin *et al.* (1999)

$$C_r(\bar{x}_3, \tilde{\varphi}, \varphi) = \frac{1}{2} \cdot u(\bar{x}_3) \cdot (\tilde{\varphi} - \varphi)^2 \tag{16}$$

Drawing intuition from equation (14), it may be appropriate to include condom use in period 1 in the heuristic approach specified in equation (16). However, including previous condom use linearly in equation (16) makes subjective personal risk independent of past behavior (see footnote 36). Since this seems highly unrealistic, I assume that the cost of rationalization is independent of past condom use. The short run self in time period 1.2 thus strives to minimize cognitive dissonance by minimizing the function:

$$F\big(\, n_1, c_f, \bar{x}_3, \tilde{\varphi}, \varphi\big) = CD\big(\tilde{\varphi}, n_1, c_f\,\big) + C_r(\bar{x}_3, \tilde{\varphi}, \varphi) \tag{17}$$

Let us briefly analyze the function specified in equation (17). The first part of $F\big(\, n_1, c_f, \bar{x}_3, \tilde{\varphi}, \varphi\big)$ is associated with anxiety related to previous risk taking behavior while the second part is associated with the perceived cost of self-deception. Note that the short term interest to minimize anxiety takes condom use in previous time periods as given. Minimizing equation (17) with respect to $\tilde{\varphi}$ defines the optimal value of personal risk, $\tilde{\varphi}^{*m} = \tilde{\varphi}^{m*}\big(n_1^{*m}, c_f\,, u(\bar{x}_3), \varphi\big)$ as given by:[36]

$$\tilde{\varphi}^{*m} = \frac{u(\bar{x}_3)\varphi + c_f(1 - n_1^{*m})\bar{x}_1}{u(\bar{x}_3) + c_f(1 - n_1^{*m})\bar{x}_1} \tag{18}$$

Equation (18) implies that, if ${n_1}^{*m} < 1$, and $\varphi < 1$ then cognitive dissonance will create incentives to rationalize by setting $\tilde{\varphi}^{*m} > \varphi$. Hence, if the actions of the short term interest in time period 1.1 results in excessive risk taking, cognitive dissonance will induce an underestimation of personal risk in time period 1.2. This in turn affects distorts the information set of the long run interest in time

[36] Including condom use in equation (16) implies that the individual minimizes the expression: $\frac{1}{2} \cdot c_f \cdot (1 - n_1) \cdot \bar{x}_1 \cdot (1 - \tilde{\varphi})^2 + \frac{1}{2} \cdot (1 - n_1) \cdot u(\bar{x}_3) \cdot (\tilde{\varphi} - \varphi)^2$, thus implying an optimal level of $\tilde{\varphi}$ equal to: $\tilde{\varphi}^{*m} = \big(u(\bar{x}_3)\varphi + c_f\bar{x}_1\big)/\big(u(\bar{x}_3) + c_f\bar{x}_1\big)$. The alternative is to include a quadratic term in equation (14) and a linear term in equation (16). However, this does not change the results in the analysis below. In order to facilitate exposition I therefore disregard the effect of condom use in time period 1 on the short run cost of rationalization.

period 2. If, on the other hand, ${n_1}^{*m} = 1$ or $\varphi = 1$, the individual does not experience any anxiety and therefore evaluates personal risk rationally. We are now ready to analyze the effects of sexual arousal and rationalizing tendencies on condom use and investments in self control. Consider the cognitive dissonance augmented utility function, as defined for the long run interest in time period 1.

$$\begin{aligned} \mathrm{U}\big(\boldsymbol{z}, \boldsymbol{n}, \bar{\boldsymbol{x}}, \omega, \varphi, \tilde{\varphi}, c_f\big) = & -C^z(z_1, \bar{x}_1) + u(\bar{x}_1) - C^n(z_1, n_1, \bar{x}_1) \\ & - CD\big(\tilde{\varphi}, n_1, c_f\big) - C^z(z_2, \bar{x}_2) + u(\bar{x}_2) \\ & - C^n(z_2, n_2, \bar{x}_2) + \varphi^{x_{us}} \cdot u(\bar{x}_3) \end{aligned} \tag{19}$$

Under perfect foresight, the long run and forward looking self in time period 1 (LR_1) rationally observes future costs and benefits of engaging in unprotected sex. As in section 2.1, perfect foresight implies that LR_1 knows that $\mathrm{SR}_{1.1}$ will treat z_1, as set by LR_1, as exogenously given when choosing ${n_1}^{m*}$. The first order condition for $\mathrm{SR}_{1.1}$ thus defines ${n_1}^{m*} = {n_1}^{m*}(z_1, \omega, \bar{x}_1)$ (see equation (11)). Since the decision variables for LR_1 is constituted by z_1,, let us in the following for simplicity denote ${n_1}^{m*} = {n_1}^{m*}(z_1)$. The rationale for including the $CD\big(\tilde{\varphi}, n_1, c_f, \bar{x}_1\big)$ function in the objective function for the long run self in time period 1 is that the long run self knows that if the behavioral choices of the short sighted self in time period 1.1 implies an excessive engagement in sexual risk taking, this will cause the individual to experience anxiety in time period 1.2. Further, with perfect foresight, LR_1 also knows that $\mathrm{SR}_{1.2}$ will set $\tilde{\varphi}^{m*}$ by minimizing the cognitive dissonance function and treating ${n_1}^{m*}$ as exogenously given. Hence, if LR_1 has perfect foresight and is rational, he will treat $\tilde{\varphi}^{m*} = \tilde{\varphi}^{m*}\big(n_1^{*m}(z_1), c_f, u(\bar{x}_3), \varphi\big)$ as a function of the level of condom use set by $\mathrm{SR}_{1.1}$and thus as a function of the investment in z_1.

$$\begin{aligned} & \tilde{\varphi}^{m*}\big(n_1^{*m}(z_1), c_f, u(\bar{x}_3), \varphi\big) \\ & \qquad = \left(\frac{u(\bar{x}_3)\varphi + c_f\big(1 - n_1^{*m}(z_1, \omega, \bar{x}_1)\big)\bar{x}_1)}{u(\bar{x}_3) + c_f\big(1 - n_1^{*m}(z_1, \omega, \bar{x}_1)\big)\bar{x}_1}\right) \end{aligned} \tag{18'}$$

Finally, LR_1 rationally anticipates that LR_2 treats the subjective personal HIV risk, as chosen by the short run self in time period 1.2 ($\tilde{\varphi}^{m*}$), as the true level of survival probability and thus base his investment decisions on this parameter rather than on φ.[37] This implies that the objective function and first order derivative for LR_2 are given by:

$$\begin{aligned} &\mathrm{U}(z_2, {n_2}^{m*}(z_2), \bar{x}_2, \tilde{\varphi}^{m*}) \\ &\quad = -C^z(z_2, \bar{x}_2) + u(\bar{x}_2) - C^n(z_2, {n_2}^{m*}(z_2), \bar{x}_2) \\ &\quad\quad + (\tilde{\varphi}^{m*})^{x_{us}(n_1^{m*}, n_2^{m*}(z_2))} \cdot u(\bar{x}_3) \end{aligned} \tag{20}$$

$$\begin{aligned} &\frac{\partial U(z_2, {n_2}^{m*}(z_2, \omega), \bar{x}_2, \tilde{\varphi}^{m*})}{\partial z_2} \\ &\quad = -\frac{\partial C^z(z_2, \bar{x}_2)}{\partial z_2} - \frac{\partial C^n(z_2, {n_2}^{m*}(z_2), \bar{x}_2)}{\partial z_2} \\ &\quad - \frac{\partial C^n(z_2, {n_2}^{m*}(z_2), \bar{x}_2)}{\partial n_2} \cdot \frac{\partial {n_2}^{m*}(z_2)}{\partial z_2} - \bar{x}_2 \cdot \ln(\tilde{\varphi}^{m*}) \\ &\quad \cdot (\tilde{\varphi}^{m*})^{x_{us}(n_1^{m*}, n_2^{m*}(z_2))} \cdot u(\bar{x}_3) \cdot \frac{\partial {n_2}^{m*}(z_2)}{\partial z_2} = 0 \end{aligned} \tag{21}$$

Note that, since $\tilde{\varphi}^{m*} = \tilde{\varphi}^{m*}\left(n_1^*(z_1, \omega), \bar{x}_1, c_f, u(\bar{x}_3), \varphi\right)$ is a function of z_1, z_2 and $n_2^{m*} = n_2^{m*}(z_2(z_1), \bar{x}_2, \omega)$ will also be functions of z_1. Hence, with perfect foresight, LR_1 sets z_1 in order to maximize equation (19), treating the choices of future selves as functions of z_1. The objective function for LR_1 under full information is thus given by:

$$\begin{aligned} &\mathrm{U}\left(z_t, \bar{x}_1, \bar{x}_2, \bar{x}_3, \omega, \varphi, c_f\ \right) \\ &= -C^z(z_1, \bar{x}_1) + u(\bar{x}_1) - C^n({n_1}^{m*}(z_1), \bar{x}_1, z_1\ ) \\ &- CD\left(\tilde{\varphi}^{*m}\left({n_1}^{m*}(z_1), \varphi, u(\bar{x}_3), c_f\ \right), c_f, \bar{x}_1\right) - C^z(z_2(z_1), \bar{x}_2\ ) + u(\bar{x}_2) \\ &- C^n\left(\bar{n}_2, {n_2}^{m*}\left(z_2(z_1)\right)\right) + \varphi^{x_{us}(n_1^{m*}(z_1, \omega), n_2^{m*}(z_2, \omega))} \cdot u(\bar{x}_3) \end{aligned} \tag{19'}$$

[37] In the model presented in this paper, rationalization is assumed to always be successful, in terms of completely changing the information set for future selves.

As is clear from equation (19'), I assume that the individual only experiences anxiety due to past risk taking in time period 1.2. In reality, as long as $\tilde{\varphi}^{*m} < 1$ and ${n_1}^{m*} < 1$, people are likely to experience anxiety from time to time even in later time periods. However, although including anxiety in time period 2 as a function of $\tilde{\varphi}^{*m}$ would be an interesting extension of the model, this would not allow us to derive analytically tractable results. Let us therefore assume that the cognitive dissonance cost is only experienced in time period 1.2. Further, in order get a clearer intuition and simplify the analysis below, let us make the following assumption:

Assumption 1: *The direct effect of condom use on cognitive dissonance outweighs the indirect effect, i.e.* $\left|\frac{\partial CD}{\partial {n_1}^{m*}}\right| > \left|\frac{\partial CD}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right|$.

In order to see the rationale for *assumption* 1, note that the total effect of condom use on the anxiety associated with cognitive dissonance is given by:

$$\frac{\partial CD}{\partial {n_1}^{m*}} + \frac{\partial CD}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}} \tag{22}$$

The first term in equation (22) describes the reduction in anxiety associated with a lower level of risk taking behavior and is negative by equation (14). The first part of the second term in equation (22) is positive from equation (14) and describes how an increase in the subjective survival probability reduces the anxiety associated with unprotected sex. Finally, $\partial \tilde{\varphi}^{m*} / \partial {n_1}^{m*}$ is associated with the reduced need to rationalize at higher levels of condom use and is negative by equation (18'). Taken together, equation (22) implies that an increase in condom use has two effects in opposite directions on anxiety. The direct effect of increased condom use reduces anxiety, but since an increase in condom use also reduces the optimal level of $\tilde{\varphi}^{m*}$, an increase in condom use indirectly *increases* anxiety. *Assumption 1* simply states that condom use induces a net reduction in the anxiety related to sexual risk taking. In order to facilitate the presentation below, let us also define:

$$C^z(z_1, \bar{x}_1) = C^{z1} \qquad C^z(z_2(z_1), \bar{x}_2) = C^{z2}$$

$$C^n(z_1, {n_1}^{m*}(z_1, \omega), \bar{x}_1) = C^{n1} \qquad C^n(z_2(z_1), {n_2}^{m*}(z_2(z_1), \omega), \bar{x}_2) = C^{n2}$$

$$CD\left(\tilde{\varphi}\left({n_1}^{m*}(z_1, \omega), \varphi, \bar{x}_3, c_f\right), c_f, \bar{x}_1\right) = CD$$

Maximizing equation (19') with respect to z_1 produces the first order condition:

$$\begin{aligned}\frac{\partial U_1^{LR}}{\partial z_1} = -\Bigg[&\frac{\partial C^{z1}}{\partial z_1} + \frac{\partial C^{n1}}{\partial z_1} \\ &+ \left(\frac{\partial C^{n1}}{\partial {n_1}^{m*}} + \bar{x}_1 \cdot u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}(z_1, z_2(z_1))}\right) \cdot \frac{\partial {n_1}^{m*}}{\partial z_1}\Bigg] \\ &- \left[\frac{\partial CD}{\partial {n_1}^{m*}} + \frac{\partial CD}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right] \cdot \frac{\partial {n_1}^{m*}}{\partial z_1} \\ &- \Bigg[\frac{\partial C^{z2}}{\partial z_2} + \frac{\partial C^{n2}}{\partial z_2} + \left(\frac{\partial C^{n2}}{\partial {n_2}^{m*}} + \bar{x}_2 \cdot u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}(z_1, z_2(z_1))}\right) \\ &\qquad \cdot \frac{\partial {n_2}^{m*}}{\partial z_2}\Bigg] \cdot \frac{\partial z_2(z_1)}{\partial z_1} = 0\end{aligned} \tag{23}$$

$\partial z_2(z_1)/\partial z_1$ can be partitioned into:

$$\frac{\partial z_2(z_1)}{\partial z_1} = \left(\frac{\partial z_2(z_1)}{\partial {n_1}^{m*}} + \frac{\partial z_2(z_1)}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right) \cdot \frac{\partial {n_1}^{m*}}{\partial z_1} \tag{24}$$

where $\partial z_2(z_1)/\partial {n_1}^{m*}$ relates to the direct effect of condom use in time period 1 on incentives to invest in self-control in time period 2, and $(\partial z_2(z_1)/\partial \tilde{\varphi}^{m*}) \cdot (\partial \tilde{\varphi}^{m*}/\partial {n_1}^{m*})$ relates to the indirect via rationalization. Let us briefly analyze the first order condition in equation (23). The expression within the first square bracket pertains to the within-period marginal benefits and costs of investments in z_1 and thus corresponds to the first order condition in equation (11). However, when the individual has the ability to rationalize past behavior, investments in self-control have additional costs and benefits. The term within the second square

bracket in equation (23) describes the marginal effect of investments in self-control on anxiety caused by cognitive dissonance and thus on incentives to engage in denial of risk. The term within the last square bracket corresponds to the first order condition for the forward looking self in time period 2 evaluated at φ. Finally, as can be seen in equation (24), investments in self-control in time period 1 affects investment incentives in time period 2 both in terms of the effect on condom use in time period 1 and thus on the probability of being HIV negative, and in terms of changing the information set due to rationalization.

Now, the main question asked in this paper is how affect induced myopia and rationalization tendencies affect sexual risk taking. In order to answer these questions, we need to analyze how rationalization affects the incentives to invest in self-control in time period 2. Let us therefore take a closer look at the two last parts of equation (23).

From equation (2') and (18') and given *assumption 1*, the term within the second square bracket of equation (23) is negative. Hence, investments in self-control in time period 1 have the additional direct marginal benefit of reducing cognitive dissonance. However, since investments in self-control also affects incentives to rationalize personal risk it also indirectly affects the incentives facing the forward looking self in time period 2. Let us denote the expression within the last square bracket in equation (23) $FOC_2(\varphi)$. If $\widetilde{\varphi}^{*m} = \varphi$, then $FOC_2(\varphi) = 0$. However, with $\widetilde{\varphi}^{*m} \neq \varphi$ it may be the case that $FOC_2(\varphi) \neq 0$, since the forward looking self maximizes perceived utility by setting $FOC_2(\tilde{\varphi}^{m*}) = 0$. Hence, in order to determine how rationalization tendencies affect incentives to engage in unsafe sex and invest in self-control we need to analyze the sign of $FOC_2(\varphi) \cdot (\partial z_2 / \partial z_1)$.

It can be shown that the marginal effect of rationalization on sexual risk taking hinge on whether rationalization causes the forward looking self in time

period 2 to under- or overestimate the marginal cost of unprotected sex. The effect can be summarized by the term:[38]

$$\ln(\varphi) \cdot \varphi^{x_{us}} - \ln(\tilde{\varphi}^{*}) \cdot (\tilde{\varphi}^{m*})^{x_{us}} \tag{25}$$

where $\ln(\varphi) \cdot \varphi^{x_{us}}$ relates to the true marginal effect of an unprotected sexual act on survival probability, and $ln(\tilde{\varphi}^{*}) \cdot (\tilde{\varphi}^{m*})^{x_{us}}$ is the marginal effect as perceived by a rationalizing individual. It can further be shown that the sign of equation (25) depends on the perceived risk of being HIV positive upon entrance in time period 2. As is shown in the appendix, this effect is captured by the expression:

$$\left(1 + x_{us} \cdot ln(\tilde{\varphi}^{*m})\right) \tag{26}$$

If equation (26) is positive, a marginal increase in $\tilde{\varphi}^{*m}$ implies that the marginal risk of an unprotected sexual act is underestimated. However, if x_{us} is sufficiently high, or if $\tilde{\varphi}^{*m}$ is sufficiently low, $\left(1 + x_{us} \cdot ln(\tilde{\varphi}^{*m})\right)$ may be negative. In this case, a marginal increase in $\tilde{\varphi}^{*m}$ actually causes an *overestimation* of the perceived marginal risk of unprotected sex, due to a perceived *increase* in the probability of being HIV negative. Whether or investments in self-control in time period 1 increases or reduces incentives to invest in self-control in time period 2 in this scenario depends on the relative effect of increased condom use on true and subjective survival probability. To see this, let us return to equation (24). The first term on the RHS in equation (24) relates to the direct effect of increased condom use in time period 1 on incentives to invest in self-control in time period 2. Since condom use increases the probability of being HIV negative in time period 2, and thus the marginal benefit of using condoms in this period, this term is unambiguously negative (see the appendix for a derivation of this result). The second term on the RHS in equation (24) relates to the indirect effect of condom use in time period 1 on incentives to invest in self-control in time period 2. As is

[38] With a linear probability function of the kind $\varphi = (1 - x_{us} \cdot PR(HIV))$ an increase in investments in self-control in time period 1 would unambiguously increase incentives to invest in self-control in time period 2. Calculations are available from the author upon request.

shown in the appendix, the sign of this term hinges on the sign of equation (26). If equation (26) is negative, rationalization increases the perceived probability of being HIV negative in time period 2 and therefore makes the total effect of condom use on incentives to invest in self-control in time period 2 ambiguous. Consider the following proposition:

Proposition 3:

3.1) If $1 + x_{us} \cdot ln(\tilde{\varphi}^{*m}) > 0$*, rationalization induces an* underestimation *of the marginal cost of unprotected sex and an* underinvestment *in self-control in time period 2. This creates incentives for precautionary savings in terms of overinvestment in self-control in time period 1*

3.2) If $1 + x_{us} \cdot ln(\tilde{\varphi}^{*m}) < 0$*, rationalization induces an* overestimation *of the marginal cost of unprotected sex. However, incentives for investments in self-control in time period 1 depend on the relative magnitude of the direct and indirect effect of condom use on incentives to invest in self-control in time period 2:*

a. If $\left|\frac{\partial z_2(z_1)}{\partial {n_1}^{m*}}\right| > \left|\frac{\partial z_2(z_1)}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right|$*, then the reduction in HIV risk due to increased condom use in time period 1 outweighs the perceived increase in perceived HIV risk due to reduced rationalization. In this case rationalization* reduces *incentives for investments in self-control in time period 1*

b. If $\left|\frac{\partial z_2(z_1)}{\partial {n_1}^{m*}}\right| < \left|\frac{\partial z_2(z_1)}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right|$ *then the reduction in HIV risk due to increased condom use in time period 1 is outweighed by the perceived reduction in HIV risk due to reduced rationalization. In this case rationalization creates incentives for precautionary savings in terms of* higher *investments in self-control in time period 1.*

Proof. See the Appendix

Investments in self-control in time period 1 have the direct benefit of reducing sexual risk taking and anxiety associated with cognitive dissonance in this period. In addition, due to the reduction in anxiety, investments in self-control in time period 1 reduce incentives to rationalize personal risk.

Consequently, the more self-control used in time-period 1, the more correctly will the forward looking self in time-period 2 judge the risk of engaging in unprotected sex. However, judging HIV risk more correctly does not necessarily imply more investments in self-control in time period 2. As mentioned above, the marginal benefit of an investment in self-control in time period 2 depends both on the perceived probability of acquiring HIV from an unprotected sexual act, and on the perceived probability of already being infected with HIV (i.e., the greater the probability of already having the virus, the smaller is the perceived benefit of abstaining from unprotected sex).[39]

Rationalization of personal risk contributes to an underestimation of the per-coital risk of an HIV infection for an HIV negative individual. However, it also affects the perceived risk of being HIV positive. Put differently, an underestimation of personal HIV risk *overestimates* the probability of being HIV negative and thus the *overestimates* the perceived marginal benefit of abstaining from unprotected sex. The result in *Proposition 3.2* implies that, if the effect of an increase in the subjective appraisal of being HIV negative is greater than the reduction in the perceived per-coital risk of an HIV infection, rationalization may lead to an overall *increase* in the perceived marginal cost of unprotected sex in time period 2.[40] Hence, from the perspective of the forward looking self in time period 1, rationalization may cause over-restrictive behavior in future time periods. However, even if investments in self-control in time period 1 reduces incentives to invest in self-control in time period 2 by reducing rationalization, the increase in condom use that follows from investments in self-control always increase the marginal benefit of condom use in time period 2 due to the reduced probability of being HIV positive.

The results in *Proposition 3.2* suggest that, if the effect of increased condom use outweighs the effect of reduced rationalization on the perceived probability of being HIV positive, investments in self-control in time period 1 always increases

[39] Indeed, disregarding the self-deception effect, the higher sexual risk taking in period 1 is, the lower will the perceived marginal cost of unsafe sex in time period 2 be.
[40] This result hinges on the assumption that the individual does not know his or her HIV status.

incentives to invest in self-control in time period 2. This implies that, if rationalization induces an overestimation of the marginal cost of unsafe sex, the forward looking self in time period 1 has incentives to prevent exaggerated self-control in time period 2 by under-investing in self-control. If, on the other hand the effect of rationalization outweighs the direct effect of condom use, increased investment in self-control in time period 1 reduces exaggerated self-control in time period 2. Hence, in this case, the forward looking self in time period 1 once again has incentives to engage in precautionary investments in self-control.

The result in *Proposition 3.2* may at first glance appear contra-intuitive. However, if HIV is perceived as more or less unavoidable, then from the perspective of the forward looking self in time period 1, investment in self-control in time-period 2 is a waste of resources. Hence, if rationalization induces an overestimation of the marginal cost of unsafe sex, it will cause future selves to engage in over-restrictive behavior. Consequently, since investing in self-control in time period 1 reduces the risk of rationalization, the forward looking self in time period 1 will have incentives to promote condom use.

So far we have assumed that individuals have perfect information about their rationalization tendencies. However, it may be reasonable to assume that individuals are more or less naïve about the existence and effects of cognitive dissonance. Let us therefore briefly analyze the consequences of naïveté on investments in self control. This is done in the next section.

2.2.2 Naïveté

Naïve individuals are usually defined as individuals that do not realize that future behavior will be affected by myopic tendencies (including sexually induced myopia). However, since the main question asked in this paper is how rationalization affects sexual risk taking I find it more interesting to focus the analysis on the cognitive dissonance aspect of naïveté. In addition, if the individual is completely naïve about sexually induced myopia, and the cost of investments in z_1 are sufficiently high, he will completely refrain from investments in z_1. Hence, condom use in equilibrium will be the same as when

self control measures are not available ($n_1{}^* = n_1{}^{m*}$). Consequently, let us assume that naïveté only concerns rationalization tendencies and define $\theta; 0 \leq \theta \leq 1$ as a measure of the degree of naïveté. This implies the following definition of naïve and sophisticated individuals.

Definition 2:

(i) *A completely sophisticated individual is an individual who is fully aware of myopic tendencies and rationalization behavior, i.e.,* $\theta = 1$

(ii) *A completely naïve individual is an individual who is aware of sexual myopia but who is ignorant about rationalization tendencies, i.e.,* $\theta = 0$

(iii) *An individual who is partially naïve about his rationalization tendencies is thus defined by* $\theta; 0 < \theta < 1$

A completely naïve individual is unaware of that unsafe sexual practices induces fear and rationalization in the future. This implies that naïve individuals ignore the effect of investments in self-control on rationalization and anxiety and thus treats $\tilde{\varphi}^{*m}$ as exogenous and equal to φ. In addition, naïveté implies that the individual will disregard that the long run self in time period 2 will base his investment decisions on $\tilde{\varphi}^{*m} \neq \varphi$, and thus presume that equation (24) only includes the first term; $\partial z_2(z_1)/\partial z_1 = (\partial z_2(z_1)/\partial {n_1}^{m*}) \cdot (\partial {n_1}^{m*}/\partial z_1)$. In other words, a completely naïve LR_1 fails to include the indirect effect of rationalization, as depicted by the second term in equation (24); $(\partial z_2(z_1)/\partial \tilde{\varphi}^{m*}) \cdot (\partial \tilde{\varphi}^{m*}/\partial {n_1}^{m*}) \cdot (\partial {n_1}^{m*}/\partial z_1)$. With the inclusion of naïveté, the first order condition for the forward looking self in time period 1 is thus given by:

$$\begin{aligned}\frac{\partial U_1^{LR}}{\partial z_1} = -\Bigg[&\frac{\partial C^{z1}}{\partial z_1} + \frac{\partial C^{n1}}{\partial z_1} \\ &+ \left(\frac{\partial C^{n1}}{\partial {n_1}^{m*}} + \bar{x}_1 \cdot u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}(z_1, z_2(z_1))}\right) \cdot \frac{\partial {n_1}^{m*}}{\partial z_1}\Bigg] \\ &- \theta \cdot \left[\frac{\partial CD}{\partial {n_1}^{m*}} + \frac{\partial CD}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right] \cdot \frac{\partial {n_1}^{m*}}{\partial z_1} \\ &- \Bigg[\frac{\partial C^{z2}}{\partial z_2} + \frac{\partial C^{n2}}{\partial z_2} \\ &+ \left(\frac{\partial C^{n2}}{\partial {n_2}^{m*}} + \bar{x}_2 \cdot u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}(z_1, z_2(z_1))}\right) \cdot \frac{\partial {n_2}^{m*}}{\partial z_2}\Bigg] \\ &\cdot \left(\frac{\partial z_2(z_1)}{\partial {n_1}^{m*}} + \theta \cdot \frac{\partial z_2(z_1)}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right) \cdot \frac{\partial {n_1}^{m*}}{\partial z_1}\end{aligned} \tag{28'}$$

As can be seen in equation (28'), the special case of $\theta = 1$ implies that the individual has perfect foresight and thus that the results from above hold. However, if $\theta < 1$, the individual underestimates his tendency to rationalize past behavior. $\theta < 1$, furthermore implies that the long forward looking self in period 1 does not consider the full cost of rationalization in terms of underestimation of HIV risk in time period 2. Consider the following proposition:

Proposition 4: *Naïveté of self-deception tendencies contributes to an* increase *in sexual risk taking in time period 1, i.e.,* $\partial z_1/\partial\theta > 0$.

Proof. See the appendix

Naïveté of self-deception tendencies prevents the individual from incorporating the full cost of engaging in unsafe sex and therefore results in excessive risk taking in time period 1. However, the incentives for increasing consumption of unprotected sex depend on the lifetime probability of acquiring HIV. As suggested by *Proposition 3*, self-deception causes an underestimation of the marginal HIV risk for individuals with a relatively low lifetime risk of acquiring HIV, and thus to lower than optimal investments in self-control in time period 2. This implies that sophisticated "low risk" individuals have incentives to

engage in precautionary condom use in order to prevent excessive risk taking in the future. Naïveté of cognitive dissonance implies that this precautionary behavior does not take place, and thus to an increase in sexual risk taking in both time periods.

In contrast, for individuals with a relatively high lifetime risk of an HIV infection, self-deception implies an overestimation of the perceived marginal risk of an HIV infection in time period 2, and thus to overly restrictive behavior in this time period. Sophisticated "high risk" individuals thus have incentives to restrict consumption of unsafe sex in time period 1 in order to prevent *lower than optimal* consumption of unprotected sex in later time periods. Hence, as for "low risk" individuals, naïveté of cognitive dissonance implies that "high risk" individuals will engage in excessive sexual risk taking in time period 1. However, for "high risk" individuals, the overconsumption of risky sex as young may actually contribute to a *reduction* in sexual risk taking in later time periods. The mechanism behind this result is that the increase in the subjective survival probability that arises due to an increase in sexual risk taking spurs investments in self-control in later time periods among individuals characterized by a high risk of acquiring HIV. In other words, rationalization may prevent fatalism. However, excessive risk taking in period 1 will only contribute to a reduction in risk taking behavior in period 2 if the effect of rationalization on the perceived probability of being HIV negative outweighs the reduction in true survival probability due to lower condom use (i.e., if equation (24) is negative).

3. Conclusion

In many cases, decisions that seem defendable during states of strong affect are later found to collide with longer term interests and thus regretted. Regret, in turn, is commonly associated with negative emotions such as anxiety. The model, presented in this paper, focuses on our tendency to rationalize past behavior as a way to reduce anxiety and restore a consistent and positive self-image. Admittedly, the consequences of affect induced myopia and cognitive dissonance

may in many situations not lead to decisive life changes. However, in the case of sexual risk taking, decisions taken under affect may be irreversible. Hence, even if an individual changes behavior after realizing the risk taken, he or she cannot eliminate the risk of being HIV positive. In addition, since HIV does not cause instant death, and since many individuals hesitate to test for HIV, anxiety may occur both due to cognitive dissonance and fear of social stigma and premature death. Since past behavior cannot be made undone and since HIV is incurable, rationalizing may be one of few instruments left to reduce anxiety.

The results presented in this paper suggest that sexual risk taking may, in addition to increasing the risk of an HIV infection directly, increase the inclination to engage in unsafe sex practices in the future and that the mechanism behind this behavior is two-fold: First, sexual risk taking during young age increases the likelihood of being infected with HIV and thus reduces the perceived marginal benefit of abstaining from unsafe sex during later periods in life. Second, if affect induced risk taking is associated with defensive denial in terms of rationalizing, the underestimation of personal per-coital risk of HIV may lead to an underestimation of the marginal cost of unprotected sex later in life and therefore to excessive risk taking behavior. However, as suggested by *Proposition 3.2*, the defense mechanism to rationalize may not be destructive in all circumstances. Since denial of risk also reduces the perceived probability of being infected with HIV it may create incentives to use protection for individuals who would otherwise resort to fatalism and reckless behavior. Hence, self-deception may not be a maladaptive coping strategy in all circumstances. This result is consistent with the relatively substantial body of psychological research presented in van der Pligt *et al.* (1993) and van der Pligt (1996).

Consistent with research in psychology, *Proposition 4* suggests that anticipating regret (i.e. being aware of cognitive dissonance and rationalizing tendencies) increases incentives to engage in precautionary behavior, and that a spread between expected and actual emotions may contribute to maladaptive behavior (e.g. Richard *et al.*, 1996; Loewenstein & Lerner, 2003). However, since the

incentives schemes underlying the behavioral reactions to reductions in self-deception differ with regards to the true risk of being infected with HIV, empirical research is necessary in order to create policy recommendations. For individuals with a relatively low lifetime risk of HIV, a reduction in rationalization unambiguously increases incentives to abstain from unsafe sex in later time periods. However, for individuals with a substantial lifetime risk of HIV, rationalization reduces incentives to engage in unsafe sex via the effect on the perceived probability of being HIV negative. If the true risk of HIV is sufficiently high and if some risk is unavoidable, investments in self-control may be perceived as relatively fruitless. This implies that the mechanism underlying safe sex practices during young age is related to the incentive to prevent future selves from engaging in over-restrictive behavior.

The true per-coital transmission rate of HIV is substantially less than 1 percent for the majority of the HIV susceptible population (e.g., Gray *et al.,* 2001; Quinn, *et al.*, 2000). However, as shown by Shaklee and Fishhoff (1990), many individuals overestimate the per-coital risk of an HIV infection. The above analysis implies that if the per-coital risk of HIV is perceived as relatively high, the knowledge that we will not be able to abstain completely from unsafe sex may induce fatalism. Hence, for individuals living in environments where HIV constitutes a significant threat it may actually prove beneficial to inform about the relatively *low* transmission probability of HIV in order to prevent excessive risk taking.

It should be noted that these results are based on the assumption that individuals do not test for HIV. If people do take HIV tests from time to time, the analysis changes. Disregarding altruistic motives, HIV positive individuals have relatively little to lose from indulging in unprotected casual sex. However, for individuals testing negative, the marginal cost of unsafe sex will increase.

Although there have been substantial advances within the economic field of research concerning risk perception, economic research usually focuses on

lotteries with monetary rewards.[41] For the subjects in these experiments, it may be easy to predict the experienced benefit of a positive outcome, or the experienced cost of a negative outcome. However, when it comes to issues of life and death, predicting experienced emotions may be more difficult. Hence, it is of immense importance to empirically investigate how decisions under risk are affected when the risk relates to issues such as HIV/AIDS. In addition, and as mentioned above, the incentives for and consequences of different coping strategies such as defensive denial needs empirical investigation, not only in the realm of sexual risk taking behavior but also related to risk taking behavior in general. Finally, the model presented in this paper assumes that rational individuals base their decisions on relatively complicated probability calculations. Empirical research is needed to investigate if this assumption really holds.

Appendix

A1. Variables, parameters and definitions

Table A1.1

Variables	
n_t	Condom use in time period t
z_t	Self-control in time period t
$\tilde{\varphi}$	Subjective per-coital risk of HIV
Parameters	
φ	Objective per-coital risk of HIV
$\bar{x}_3$	Exogenous supply of attractive sexual opportunities in time period t
ω	Worry
c_f	Cognitive dissonance cost (fear)
Superindex	
m	Myopic optimum
FB	First Best optimum
SC	Self-control optimum

[41] E.g. Kahneman & Tversky, 1979

A2. Proofs

Proof of proposition 1

Compare the first order conditions for a far sighted and a short sighted individual. Equation (3) and (4) suggests that an individual without myopic tendencies maximizes utility by setting:

$$\frac{\partial C^n(n_t, \bar{x}_t)}{\partial n_t} = -\bar{x}_t \cdot u(\bar{x}_3) \cdot ln(\varphi)\, \varphi^{x_{us}} \tag{A.1}$$

Myopic agents, on the other hand, maximize short term utility by setting:

$$\frac{\partial C^n(n_t, \bar{x}_t)}{\partial n_t} = \omega \cdot \bar{x}_t \tag{A.2}$$

Substituting $\omega \cdot \bar{x}_t$ from equation (A.2) into equation (A.1) gives us an estimate of the risk evaluation error that the sexually aroused self makes in t.1:

$$\bar{x}_t \cdot (\omega + u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}) \tag{A.3}$$

Hence, if $\omega < -u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}$, the value of using condoms is underestimated by the myopic agent in comparison to a rational individual without myopic tendencies and thus $n_1^{*m} < n_1^{*FB}$. If if $\omega > -u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}$, $n_1^{*m} > n_1^{*FB}$,
q. e .d.

Proof of proposition 2

Let us start by noting that, in the absence of myopic selves, the first order conditions for z_t are given by:

$$\frac{\partial U}{\partial z_t} = -\frac{\partial C^z(z_t, \bar{x}_t)}{\partial z_t} - \frac{\partial C^n(n_t, \bar{x}_t, z_t)}{\partial z_t} = 0 \tag{A.4}$$

Equation (A.4) implies that the optimal level of z_t for an individual without myopic problems is given by:

$$z_t{}^{FB} = \frac{\sqrt{2}}{n_t} \tag{A.5}$$

However, since $z_t \in [0,1]$, and since $n_t \in [0,1]$, the first order condition in equation (A.4) can never be fulfilled. In other words, we have a corner solution where the forward looking individual sets $z_t{}^{*FB} = 1 < \frac{\sqrt{2}}{n_t}$, and where

$$\frac{\partial U}{\partial z_t} = -\frac{\partial C^z(z_t, \bar{x}_t)}{\partial z_t} - \frac{\partial C^n(n_t, \bar{x}_t, z_t)}{\partial z_t} > 0 \tag{A.4'}$$

Now consider the first order condition in equation (18), and define:

$$\begin{aligned} A &= -\left(\frac{\partial C^n(n_t^{*m}(z_t), \bar{x}_t, z_t)}{\partial n_t^{*m}} + \bar{x}_t \cdot u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}\right) \cdot \frac{\partial n_t^{*m}}{\partial z_t} \\ &= -(n_t^{*m} \cdot \bar{x}_t \cdot z_t + \bar{x}_t \cdot u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}) \cdot \frac{\partial n_t^{*m}}{\partial z_t} \end{aligned} \tag{A.6}$$

Note that, with the access to investments in self control, n_t^{*m} is now given by:

$$n_1^{*m} = \frac{\omega}{z_1^*} \tag{A.7}$$

Substituting the expression in equation (A.7) into equation (A.6) gives us:

$$A = -(\omega + u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}) \cdot \bar{x}_t \cdot \frac{\partial n_t^{*m}}{\partial z_t} \tag{A.8}$$

Since $\partial n_t^{*m}/\partial z_t < 0$, it follows that if $\omega < u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}$, $A < 0$. Hence, if $\omega < u(\bar{x}_3) \cdot \ln(\varphi)\, \varphi^{x_{us}}$, we can no longer rule out an interior solution for z_t. Let us further compare the first order condition for a sexually aroused self in time-period t.1 with and without the presence of self-control:

$$n_t^{*m} = \omega \tag{A.9}$$

$$n_t^{*SC} = \frac{\omega}{z_t^{*SC}} \tag{A.10}$$

Hence, if we have an interior solution, condom use will be higher when the LR_1 has access to self controlling measures than when these measures are not available, q. e. d.

Proof of proposition 3

In order to see proposition 3, let us first analyze how the sign of $FOC_2(\varphi)$ is affected by $\tilde{\varphi}^{*m} > \varphi$. In order to do this, let us define:

$$\tilde{A} = -\bar{x}_2 \cdot ln(\tilde{\varphi}^*) \cdot (\tilde{\varphi}^{m*})^{x_{us}} \cdot u(\bar{x}_3) \cdot \frac{\partial n_2}{\partial z_2} \tag{A.11}$$

$$A = -\bar{x}_2 \cdot ln(\varphi) \cdot \varphi^{x_{us}} \cdot u(\bar{x}_3) \cdot \frac{\partial n_2}{\partial z_2} \tag{A.12}$$

where $\tilde{A}$ pertains to the perceived marginal benefit of investments in self-control in terms of reduced HIV risk in the case of self-deception, and A is associated with the true marginal benefit in the absence of self-deception. Let us now add and subtract $\tilde{A}$ and A from $FOC_2(\varphi)$in equation (28). By the first order condition for LR_2 in equation (21) we can easily see that $\left[FOC_2(\varphi) - A + \tilde{A}\right] = 0$. Consequently, the sign of $FOC_2(\varphi)$ hinges on the sign of $\left(A - \tilde{A}\right)$, and thus ultimately on $[\ln(\varphi) \cdot \varphi^{x_{us}} - \ln(\tilde{\varphi}^*) \cdot (\tilde{\varphi}^{m*})^{x_{us}}]$:

$$FOC_2(\varphi) = -\bar{x}_2 \cdot u(\bar{x}_3) \cdot \frac{\partial {n_2}^{m*}}{\partial z_2} \cdot [\ln(\varphi) \cdot \varphi^{x_{us}} - \ln(\tilde{\varphi}^*) \cdot (\tilde{\varphi}^{m*})^{x_{us}}] \tag{A.13}$$

The term within square brackets in equation (A.13) corresponds to the difference in perceived marginal cost of unsafe sex with and without rationalization. If $[\ln(\varphi) \cdot \varphi^{x_{us}} - \ln(\tilde{\varphi}^*) \cdot (\tilde{\varphi}^{m*})^{x_{us}}] < 0$, rationalization implies that the individual in t.2 underestimates the marginal cost of unsafe sex. This implies that the forward looking self in t.2 will under-invest in self-control from the perspective of the forward looking self in t.1, i.e., $FOC_2(\varphi) < 0$. In contrast, if $[\ln(\varphi) \cdot \varphi^{x_{us}} - \ln(\tilde{\varphi}^*) \cdot (\tilde{\varphi}^{m*})^{x_{us}}] > 0$, rationalization implies that the forward looking self in t. 2 *overestimates* the marginal cost of unprotected sex, and thus that that the forward looking self in time period 2 overinvests in self-control from the perspective of the long run self in t.1, i.e., $FOC_2(\varphi) < 0$.

As mentioned above, if $\tilde{\varphi}^{m*} = \varphi$, then $[\ln(\varphi) \cdot \varphi^{x_{us}} - \ln(\tilde{\varphi}^{*}) \cdot (\tilde{\varphi}^{m*})^{x_{us}}] = 0$ and consequently $FOC_2(\varphi) = 0$. Rationalizing behavior by assumption implies that $\tilde{\varphi}^{m*} > \varphi$. However, as can be seen in figure A1 below, due to the non-linearity of the survival probability function, a higher perceived survival probability does not necessarily imply a reduction in the marginal cost of unprotected sex.

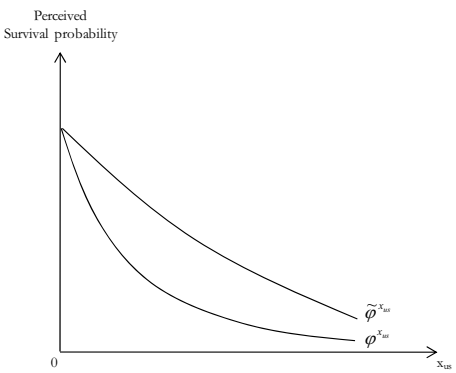


Figure A1: Survival probability as a function of unprotected sex

If we differentiate $[\ln(\varphi) \cdot \varphi^{x_{us}} - \ln(\tilde{\varphi}^{m*}) \cdot (\tilde{\varphi}^{m*})^{x_{us}}]$ with respect to $\tilde{\varphi}^{m*}$ at a given level of unprotected sex, we can derive an expression for the breaking point of the change in perceived marginal cost:

$$\frac{\partial}{\partial \tilde{\varphi}^{m*}} [\ln(\varphi) \cdot \varphi^{x_{us}} - ln(\tilde{\varphi}^{*}) \cdot (\tilde{\varphi}^{m*})^{x_{us}}]\Big|_{x_{us}} = -(\tilde{\varphi}^{m*})^{x_{us}-1} \cdot \left(1 + x_{us} \cdot ln\,(\tilde{\varphi}^{*})\right) \tag{A.14}$$

Hence, if $\left(1 + x_{us} \cdot ln\,(\tilde{\varphi}^{m*})\right) > 0$, rationalization results in a lower perceived marginal cost of unprotected sex as compared to the case without rationalization and vice versa. The result in equation (A.14) suggests that effect of rationalization depends on the perceived probability of being HIV positive. If this risk is sufficiently large (so that $1 + x_{us} \cdot l\,n(\tilde{\varphi}^{*}) < 0$), then rationalization may increase the marginal benefit of abstaining from unsafe sex due to the perceived increase in the likelihood of being HIV negative.

Likewise, taking a closer look at $\partial z_2/\partial z_1$ in equation (29), we see that the sign of this expression hinges on the sign and relative magnitude of $\partial z_2/\partial \tilde{\varphi}^{m*}$. To see this, differentiate the first order condition for LR_2 in equation (21) with respect to z_2 and n_1^{*m} and denote these derivatives $\Omega_{z_2 n_1^{*m}}$ and $\Omega_{z_2 z_2}$ respectively. $\partial z_2/\partial n_1^{*m}$ is then given by:

$$\frac{\partial z_2}{\partial n_1^{*m}} = -\frac{\Omega_{z_2 n_1^{*m}}}{\Omega_{z_2 z_2}} \tag{A.15}$$

If we have an interior solution, from the second order condition for a maximum it follows that $\Omega_{z_2 z_2} < 0$. The derivative of equation (21) with respect to n_1^{*m} is given by:

$$\Omega_{z_2 n_1^{*m}} = \bar{x}_1 \cdot \bar{x}_2 \cdot u(\bar{x}_3) \cdot ln(\tilde{\varphi}^{m*})^2 \cdot (\tilde{\varphi}^{m*})^{x_{us}} \frac{\partial n_2^{m*}}{\partial z_2} < 0 \tag{A.16}$$

Hence, the first term in equation (29) is unambiguously negative. The intuition behind this result is that, since increased condom use in period 1 reduces the likelihood of being infected by HIV, it raises the marginal benefit of investing in self control in time period 2. The second term within the square brackets relates to the partial derivative: $\frac{\partial z_2(z_1)}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}$. From equation (18) it can be shown that $\partial \tilde{\varphi}^{*m}/\partial n_1 < 0$. $\partial z_2/\partial \tilde{\varphi}^{m*}$ is given by:

$$\frac{\partial z_2}{\partial \tilde{\varphi}^{m*}} = -\frac{\Omega_{z_2 \tilde{\varphi}^{m*}}}{\Omega_{z_2 z_2}} \tag{A.17}$$

where $\Omega_{z_2 \tilde{\varphi}^{m*}}$ is obtained by differentiating equation (21) with respect to $\tilde{\varphi}^{m*}$:

$$\Omega_{z_2 \tilde{\varphi}^{m*}} = -(\tilde{\varphi}^{m*})^{x_{us}-1} \cdot \bar{x}_2 \cdot u(\bar{x}_3) \cdot \frac{\partial n_2^{m*}}{\partial z_2} \cdot \left(1 + x_{us} \cdot ln\,(\tilde{\varphi}^{*})\right) \tag{A.18}$$

As can be seen in equation (A.18), the sign of $\Omega_{z_2 \tilde{\varphi}^{m*}}$ and thus of $\partial z_2/\partial \tilde{\varphi}^{m*}$ hinge on whether $\left(1 + x_{us} \cdot ln\,(\tilde{\varphi}^{*})\right)$ is greater or less than zero. Combining the result in equation (A.14) and (A.19) we thus have the following result:

1. If $\left(1 + x_{us} \cdot ln\ (\tilde{\varphi}^{m*})\right) > 0$,then $\partial z_2/\partial \tilde{\varphi}^{m*} > 0$ and $[\ln(\varphi) \cdot \varphi^{x_{us}} - \ln(\tilde{\varphi}^*) \cdot (\tilde{\varphi}^{m*})^{x_{us}}] < 0$. Consequently, $FOC_2(\varphi) < 0$ and $\partial z_2/\partial z_1 > 0$.
2. If $\left(1 + x_{us} \cdot ln\ (\tilde{\varphi}^*)\right) < 0$, then $\partial z_2/\partial \tilde{\varphi}^{m*} < 0$ and $[\ln(\varphi) \cdot \varphi^{x_{us}} - \ln(\tilde{\varphi}^*) \cdot (\tilde{\varphi}^{m*})^{x_{us}}] > 0$. Consequently, $FOC_2(\varphi) > 0$. However, since $\partial z_2/\partial n_1^{*m} < 0$ the sign of $\partial z_2/\partial z_1$ depends on the relative magnitude of $\partial z_2/\partial n_1^{*m}$ and $(\partial z_2/\partial \tilde{\varphi}^{m*}) \cdot (\partial \tilde{\varphi}^{m*}/\partial n_1^{*m})$.
    a. If $\left|\frac{\partial z_2(z_1)}{\partial {n_1}^{m*}}\right| > \left|\frac{\partial z_2(z_1)}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right|$, then $\partial z_2/\partial z_1 > 0$
    b. If $\left|\frac{\partial z_2(z_1)}{\partial {n_1}^{m*}}\right| < \left|\frac{\partial z_2(z_1)}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right|$, then $\partial z_2/\partial z_1 < 0$, q.e.d.

Proof of proposition 4

In order to compare the behavior of a sophisticated individual to that of a naïve individual, let us differentiate equation (30') with respect to θ and $z_1$and define these derivatives $\Omega_{z_1\theta}$ and $\Omega_{z_1z_1}$, respectively. The effect of naïveté on investments in self-control in time period 1 is thus given by:

$$\frac{\partial z_1}{\partial \theta} = -\frac{\Omega_{z_1\theta}}{\Omega_{z_1z_1}} \tag{A.19}$$

where $\Omega_{z_1\theta}$ is given by:

$$\Omega_{z_1\theta} = -\left[\frac{\partial CD}{\partial {n_1}^{m*}} + \frac{\partial CD}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right] \cdot \frac{\partial {n_1}^{m*}}{\partial z_1} + FOC_2 \cdot \frac{\partial z_2(z_1)}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}} \cdot \frac{\partial {n_1}^{m*}}{\partial z_1} \tag{A.20}$$

Now, given *assumption 1*, $\left[\frac{\partial CD}{\partial {n_1}^{m*}} + \frac{\partial CD}{\partial \tilde{\varphi}^{m*}} \cdot \frac{\partial \tilde{\varphi}^{m*}}{\partial {n_1}^{m*}}\right] < 0$, and from *proposition 3* we know that $FOC_2 \cdot \frac{\partial z_2(z_1)}{\partial \tilde{\varphi}^{m*}} < 0$. Hence, $\Omega_{z_1\theta} < 0$, and we thus have that $\partial z_1/\partial \theta < 0$, q. e. d.

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IV

Conflicting Identities and Social Pressure

-Effects on the long-run evolution of female labor supply*

Andrea Mannberg+ and Tomas Sjögren$^{\Psi}$

Abstract

Over the last half-century female employment rates have increased significantly in many countries. This change has partly been attributed to a change in gender norms. The purpose of this paper is to present a dynamic model within which the evolution of female labor supply can be analyzed. Drawing on psychological literature, we let individuals define themselves in terms of different social identities, each of which prescribes a certain type of behavior. These prescriptions may imply conflicting incentives which provide agents with a motive to continuously revise the importance they attach to a given identity. Applying this approach within the context of a dynamic model of labor supply, we are able to make some novel predictions about what may cause labor supply to change over time. Our results suggest that the fear of becoming an outsider in society may have prevented a complete transition of women from housewives to breadwinners. In addition, we show that the discrepancy between personal and social norms may have interesting implications for labor supply: an increase in the hours of work prescribed by a working norm need not necessarily lead to more hours of work. Finally, our analysis shows that not recognizing that the weights attached to different social identities are endogenous may imply that the long-run effects on labor supply of a higher wage may be underestimated.

Key words: Female Labor Supply, Social Norms.
JEL Classification: J21, J22.

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1. Introduction

What may cause personal norms, or preferences, to change over time and how will this influence the long-run supply of labor? To answer these questions, we believe that it is fruitful to borrow ideas from the psychology literature which emphasize that personal identities play a key role for understanding human behavior. In this paper, we try to incorporate such ideas within the context of a dynamic model for labor supply and we show how this can add to our understanding of how norms influence labor market participation in the long-run. In particular, we hypothesize that social interaction and conflicts between identities may play an important role in explaining the observed changes in women's participation on the labor market.

Over the last century, the prescribed roles of men and women in society have changed dramatically. For example, World War II changed the world in many aspects, among those the labor market participation of women. In the United States, as elsewhere, the demand for male soldiers created an unprecedented demand for female labor. Although the end of the war implied a return of the male labor force, the trend of increasing female labor market participation persisted. At the end of World War II, the rate of female labor market participation (LFP) was still only 30 percent[1] whereas, today, this rate exceeds 70 percent. The same trend can be found in many other countries. For example, in Iceland and Sweden female LFP rates of 80 percent and higher have been recorded.[2]

Possible explanations for the increase in female employment rates are higher female wages, lower fertility rates and higher educational attainment among women.[3] However, these factors have only been partially successful in explaining the evolution of female employment rates.[4] Instead, there is mounting evidence

[1] See e.g., Schweitzer (1980).
[2] UN Gender Info 2007.
[3] See, for e.g., Killingsworth & Heckman (1986), and Goldin (1990).
[4] Neumark & Postlewaite (1998).

that changes in social norms are potentially important for understanding these developments.[5] Data on gender attitudes and labor supply lend support to this hypothesis. *Figure 1* below depicts the female share of labor supply in the OECD countries for which data were available in 1970 and 2005, and *Table 1* shows the attitudes in 2002 among people in the same OECD countries towards a traditional male-only breadwinner norm.

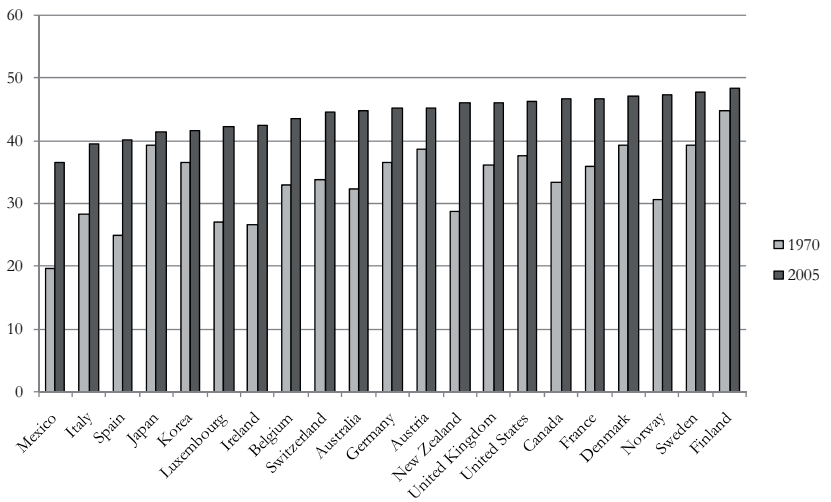


Figure 1: Female share of the labor force in OECD countries for which data was available in 1970. Source: *OECD Labor Market Statistics.*

As can be seen in *Figure 1*, large differences persist between countries: while the gap between female and male labor supply was almost eliminated in the Nordic countries in 2005, female labor supply remained below 40 % in Mexico and Italy. Similarly, *Table 1* (below) shows that a large majority in the Nordic countries rejects the traditional gender norm whereas a majority in Mexico supports it; the same countries that we find in the upper and lower ends in *Figure 1*.

[5] See Golding (1990, 1994), Romme (1990), and van der Lippe and Siegers (1994).

Table 1: Attitudes towards female and male labor market participation.

	A man's job is to earn money; a woman's job is to look after the home and the family		
	Strongly agree or agree	Neither agree or disagree	Disagree or strongly disagree
Sweden	7.65	14.73	77.62
Norway	9.46	13.19	77.35
Finland	11.74	20.49	67.77
Netherlands	12.33	20.21	67.46
Denmark	13.57	9.61	76.83
France	17.88	13.2	68.92
Ireland	18.56	13.76	67.68
Germany	18.96	13.09	67.945
United Kingdom	19.77	18.31	61.92
New Zealand	19.81	17.73	62.47
Australia	21.63	22	56.36
Switzerland	23	18.03	58.96
United States	23.6	23.85	52.55
Spain	24.68	8.91	66.4
Austria	29.49	24.58	45.93
Portugal	30.59	11	58.41
Japan	30.88	20.59	48.52
Mexico	49.76	10.78	39.45

Source: *ISSP 2002*.[6]

In *Figure 2*, we depict the correlation between the share of individuals disagreeing with the traditional breadwinner norm and the female share of employment in each country. As is clear from the figure, the correlation between norms and female labor supply is positive. The Pearson correlation coefficient is .609 and significant (p = 0.009). This correlation suggests that female LFP may be related to the prevailing norms in society and that a substantial increase in female LFP may be facilitated by a change towards more gender neutral social norms.[7]

[6] ISSP, 2002, Family and Changing Gender Roles III (Koeln: GESIS, Zentralarchiv für Empirische Sozialforschung).

[7] Admittedly, the relationship is not completely clear-cut. In Ireland and Spain, for example, large majorities disagree with the traditional breadwinner norm in spite of a relatively low female share of employment. However, note that if we consider the *change* in the female share of employment between 1970 and 2005, the relatively low level of female LFP in 2005 does not necessarily contradict the role of norms for LFP.

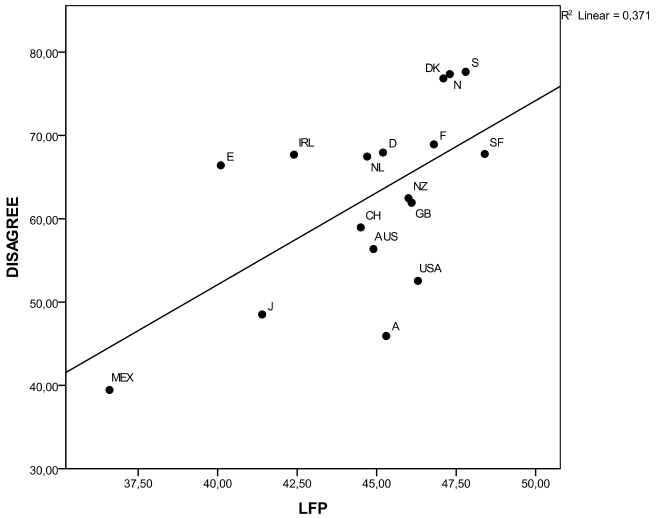


Figure 2: Correlation between the share of respondents disagreeing with the statement "A man's job is to earn money; a woman's job is to look after the home and the family" and the female share of the labor force. Source: *ISSP 2002 and OECD labor market statistics*

In this paper, we present a model which aims to explain how the attitudes towards a given norm may change over time. Before discussing our approach, let us first briefly review the relevant literature. The role of social norms in economic behavior has a relatively long history in economics.[8] The inclusion of social sanctions for norm violating behavior in economic models has enabled economists to explain seemingly irrational behavior such as the lack of underbidding of inefficiently high wages. However, social norms in isolation cannot explain why costly behavior persists in the absence of surveillance or why people engage in sanctions of behavior that, at least at first glance, does not affect them personally.[9] In other words, social norms do not provide us with a comprehensive answer to why anonymous responses to questions of the kind in *Table 1* differ substantially between countries, and we are still left with the question of what may cause norms to change over time.

[8] See e.g,. Akerlof (1980); Bernheim (1994); Lindbeck (1995, 1997) and Lindbeck *et al.* (1999).
[9] An example given in Elster (1989) is the presence of vengeance norms. The threat of vengeance is only credible if it is believed that the individual will follow through regardless if the expected benefit is positive or negative.

A potential answer to this question may be found by drawing on research in psychology on the interdependent relationship between social norms, identity and individuals' need to maintain a coherent and positive self-image. Psychological theories of personality suggest that, although most individuals perceive themselves to have a coherent overall personal identity, they nonetheless define themselves in terms of a *set of different* identities related to the social groups to which they ascribe membership.[10] For example, if you were given the question, 'Who are you?' your answer would most likely involve identities related to your gender, your nationality, your profession and perhaps your hobbies. Each of these identities is associated with both social and *personal* norms[11] in terms of prescribed characteristics, behavior and values.[12]

Both social and personal norms guide individual behavior via carrots and sticks. However, while compliance with social norms is driven by the fear of social sanctions or with the wish for social rewards, compliance with *personal* norms is enforced by the fear of negative (guilt, shame, reduced self-esteem) or wish for positive (pride, enhanced self-esteem) self-evaluations.[13] Many of the prescriptions associated with different identities are likely to be relatively compatible with each other. However, in some instances the different identities of an individual may present him or her with conflicting incentives. If the prescriptions associated with different valued identities are incompatible with each other, *Cognitive Dissonance Theory*[14] may offer a potential explanation to the evolution of both social and personal norms over time. According to this theory, and the related theory of *Self-Affirmation*[15], the perceived consistency of an individual's self-concept is fundamental for his or her mental well-being. These theories predict that a behavioral act that is inconsistent with an individual's self-image, in terms of violating a valued personal norm, questions the credibility of

[10] See e.g., Abrams & Hogg (1990); Hogg & Terry (2000).
[11] A personal norm can be defined as an internalized rule prescribing values, beliefs and behaviors that are consistent with an individual's desired self-image (or self-concept)
[12] See e.g. Tajfel (1974); Turner (1991).
[13] Swartz (1977); Steele (1988); Kerr *et al.* (1997); Bamberg *et al.,* (2007).
[14] Festinger (1957); Aronson (1968, 1992).
[15] Steele, (1988).

this self-image and therefore creates a sense of unease (i.e. cognitive dissonance). The sense of unease, in turn, creates incentives to restore consistency in terms of either changing the behavior or by degrading the value of that particular norm in the individual's overall identity.[16]

During the last decade, the roles of personal norms and identity for economic behavior have started to gain an increased interest among economists. In their seminal papers on the subject, Akerlof & Kranton (2000; 2002; 2005) show that if utility in part depends on whether an agent's behavior is consistent or not with the social norms associated with a valued social identity, deviant (both the agent's own and others) behavior will cause utility loss in terms of threatening the individual's sense of identity. Hence, individuals may both have incentives to punish deviant behavior that threatens this social identity and to act in a way that may differ from their internal preferences.[17] Akerlof & Kranton (2000; 2002; 2005) assume that individuals have primarily one identity and analyze behavior in a static model. In the short run, this is probably a reasonable assumption.

However, using this approach we cannot explain the evolution of norms, or changes in attitudes, in the long run.[18] A few economists have therefore adopted a dynamic framework in order to study how people's need for a consistent and positive self-image (e.g. Vendrik, 2003; Bénabou & Tirole, 2006) and social group affiliation (e.g. Horst *et. al.,* 2007) affect the formation of personal norms and social groups over time. By modeling the interdependent relationship between identity and behavior, these papers have provided important insights on the internalization process of social norms and on changes in preferences over time.

Horst *et al.,* (2007) analyze how individuals' strive for self-fulfillment affect the dynamic evolution of personal and social identities. In their model, individuals may improve their self-image by joining social groups and adopting the typical characteristics of these groups. However, since the group's characteristic depends on its members, groups are modified over time by the people joining them. This

[16] See e.g., Cooper & Hogg (2002)
[17] See also, Oxoby (2004).
[18] See Davis (2006; 2007) for a critique of the Akerlof and Kranton papers.

may induce individuals to revise their previous choices and eventually choose different groups.

Bénabou & Tirole (2006), argue that individuals have incomplete information concerning their personal values and beliefs, and that they therefore use past behavior as signals of their characteristics. Consequently, individuals may invest in a desired self-image by acting in accordance with the prescriptions of a valued social identity. Bénabou and Tirole's theoretical analysis suggests that investments in identity increase when contradicting information on personal preferences is scarce, such as in tightly knitted social groups, or when contextual cues remind the individual of his or her desired identity.

Finally, Vendrik (2003) analyzes how the costs and benefits, associated with complying and deviating from social and personal norms, affect both behavior and belief in norms over time. Vendrik shows that, if an individual's utility level in part depends on the level of consumption and in part depends on norm fulfillment, violation of a norm may cause complete norm erosion. The economic model is used to analyze the impact of a traditional household norm on married women's labor supply, and shows that an increase in the market wage for women may create a process where women make the full transition from housewives to career women due to the existence of cognitive dissonance. Vendrik argues that the erosion in the belief in the household norm may have played an important role in the long run increase in married women's labor supply in many OECD countries.

In the model presented in this paper, we draw on some of the ideas developed by primarily Akerlof and Kranton (2002) and Vendrik (2003) in order to analyze the mechanisms underlying changes in time allocation between market labor and household production. In contrast to the Akerlof and Kranton (2002) and Vendrik (2003) papers, however, we suggest that it is not only the conflict between *one* personal and social norm that drive the evolution of behavior over time. Instead, we argue that the presence of *conflicting identities (or norms)* may hold important information for explaining both the evolution of norms and behavior.

The purpose of this paper is thus to analyze the role of conflicting identities by developing a dynamic model where the importance attached to a given norm is endogenous. In the analysis below, we focus on identities related to an individual's profession (e.g. making a career) and to the family (e.g. being a good father/husband, mother/wife). The potential conflict arises since the norms associated with these two identities potentially prescribe incompatible hours of work. We assume that if an agent acts in discordance with one of his/her personal norms, he/she will experience a sense of unease that creates an incentive to revise the importance of that norm and thereby of that identity in his/her overall self-image. This revision is assumed to be a relatively slow process and is formally treated as a disinvestment in the degree of importance attached to the norm in question. Analogously, when an agent´s actual choice of hours of work is in line with what is prescribed by one of his/her personal norms, the agent has an incentive to invest in the relative weight of that norm. This approach allows us to describe the time path of the weight attached to each norm which, in turn, also determines the long-run evolution of an agent's labor supply.

The main contribution of the paper is that we, by explicitly incorporating how conflicting incentives related to *different identities* give rise to norm evolution, are able to explain both the transition of women from housewives to career women *and* the observed persistence of part-time labor of women. In addition, our theoretical approach enables us to explain differences between countries concerning both women's behavioral conformity and personal agreement with traditional gender norms. The outline of the paper is as follows. In section 2, we present the basic model for analyzing individual behavior in the presence of conflicting identities. In section 3, we use the framework developed to analyze the effects of structural changes and in section 4 we discuss these structural changes in terms of the evolution of female labor supply. The paper is concluded in section 5.

2. Theoretical Approach

Consider a social group made up of *N* individuals. Each agent derives utility from the consumption of a numeraire good, c, as well as from the time spent not working, z. This time captures all the things an agent may do outside work such as taking care of children, doing household work etc. In the following we will refer to z as household time. If we let h denote total time available and l the hours of work, household time is given by $z = h - l$. The variables c and z define the *standard part* of the utility function. We assume that this part is quasi-linear and can be written $c + \rho(z)$, where $\rho(z)$ is an increasing and concave function of z.

2.1 Personal Norms

Turning to the *non-standard part* of the utility function, we assume that the agent also derives utility from his/her set of social identities, each of which is being associated with a certain type of personal norm. In this model, the agent defines him/herself in terms of two social identities; a professional (work) identity and an identity related to the individual's role within a household (e.g. as a mother/father or husband/wife). The agent is assumed to have a mental picture which defines what it means to be successful w.r.t. each type of social identity. For example, an agent who works as a researcher may define success at work in terms of being able to publish in top journals whereas an agent who works as a lawyer may define success at work in terms of the number of court cases won. How successful the agent is in fulfilling his/her ambition is likely to depend on how much time and effort he/she puts into the work. Assume that the agent perceives that $\bar{l}_1$ is the amount of time he/she needs to spend at work to achieve his/her professional goal. If the agent works less than $\bar{l}_1$, not enough effort is put into the work to achieve the personal ambition whereas if he/she works more than $\bar{l}_1$, the quality of the work is reduced (e.g. because of exhaustion). We will refer to $\bar{l}_1$ as the agent's personal working norm (or norm 1). The level of $\bar{l}_1$ is likely to depend on the job characteristics and on the characteristics of the individual. Since these characteristics are exogenous in our model, so will be the

level of $\bar{l}_1$. The agent also has a mental picture which prescribes how to behave in order to be a good father/mother or husband/wife. Using a similar argument as above, let $\bar{z}_2$ be the amount of time the agent perceives that he/she must devote to the family to achieve success/high self-esteem in this dimension. This could, for example, involve not working at all when the kids are small, in which case $\bar{z}_2 = 24$ hours per day, or it could involve working hard when the children are adolescent in order to serve as a role model in terms of diligence and responsible behavior. We will refer to $\bar{l}_2 = h - \bar{z}_2$ as the agent's personal household norm (or norm 2). Since the personal norms arise from two entirely different mental pictures, $\bar{l}_1$ and $\bar{l}_2$ need not coincide. If $\bar{l}_1 \neq \bar{l}_2$, we say that the two personal norms are in conflict with each other. If, on the other hand, $\bar{l}_1 = \bar{l}_2$, then there is no conflict between the two mental pictures in which case the two personal norms collapse into one overall personal norm.

The agent's well-being depends on how well he/she lives up to the mental picture associated with personal norm i = 1, 2 (if there is only one overall norm then i = 1). Let P_i be the utility associated with fulfilling norm i. It is given by

$$P_i = n_i \cdot \left[\alpha_i - \frac{1}{2} \cdot (l - \bar{l}_i)^2\right] \tag{1}$$

where α_i is a nonnegative constant, $l - \bar{l}_i$ is the difference between the actual choice of hours of work and that prescribed by the personal norm, and $n_i \in (0, \infty)$ describes the relative *importance*, or *weight*, of identity i in the individual's set of social identities. If $n_i = 0$, identity i is of no importance for the agent, bur for positive values of n_i the agent to some degree identifies him/herself in terms of identity i. The larger n_i is, the stronger is this identification and thus the greater is the perceived importance of behaving in accordance with the norm associated with identity i.

The functional form in equation (1) satisfies the following properties:

(i) When the agent fulfils the personal norm completely ($l = \bar{l}_i$), then the agent achieves maximum bliss, $P_i = n_i \cdot \alpha_i > 0$.

(ii) The utility associated with fulfilling personal norm *i* will be positive also for small deviations around $\bar{l}_i$.

(iii) If the agent deviates significantly from $\bar{l}_i$, this questions the individual's self-image in terms of social identity i and the sense of bliss will be replaced by a feeling of frustration or guilt for not living up to the mental picture related to that identity. In this situation, the agent will experience *cognitive dissonance*, $P_i < 0$.

(iv) The specification in equation (1) implies that the stronger the agent identifies him/herself in terms of identity *i*, the larger will be the utility (or disutility) associated with fulfilling (or deviating from) the norm.

Property (ii) states that an agent needs not live up to the norm perfectly in order to feel satisfaction. Almost fulfilling the personal norm will also give rise to bliss w.r.t. to the norm, albeit not as high as when $l = \bar{l}_i$. On the other hand, there is a cut-off distance from $\bar{l}_i$ beyond which the feeling of bliss is replaced by guilt for not living up to the norm, as stated in property (iii). Observe also that when $\alpha_i = 0$, equation (1) reduces to $P_i = -0.5 \cdot n_i \cdot \left(l - \bar{l}_i\right)^2$, which is a functional form used in earlier literature on norms.[19] As such, the functional form used in equation (1) can be viewed as a more general version of the standard model. The motivation for using the formulation in equation (1) is that in a dynamic framework where an agent is able to change the relative importance, n_i, of social identity *i* over time (see below), it makes no sense investing in a given social identity if this behavior only gives rise to cognitive dissonance.

Let us now turn our attention to the weights n_i and n_j that the agent attaches to identity *i* and a conflicting identity *j* (if it exists). These weights will be

[19] Observe also that much of the earlier literature on norms has been set within a static framework. In that context $\alpha_i \cdot n_i$ will be constant and effectively redundant even when $\alpha_i > 0$.

endogenous in the long-run and we assume that they have the following properties:

(i) If the agent attaches maximum weight to identity *i* ($n_i \to \infty$), then the weight attached to the conflicting identity *j* will approach zero ($n_j \to 0$,) in which case $l \to \bar{l}_i$.

(ii) **A2:** An agent who *does not* attach maximum importance to identity *i* ($n_i < \infty$) will attach some weight to a conflicting identity ($n_j > 0$) .

(iii) **A3:** The weights n_i and n_j are inversely related in the sense that the higher weight an agent attaches to identity *i*, the lower weight will he/she attach to the conflicting identity *j*.

Property (i) is an assumption about consistency in the sense that if an agent only has one social identity, then his/her choice of *l* will be equal to what is prescribed by the personal norm associated with that social identity. Given the specification in equation (1), the agent's choice of *l* will for certain coincide with $\bar{l}_i$ if $n_i \to \infty$ (see first-order condition 14 below). The underlying idea behind properties (ii) and (iii)is that the higher weight an agent attaches to a given social identity, the more difficult it is to maintain a social identity with conflicting behavioral prescriptions. In terms of norms 1 and 2, these assumptions imply that n_1 and n_2 will be inversely related in the sense that the weight attached to one social identity cannot change without the weight attached to the other, conflicting, identity changing in the opposite direction. This means that we can write n_2 as a function of n_1, $n_2(n_1)$, where $dn_2/dn_1 < 0$. We will refer to this relationship as the *norm function* and *Figure 3* illustrates two possible configurations of this function. As can be seen, we do not put any restrictions on the shape of the norm function except in the tails, where assumption (i) defined on the previous page implies that the norm function will ultimately be convex.

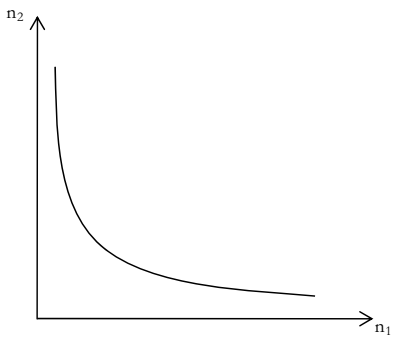


Figure 3a: The norm function.

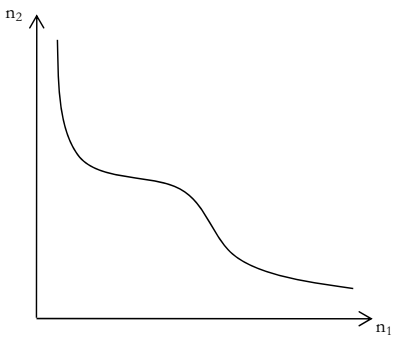


Figure 3b: The norm function.

2.2 Social Norms

Let us now turn our attention to how the personal norms discussed above are related to the norms at the social level. Here the basic idea is that when an agent meets another person, the agent judges that person from how well he/she lives up to the agent's personal norms. To illustrate this, consider an agent *j* with a professional identity as a researcher in economics and who believes that success as a researcher is achieved by working hard. In our model, this argument is represented by a personal working norm prescribing a relatively high number of work hours, e.g., $\bar{l}_1^j = 10$ hours of work per day. Now, since we assume that an individual's overall personal identity may be constituted by different social identities with conflicting behavioral prescriptions, the same agent may be convinced that a responsible parent should only work half-time when the kids are small. As such, the agent's personal household norm would in this case be given by, e.g., $\bar{l}_2^j = 4$. Assume now that agent *j* is acquainted with another hard working researcher who has small kids. In social settings where the professional identity is salient, such as the work place, agent *j* may complement the other person for working so hard. However, in other social settings the same agent may instead rebuke the other person for not fulfilling his/her role as a 'good' father/mother. As such, the conflict between agent *j*'s personal norms means that

the other person will receive both appraisals and rebukes when he associates with the agent. If the agent attaches great importance to professional identity and a relatively low importance to the household norm, i.e. n_1^j is large whereas n_2^j is small, then the appraisals come more often than the rebukes. In this situation, the other person's net utility from the social contact with the agent will be positive. The opposite happens if it is n_2^j that is large.

To capture these arguments formally, we will use a formulation which resembles that used in equation (1). As such, if the other person´s actual choice of hours of work is l, let us define

$$P_i^j = n_i^j \cdot \left[\alpha_i^j - \frac{1}{2} \cdot \left(l - \varphi_i \cdot \bar{l}_i^j\right)^2\right] \tag{2}$$

to be the utility experienced by the other person in terms of appraisals/rebukes from agent *j* regarding norm *i*. The parameter where φ_i is equal to one at the outset and will therefore be dropped below. The functional form in equation (2) satisfies properties similar to those in equation (1):

(i) When the other person lives up to agent *j*'s personal norm completely in the sense that $l = \bar{l}_i^j$, then agent *j* gives maximum appraisal to the other person, that is $P_i^j = n_i^j \cdot \alpha_i^j > 0$.

(ii) When the deviation of l from $\bar{l}_i^j$ is small, then $P_i^j > 0$ which reflects that agent *j* will still give the other person appraisal but not as strongly and as frequently as in (i).

(iii) When the deviation of l from $\bar{l}_i^j$ is large, then $P_i^j < 0$ which reflects that the appraisals will be replaced by rebukes in which case the other person experiences a utility loss.

(iv) The larger $\bar{n}_i$ is, the more often will the appraisals/rebukes come and the larger will P_i^j be in absolute value.

Properties (i) – (iv) capture that the more important agent *j* perceives social identity *i* to be, the more appraisal will the agent give to the other individual if $\alpha_i^j - 0.5 \cdot \left(l - \bar{l}_i^j\right)^2 > 0$, and the more criticism will the agent give if $\alpha_i^j - 0.5 \cdot \left(l - \bar{l}_i^j\right)^2 < 0$. Consequently, the level of utility or disutility experienced by the other person when he/she associates with agent *j* will depend on the weight n_i^j that the agent attaches to social identity *i*.

The arguments presented above imply that each agent will encounter the personal norms prescribed by the other persons in the society. The utility in terms of appraisals/rebukes associated with norm *i* experienced by an agent moving around in this society made up of *N* individuals will be a sum of these encounters and is written as

$$S_i = \beta \cdot \sum_{j=1}^{N} P_i^j \tag{3}$$

where S_i will be referred to as the *social pressure,* or alternatively, the *social loss/gain* associated with norm *i*, and the parameter β reflects the *degree* of social pressure. It is a nonnegative constant and if β is zero, the agent is is not subject to any social pressure. Observe that the formulation in equation (3) implies that there need not exist a unique social working norm and a unique social household norm. Instead, since the agent meets different people with different personal norms, he/she will receive different treatment from different people and it is the average utility experience of these contacts that makes up the social pressure.

Finally, for the analysis to be conducted below, let us also define the *average* socially prescribed hours of work related to norm *i* facing an agent as:

$$\bar{L}_i = \frac{1}{N} \cdot \sum_{j=1}^{N} \varphi_i \cdot \bar{l}_i^j \tag{4}$$

where $\varphi_i = 1$ to begin with. As defined, $\bar{L}_i$ is a fixed parameter.

2.3 Formulating the Agent's Intertemporal Maximization Problem

The discussion above implies that an agent´s overall utility is a function of c, l, P_i, and S_i. The following quasi-linear instantaneous utility function will be used to represent these preferences:

$$u = c + \rho(h - l) + \sum_i [P_i(\cdot) + S_i(\cdot)] - C(\cdot) \tag{5}$$

where $C(\cdot)$ is a psychological cost function to be defined below. At time zero, the agent's objective is to maximize the intertemporal utility:

$$\max U(0) = \int_0^\infty u(t) \cdot e^{-\theta \cdot t} dt \tag{6}$$

where *t* denotes time, $u(t)$ is the instantaneous utility function defined in equation (5) and θ is the discount rate. The agent has perfect foresight and supplies labor in return for the wage $w(t)$. If we let $r(t)$ denote the interest rate, the agent's budget constraint at time *t* can be written as:

$$\frac{ds(t)}{dt} = w(t) \cdot l(t) + m(t) + r(t) \cdot s(t) - c(t) \tag{7}$$

where $s(t)$ is the saving and $m(t)$ is non-labor income. Although we do not explicitly consider households in this model, non-labor income may nevertheless be interpreted as a predetermined income transfer between spouses in a household. The time paths of $m(t)$, $w(t)$ and $r(t)$ are exogenous and we assume that in the long-run, these variables converge to fixed steady-state values $\tilde{m}$, $\tilde{w}$ and $\tilde{r}$, where "~" denotes a steady-state value. The price of good c is normalized to one and it is assumed that the initial endowment of capital is positive, i.e. $s(0) = s_0 > 0$.

Investment in a Social Identity

Following Vendrik (2003), we assume that the agent treats n_i as exogenous in the short-run but that n_i may change over time. This intrapersonal process of the

evolution of the relative importance of different social identities occurs because violating or living up to a personal norm will affect the individual's self-image. If the agent violates a personal norm associated with a given social identity, the agent has an incentive to downplay the importance of identity *i* in his/her overall identity by disinvesting in n_i. Similarly, if an individual lives up to his/her ideal self in terms of fulfilling a personal norm, this behavior confirms his/her identity in which case he/she has an incentive to reinforce the importance of that aspect of his/her overall identity by investing in n_i. In other words, to improve (or relieve) the bliss (or unease) of living up to (or violating) a norm, the agent will allow the relative weight of the social identity associated with that norm to increase (decrease). Although this is most likely a subconscious process, the change in n_i may nevertheless be viewed as the outcome of long-run optimization. As such, it will be incorporated into the agent's intertemporal maximization problem.

In line with Vendrik (2003),[20] we assume that because of the existence of psychological adjustment costs, the change in the weights treat n_1 and n_2 is a relatively slow process which takes place over time. As such, we can treat n_1 and n_2 as state variables in which the agent can invest or disinvest. Since the weights are connected via the norm function $n_2(n_1)$, we need only to consider the time path of n_1 to fully characterize the evolution of these weights. As such, let i_1 denote the investment in n_1, which means that the evolution of n_1 will be determined by the following differential equation:

$$\frac{dn_1(t)}{dt} = i_1(t) \tag{8}$$

Vendrik (2003) assumes that the psychological adjustment cost of investing/disinvesting in the belief in a norm is captured by a quadratic cost function $0.5 \cdot \kappa \cdot i_1^2$, where κ is a positive constant. This psychological adjustment cost arises as a consequence of *internal pressure*. It reflects that re-evaluating a deep

[20] It should be noted that Vendrik models investment in the *degree of belief* in a single norm while we model the *weight* the individual attaches to a different social identities.

rooted idea is a slow process which requires some psychological effort. In addition to the internal pressure, we assume that the psychological adjustment cost is also subject to *external pressure*, or *worrying*. Here, the idea is that the more an agent invests in the working identity, the closer will be the agent's future choices of labor supply to $\bar{l}_1$. However, if $\bar{l}_1$ deviates from the working norms among other people in the society, an investment in n_1 may lead to a future social loss in terms of less appraisals and more rebukes. In other words, by investing in a given identity, the agent risks becoming an outsider in a social group to which he or she ascribes membership. This recognition will induce an additional psychological cost today in terms of worrying over how other people will perceive the agent in the future and will restrain the agent from deviating "too much" from the norms observed in the society. We propose that the psychological cost, C_1, associated with the external pressure of investing in n_1 should have the following basic characteristics:

(i) If $\bar{l}_1$ coincides the working norms among the other people in the society, then $C_1 = 0$.

(ii) The more $\bar{l}_1$ deviates from the working norms among other people in the society, the larger (in absolute value) will be C_1.

(iii) The larger n_1 is, the larger (in absolute value) will be C_1 because investing in n_1 will reinforce the tendency to choose future labor supply close to $\bar{l}_1$.

(iv) All else equal, the stronger the degree of social pressure associated with the working norm, β the larger (in absolute value) will be C_1 because the potential social loss of deviating from the social norms is now larger.

(v) If $\bar{l}_1 \neq \bar{L}_1$ a reduction in n_1 may lead to a social gain in the future in terms of more appraisals and less rebukes. Then the worrying is replaced by relief, implying that C_1 will be negative when $i_1 < 0$.

A functional form for the external pressure associated with investing in n_1 which satisfies the criteria laid out above is:

$$C_1 = \beta \cdot i_1 \cdot n_1 \cdot \left(\bar{l}_1 - \bar{L}_1\right)^2 \tag{9}$$

where $\bar{L}_1$ is the average socially prescribed hours of work, defined in equation (4). Arguably, one could use more elaborate functional forms to capture this cost[21] but for our purposes, the functional form in (9) is sufficient. Observe also that condition (v) implies that if the agent disinvests in n_1, then C_1 will be negative. This reflects the notion that disinvesting in n_1 will reduce the tendency to deviate from $\bar{L}_1$ in the future which relieves the stress of potentially becoming an outsider in the future. Another interpretation is that disinvesting in n_1 is equivalent to devaluating the social group related to identity *i*. The smaller n_1 is, the less important will the opinions of other members of that social group be, and thus the less will the agent care about future rebukes.

The arguments presented above can also be applied to define a psychological cost function associated with external pressure related to the household norm. Using the same line of argumentation as above, and observing that an investment in n_2 is equivalent with a disinvestment in n_1, the psychological adjustment cost associated with the external pressure related to the investment in n_2 can be written:[22]

$$C_2 = -\beta \cdot i_1 \cdot n_2 \cdot \left(\bar{l}_2 - \bar{L}_2\right)^2 \tag{10}$$

Adding $0.5 \cdot \kappa \cdot i_1^2$ together with equations (9) and (10) allows us to write the total psychological cost as:

$$C(\cdot) = \frac{1}{2} \cdot \kappa \cdot i_1^2 + \beta \cdot i_1 \cdot n_1 \cdot \left(\bar{l}_1 - \bar{L}_1\right)^2 - \beta \cdot i_1 \cdot n_2 \cdot \left(\bar{l}_2 - \bar{L}_2\right)^2 \tag{11}$$

[21] One alternative would be to make this cost an explicit function of all future utility losses generated by the future changes in labor supply induced by the change in n_1. However, this would make it very difficult to solve the resulting intertemporal maximization problem and we therefore do not choose that approach.

[22] Observe that since n_1 and n_2 are related via the norm function $n_2(n_1)$, an investment in n_1 by the amount i_1 is equivalent to a disinvestment in n_2 by the amount $i_1 \cdot dn_2/dn_1$. As such, one could argue that the psychological adjustment cost terms in equation (10) should be scaled by dn_2/dn_1. We will disregard from this potential complexity in the analysis.

This is the psychological cost function used in the definition of the instantaneous utility function, $u(\cdot)$, presented in equation (5).

2.4 Solving the Intertemporal Maximization Problem

Substituting equation (11) into $u(\cdot)$, the problem facing the agent at time zero is to choose c, l and i_1 so as to maximize the intertemporal objective function in equation (6) subject to equations (7) and (8), as well as subject to the initial conditions for s and n_1, and the terminal conditions $\lim_{t\to\infty} s(t) \geq 0$ and $\lim_{t\to\infty} n_1(t) \geq 0$. The current-value Hamiltonian corresponding this intertemporal maximization problem can be written as:

$$H = u + \lambda \cdot (w \cdot l + m + r \cdot s - c) + \mu \cdot i_1 \tag{12}$$

where λ and μ are the co-state variables (or equivalently, the shadow prices) associated with equations (7) and (8). The necessary conditions for an optimal path become:

$$\frac{\partial H}{\partial c} = 1 - \lambda \ = 0 \tag{13}$$

$$\frac{\partial H}{\partial l} = w - \rho'(h - l) + \sum_i \left[\frac{\partial P_i(\cdot)}{\partial l} + \frac{\partial S_i(\cdot)}{\partial l}\right] = 0 \tag{14}$$

$$\frac{\partial H}{\partial i_i} = \mu - \frac{\partial C(\cdot)}{\partial l} = 0 \tag{15}$$

$$\dot{\lambda} - \theta \cdot \lambda = -r \cdot \lambda \tag{16}$$

$$\dot{\mu} - \theta \cdot \mu = \sum_i \left[-\frac{\partial P_i(\cdot)}{\partial n_1} + \frac{\partial C(\cdot)}{\partial n_1}\right] \tag{17}$$

$$\lim_{t\to\infty} \lambda \cdot e^{-\theta \cdot t} \geq 0 \left(= 0 \text{ if } \lim_{t\to\infty} n_i > 0\right) \tag{18}$$

$$\lim_{t\to\infty} \mu \cdot e^{-\theta \cdot t} \geq 0 \left(= 0 \text{ if } \lim_{t\to\infty} s > 0\right) \tag{19}$$

Together with equations (7) and (8), these necessary conditions implicitly determine the time paths of l, i_1 and n_i (which are the variables of interest in this analysis). To characterize these dynamics, observe first that equation (13) implies $\lambda = 1$. This is a consequence of assuming that the utility function is additive and linear in consumption. Although this is a strong assumption in a dynamic

framework,[23] it will facilitate the analysis below considerably since the time paths of l, i_1 and n_i will be independent of the time paths of c and s. As such, we will be able to characterize the dynamics of l, i_1 and n_i without having to be concerned with c and s.

The labor supply decision is implicitly determined by equation (14). The first two terms on the right hand side (RHS) of that equation, $w - \rho'(h - l)$, will be referred to as standard terms because they capture the standard trade-off between consumption and leisure. The remaining non-standard terms appear as a consequence of the two norms. Equation (14) implicitly defines labor supply as a function:

$$l = l\left(n_1, w, \bar{l}_1, \bar{l}_2, \sum_{J=1}^{N} \bar{l}_1^j, \sum_{J=1}^{N} \bar{l}_2^j, \sum_{J=1}^{N} n_1^j, \sum_{J=1}^{N} n_2^j, \beta\right) \tag{20}$$

It is straightforward to show that the labor supply is strictly increasing in the wage. This is a consequence of assuming that the agent has a quasi-linear utility function in which case the income effect is redundant and only the substitution effect of a higher wage remains. In addition, as long as l is situated in the interval $\bar{l}_2 < l < \bar{l}_1$, labor supply will also be an increasing function of n_1. Finally, an increase in the amount of working time prescribed by the norms, either at the personal or at the social level, will have a positive effect on l.

Turning to the dynamics of the system, observe first that equations (15) and (17) can be used to derive the following differential equation for the investment in n_1:

$$\begin{aligned} \frac{di_1}{dt} = {} & \theta \cdot i_1 + \frac{\theta}{\kappa} \cdot \beta \cdot \left[n_1 \cdot \left(\bar{l}_1 - \bar{L}_1\right)^2 - n_2(n_1) \cdot \left(\bar{l}_2 - \bar{L}_2\right)^2\right] \\ & - \frac{1}{\kappa} \cdot \left[\alpha_1 - \frac{1}{2} \cdot \left(l - \bar{l}_1\right)^2\right] - \frac{1}{\kappa} \cdot \frac{dn_2(n_1)}{dn_1} \cdot \left[\alpha_2 - \frac{1}{2} \cdot \left(l - \bar{l}_2\right)^2\right] \end{aligned} \tag{21}$$

[23] Vendrik (2003) instead assumes that the agent can neither borrow, nor lend, between time periods. If we would choose that approach, it would not change any of the qualitative results to be derived below.

By using that equation (20) implies that l is a function of n_1, equation (21) in combination with equation (8) defines a dynamic system which completely determines the evolution of i_1 and n_1. The dynamic properties of this system are summarized in Proposition 1:

Proposition 1: *The dynamic system characterized by equations (8) and (21) has the following properties;*

(i) *There exists at least one interior steady-state where* $\tilde{n}_1$ *is nonzero and finite.*

(ii) *If only one steady-state exists, the* $di_1/dt = 0$ *locus will intersect the* $dn_1/dt = 0$ *locus from above at that point and the steady-state will be saddle-point stable.*

(iii) *If multiple steady-states exist, the number of steady-states will be odd. Each odd-numbered steady-state will be saddle-point stable whereas each even-numbered steady-state will be an unstable node/focus. In the latter types of steady-state(s) the* $di_1/dt = 0$ *locus intersects the* $dn_1/dt = 0$ *locus from below.*

Proof: See the Appendix.

Proposition 1 is illustrated in *Figure 4* in the case when there exists only one, saddle-point stable steady-state.

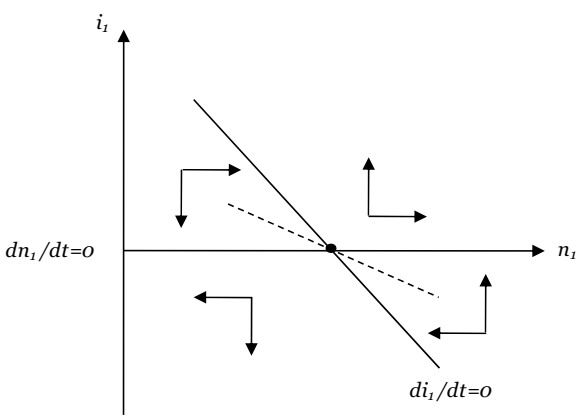


Figure 4: The saddle-point stable steady-state.

It is important to recognize the fundamental reason for why the dynamic system is saddle-point stable. This dynamic property arises as a consequence of the psychological costs associated with the external pressure discussed in section 2.4. This external pressure will provide the agent with an incentive to hold back his/her investment/disinvestment in i_1 which, in turn, prevents n_1 from either exploding to infinity or converging to zero. As such, the external pressure will force the individual to a certain degree of conformity with the social group. The degree of conformity will depend on how strong social pressure the social group can exercise over the individual agent. Consequently, it is only when the external pressure is zero that the agent can freely choose how much to invest/disinvest in the two norms. From equations (9) and (10) we see that $C_1 = C_2 = 0$ if (i) $\beta = 0$ or if (ii) $\bar{l}_1 = \bar{L}_1$ *and* $\bar{l}_2 = \bar{L}_2$. To see how the agent behaves in this situation, consider Proposition 2 which summarizes the dynamics in this special case;

Proposition 2: *If (a) the degree of social pressure, β, changes from positive to zero or (b) if $\bar{l}_1$ becomes equal to $\bar{L}_1$ and $\bar{l}_2$ becomes equal to $\bar{L}_2$, then the dynamic system characterized by equations (9) and (24) changes from being fundamentally saddle-point stable to becoming fundamentally unstable. The latter dynamic system has the following properties:*

(i) *There exists at least one interior steady-state where $\tilde{n}_1$ is nonzero and finite.*

(ii) *If only one steady-state exists, the di_1/dt locus will intersect the dn_1/dt locus from below at that point and the steady-state will be an unstable node/focus.*

(iii) *If multiple steady-states exist, the number of steady-states will be odd. Each odd-numbered steady-state will be an unstable node/focus whereas each even-numbered steady-state will be saddle-point stable*

Proof: See the Appendix.

This is illustrated in *Figure 5* which shows that when either condition (a) or condition (b) is fulfilled, then the slope of the $di_1/dt = 0$ locus, evaluated at the steady-state, changes from negative to positive.

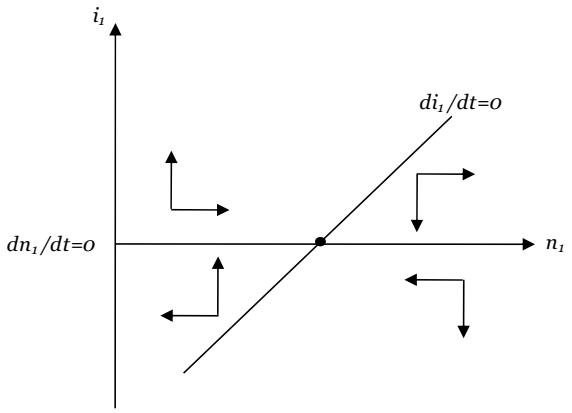


Figure 5: Dynamics in the absence of external pressure.

The implication of Proposition 2 is that in the absence of external pressure, there is nothing restraining the agent from completely investing/disinvesting in n_1. To understand the fundamental mechanism behind process, consider the following example. Assume that initially we observe $P_1 > P_2$ and $\beta = 0$. In this situation, the agent has an incentive to invest in n_1 and disinvest in n_2. This will cause the future choice of labor supply to increase and as long as $\bar{l}_2 < l < \bar{l}_1$, the future choice of labor supply will now be closer to $\bar{l}_1$ than to $\bar{l}_2$. As a consequence, P_1 will increase whereas P_2 will decrease. Both these effects will reinforce the incentive to invest in n_1. This process will continue until n_2 is eroded to zero. The opposite happens if we instead observe that $P_1 < P_2$ holds initially. Consequently, the agent will (except in the special case when $P_1 = P_2$) end up in a corner solution with the identity solely defined in terms of one norm.

However, since there are many examples from the real world where complete norm erosion is not happening, we will treat the outcome described in Proposition 2 as a special case. The remaining part of the analysis will therefore be based on the assumption that an agent is in the saddle-point stable steady-state as defined in Proposition 1.

3. Structural Changes

As mentioned in the introduction, some of the key factors explaining the development of female labor supply are higher wages and changed norms. In this section, we will use the framework developed in this paper to analyze how these factors influence l and n_1 in the long-run. As such, we will focus on the following questions:

(i) What are the long-run effects of a higher wage on labor supply when the weights n_1 and n_2 are endogenous?

(ii) What are the effects of a change in the personal working norm, $\bar{l}_1$?

(iii) What are the effects of a change in the social working norm, here captured by changing the parameter φ_1?

The effects of these structural changes will be evaluated conditional on that the agent is initially in the saddle-point stable steady-state depicted in *Figure 3*. Since $dn_1/dt = i_1 = 0$ at that point, the steady-state levels of labor supply, $\tilde{l}$, and the weight attached to the working norm, $\tilde{n}_1$, are uniquely determined by the first-order condition for labor (equation 14) and equation (21). The latter equation is evaluated when $di_1/dt = i_1 = 0$ and for the reader's convenience, we state these equations here.

$$0 = w - \rho'(h - l) - n_1 \cdot \left(l - \bar{l}_1\right) - n_2(n_1) \cdot \left(l - \bar{l}_2\right) - \beta \cdot \sum_{J=1}^{N} n_1^j \cdot \left(l - \varphi_1 \cdot \bar{l}_1^j\right) - \beta \cdot \sum_{J=1}^{N} n_2^j \cdot \left(l - \varphi_2 \cdot \bar{l}_2^j\right) \tag{22}$$

$$0 = \theta \cdot \beta \cdot \left[n_1 \cdot \left(\bar{l}_1 - \bar{L}_1\right)^2 - n_2(n_1) \cdot \left(\bar{l}_2 - \bar{L}_2\right)^2\right] - \left[\alpha_1 - \frac{1}{2} \cdot \left(l - \bar{l}_1\right)^2\right] - \frac{dn_2(n_1)}{dn_1} \cdot \left[\alpha_2 - \frac{1}{2} \cdot \left(l - \bar{l}_2\right)^2\right] \tag{23}$$

Differentiating equations (22) and (23) w.r.t. $l, n_1, w, \bar{l}_1$ and φ_1 produces

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \cdot \begin{bmatrix} d\tilde{l} \\ d\tilde{n}_1 \end{bmatrix} = \begin{bmatrix} -1 \cdot dw & -n_1 \cdot d\bar{l}_1 & b_1 \cdot d\varphi_1 \\ 0 & b_2 \cdot d\bar{l}_1 & b_3 \cdot d\varphi_1 \end{bmatrix} \tag{24}$$

where

$$a_{11} = \rho'' - n_1 - n_2 - \beta \cdot \sum_{J=1}^{N} n_1^j - \beta \cdot \sum_{J=1}^{N} n_2^j < 0$$

$$a_{12} = -\left(l - \bar{l}_1\right) - \frac{dn_2}{dn_1} \cdot \left(l - \bar{l}_2\right)$$

$$a_{21} = -a_{12}$$

$$a_{22} = \theta \cdot \beta \cdot \left[\left(\bar{l}_1 - \bar{L}_1\right)^2 - \frac{dn_2}{dn_1} \cdot \left(\bar{l}_2 - \bar{L}_2\right)^2\right] - \frac{d^2 n_2}{dn_1^2} \cdot \left[\alpha_2 - \frac{1}{2} \cdot \left(l - \bar{l}_2\right)^2\right]$$

$$b_1 = -\beta \cdot \sum_{J=1}^{N} n_1^j \cdot \bar{l}_1^j < 0$$

$$b_2 = \left(l - \bar{l}_1\right) - 2 \cdot \theta \cdot \beta \cdot n_1 \cdot \left(\bar{l}_1 - \bar{L}_1\right)$$

$$b_3 = 2 \cdot \theta \cdot \beta \cdot \left(\bar{l}_1 - \bar{L}_1\right) \cdot \frac{n_1}{N} \cdot \sum_{j=1}^{N} \bar{l}_1^j$$

For the analysis below, note that that saddle-point stability will imply, as we show in the Appendix, that $a_{11} \cdot a_{22} - a_{12} \cdot a_{21} < 0$ and $a_{22} > 0$.

To facilitate the analysis, it is helpful to illustrate the comparative static results to be derived below graphically. To do this, observe that both equation (22) and equation (23) implicitly defines a relationship between l and n_1. Beginning with equation (22), it is the first-order condition for labor supply and as such, it shows what level of l the agent will choose conditional on n_1. We will refer to this as the **S**hort-run relationship between **L**abor supply and the weight attached to the personal working **N**orm, or the **SLN** function. The slope of this function is given by

$$\frac{dl}{dn_1}(SLN) = -\frac{a_{12}}{a_{11}} \tag{25}$$

As long as the labor supply is situated in the interval $\bar{l}_2 < l < \bar{l}_1$, the term a_{12} will be positive in which case the SLN function has a positive slope in (n_1, l) space. This is illustrated in *Figure 6*.

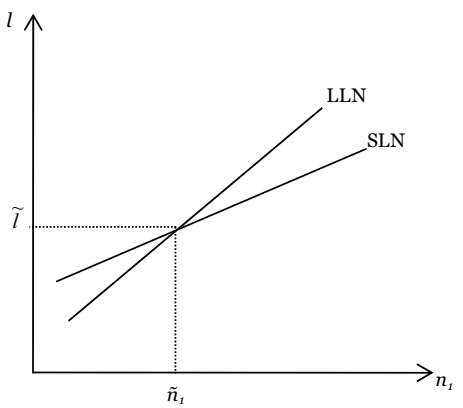


Figure 6: The SLN and LLN functions when $\bar{l}_2 < l < \bar{l}_1$.

To interpret equation (23), observe that from equations (9) and (10), it follows that the terms in the first row of equation (23) correspond to $\theta \cdot (\partial C_1/\partial i_1 + \partial C_2/\partial i_1)$. In addition, the definition in equation (1) implies that the terms in the second row of equation (23) correspond to $-(\partial P_1/\partial n_1 + \partial P_2/\partial n_1)$. Substituting these definitions into equation (23), multiplying the resulting expression with $-1/\theta$ and rearranging, produces

$$\underbrace{\frac{1}{\theta} \cdot \left(\frac{\partial P_1}{\partial n_1} + \frac{\partial P_2}{\partial n_1}\right)}_{\hat{MB}} - \underbrace{\left(\frac{\partial C_1}{\partial i_1} + \frac{\partial C_2}{\partial i_1}\right)}_{\hat{MUC}} = 0 \tag{26}$$

This expression has a straightforward interpretation. The first term on the left-hand side is the marginal benefit (MB) for the agent of an increase in n_1, evaluated in steady-state (where $i_1 = 0$). To see this, observe that the expression

inside the left parenthesis is the instantaneous marginal benefit to the agent following an increase in n_1 (i.e. $\partial\tilde{u}/\partial n_1$), evaluated in steady-state. Multiplying this term by $1/\theta$, we obtain the discounted present value, in utility terms, of the increase in n_1 from today (time zero) to infinity. Hence since $\partial\tilde{u}/\partial n_1$ is constant, it follows that

$$MB = \int_0^{\infty} \frac{\partial\tilde{u}(\cdot)}{\partial n_1} \cdot e^{-\theta \cdot t} dt = \frac{1}{\theta} \cdot \frac{\partial\tilde{u}(\cdot)}{\partial n_1} \tag{27}$$

Turning to the second term on the left-hand side of equation (26), it is the marginal utility cost (MUC) that would arise if the agent were to make an additional investment in n_1 at $(\tilde{n}_1, \tilde{l})$ (i.e. $\text{MUC} = \partial\tilde{u}/\partial i_1$). This means that equation (26), which implies $MB = MUC$, can be interpreted as a condition which defines the optimal level of n_1 in steady-state. As such, the relationship between l and n_1 implied by equation (26), and hence also implied by equation (23), gives the combinations of l and n_1 which correspond to an optimal long-run investment in the weight attached to the working norm. Therefore, this relationship between l and n_1 will be referred to as the **L**ong-run relationship between **L**abor supply and the weight attached to the personal working **N**orm, or the **LLN** function. Differentiating equation (23), we obtain the slope of the LLN functions as

$$\frac{dl}{dn_1}(LLN) = -\frac{a_{22}}{a_{21}} \tag{28}$$

For $\bar{l}_2 < l < \bar{l}_1$, the LLN function will be positively sloped in (n_1, l) space.

The saddle-point stable steady-state defined in Proposition 1 corresponds to the point in (n_1, l) space where the SLN and the LLN functions intersect. In the Appendix we show that the properties arising from saddle-point stability imply that in a neighborhood of the saddle-point stable steady-state, the slope of the LLN function will be larger in absolute value than the slope of the SLN function.

When both functions have positive slopes, this implies that the LLN function crosses the SLN function from below as illustrated in *Figure 6*.

After these preliminaries, we now have a suitable framework within which to analyze the effects of the structural changes mentioned above, and we begin by addressing the long-run effects of an increase in the wage.

3.1 An Increase in the Wage

The effects of a higher wage are illustrated in *Figure 7* and we will base the interpretations on the assumption that labor supply is situated in the interval $\bar{l}_2 < l < \bar{l}_1$.

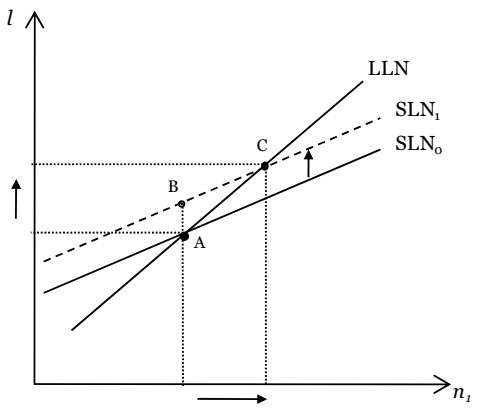


Figure 7: Effects of a higher wage.

Initially, the agent is in the saddle-point stable steady-state at point A. If the wage now increases, the SLN function will shift upwards. This reflects a standard labor supply response; conditional on the level of n_1, the direct effect of w on l is unambiguously positive when the agent has a utility function which is quasi-linear in income. This short-run effect on labor supply is readily obtained by differentiating equation (22) w. r. t. l and w, and in terms of *Figure 7* the short-run labor supply response corresponds to the vertical distance between points A and B. However, this is not the end of the story. A consequence of this initial labor supply response is that the agent is now closer to fulfilling the personal working norm, $\bar{l}_1$, and further away from fulfilling the personal household norm, $\bar{l}_2$ (recall

that $\bar{l}_2 < l < \bar{l}_1$ initially). As such, the utility associated with fulfilling the working norm, P_1, has now increased whereas the utility associated with fulfilling the household norm, P_2, has been reduced. This creates an incentive for the agent to revise the self-images associated with the two norms. To reinforce the sense of bliss associated with being able to conform better w. r. t. the personal working norm, and to relieve the frustration of not being able to conform so well w. r. t. the personal household norm, the agent will start to invest in n_1 and disinvest in n_2. This investment in the agent's professional identity also increases the perceived importance to fulfill the working norm and will induce the agent to increase the labor supply further in subsequent time periods, a process which continues until the new saddle-point stable steady-state, point C, is reached. This additional long-run effect on labor supply, which is the vertical distance between B and C, is a norm induced effect of a higher wage. Proposition 3 summarizes:

Proposition 3: *Consider an increase in the wage when* $\bar{l}_2 < l < \bar{l}_1$. *This will have a positive short-run effect on labor supply. The long-run effects on the weight attached to the working norm and on labor supply are given by*

$$\frac{\partial \tilde{n}_1}{\partial w} = \frac{a_{21}}{a_{11} \cdot a_{22} - a_{12} \cdot a_{21}} > 0 \tag{29}$$

$$\frac{\partial \tilde{l}}{\partial w} = -\frac{a_{22}}{a_{11} \cdot a_{22} - a_{12} \cdot a_{21}} > 0 \tag{30}$$

The long-run effect on labor supply will exceed the short-run effect.

The last part of Proposition 3 is formally proved in the Appendix.

3.2 An Increase in the Personal Working Norm $\bar{l}_1$

Let us now consider the effects of an increase in the ideal hours of work prescribed by the personal working norm. These effects are illustrated in *Figures 8a* and *8b*, and we will base the interpretations on the assumption that labor supply is in the interval $\bar{l}_2 < l < \bar{l}_1$.

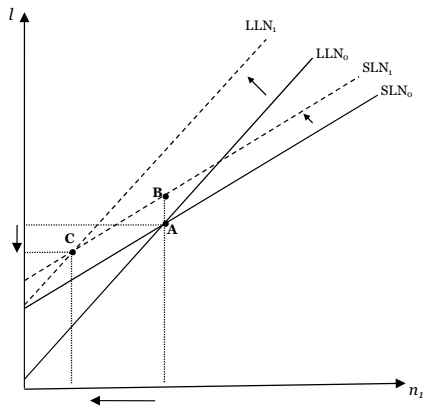


Figure 8a: Effects of an increase in $\bar{l}_1$.

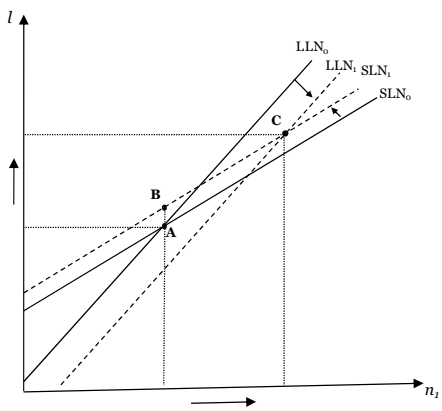


Figure 8b: Effects of an increase in $\bar{l}_1$.

The short-run effect of an increase in $\bar{l}_1$ is to shift the SLN function upwards. This reflects that if more hours of work are prescribed by the personal working norm, the agent will respond to this by increasing the supply of labor. However, in contrast to when the wage increases, this structural change also induces a shift in the LLN function (except in a special case). This reflects that a change in $\bar{l}_1$ will directly influence the long-run incentives to invest in the weight attached to the working norm. An increase in $\bar{l}_1$ will affect the incentive to invest in n_1 via two mechanisms, one affecting the marginal benefit (MB) of investing in n_1 and another affecting the marginal utility cost (MUC) of investing in n_1. The first effect arises because when $\bar{l}_1$ increases, the difference $\left(l - \bar{l}_1\right)$ will also increase (recall that $l < \bar{l}_1$ initially). This implies that it will now be more difficult than before to live up to the personal working norm which will have a direct negative effect on the marginal benefit of investing in n_1 via the term $\partial P_1/\partial n_1 = \left[\alpha_1 - 0.5 \cdot \left(l - \bar{l}_1\right)^2\right]$. As a consequence, the long-run incentive to invest in n_1 will be reduced and this will work in the direction of shifting the LLN function to the left. The size of this shift depends on how much MB is reduced which, in turn, is determined by

$$\frac{\partial MB}{\partial \bar{l}_1} = \frac{1}{\theta} \cdot \frac{\partial^2 P_1}{\partial \bar{l}_1^2} = \frac{1}{\theta} \cdot \left(l - \bar{l}_1\right) < 0 \tag{31}$$

As such, the closer the actual level of labor supply is to the personal working norm, the smaller will this effect be.

Second, an increase in $\left(l - \bar{l}_1\right)$ will also influence the long-run marginal utility cost of investing in n_1. This effect works via the term $\partial C_1/\partial i_1 = \beta \cdot n_1 \cdot \left(\bar{l}_1 - \bar{L}_1\right)^2$ which is one component making up MUC. If MUC increases (decreases), the incentive to invest in n_1 will be reduced (improved). All else equal, this will shift the LLN function to the left (right). The size of this shift depends on how much MUC increases/decreases in response to the increase in $\bar{l}_1$. This is determined by

$$\frac{\partial MUC}{\partial \bar{l}_1} = \frac{\partial^2 C_1}{\partial i_1 \partial \bar{l}_1} = 2 \cdot \beta \cdot n_1 \cdot \left(\bar{l}_1 - \bar{L}_1\right) \tag{32}$$

As can be seen in equation (32), MUC will increase (decrease) if $\bar{l}_1$ initially exceeds (falls short of) the average social working norm, $\bar{L}_1$, because in this situation an increase in $\bar{l}_1$ will exacerbate (reduce) the deviation between $\bar{l}_1$ and $\bar{L}_1$. Combing equations (31) and (32) produces

$$\frac{\partial MB}{\partial \bar{l}_1} - \frac{\partial MUC}{\partial \bar{l}_1} = \frac{b_2}{\theta} = \frac{1}{\theta} \cdot \left(l - \bar{l}_1\right) - 2 \cdot \beta \cdot n_1 \cdot \left(\bar{l}_1 - \bar{L}_1\right) \tag{33}$$

The LLN function will shift to the left (right) if this expression is negative (positive). The LLN function remains unchanged if equation (30) is equal to zero. As such, the long-run effects of an increase in $\bar{l}_1$ will depend on the 'initial' levels of l, $\bar{l}_1$ and $\bar{L}_1$ because this will determine the signs of $\left(l - \bar{l}_1\right)$ and $\left(\bar{l}_1 - \bar{L}_1\right)$ on the RHS of equation (33). These 'initial' levels can, in turn, be related to the different situations facing a woman on the labor market depending on whether she lives in a society where the traditional male-only breadwinner norm is predominant or not. Let us, therefore, first consider a society where a majority in the population supports the traditional male-only breadwinner norm which requires men to do much of the market work whereas women are primarily

expected to take care of the household. In terms of our model this means that the average social working norm for men, $\bar{L}_1^m$, is relatively large whereas the average social working norm for women, $\bar{L}_1^w$, is relatively small . The superindices "m" and "w" refer to men and women, respectively.

Now, consider a woman, who has internalized the male-only breadwinner norm and who lives up to it, that is $l^w \approx \bar{l}_1^w \approx \bar{L}_1^m$ (e.g., $\bar{L}_1^m = 2$ hours of market work per day). For this woman, the expression on the RHS of equation (33) is close to zero which means that if the woman's personal working norm increases, the shift in the LLN function will be small. If the shift in the LLN function is negligible, *Figure 7* in section 3.1 can be used to illustrate the long-run outcome in this situation. After the initial shift of the SLN function, the woman is at point B where she has an incentive to invest in n_1. This is a process which will continue until point C is reached where both labor supply and the weight attached to the personal working norm have increased.

The outcome will be quite different for a woman who does *not* believe in the traditional male-only breadwinner norm but who wants to be a breadwinner herself by working full time. Whether this woman's actual choice of hours of work will be close to $\bar{l}_1^w$ or to close $\bar{L}_1^w$ depends how strong the social pressure is. We will focus on the, arguably, realistic situation where the social pressure in the traditional society is sufficiently strong so as to force the woman to choose her hours of work in line with what is prescribed by the social norm, that is $l^w \approx \bar{L}_1^w$. This means that initially, the woman deviates significantly from her personal working norm ($l^w \ll \bar{l}_1^w$= e.g., 8 hours of market work per day) in which case she is likely to experience cognitive dissonance w. r. t. the personal working norm. If $\bar{l}_1^w$ increases in this situation, this will reinforce the cognitive dissonance associated with the personal working norm. To relieve the increased stress of not being able to live up to this norm, the woman will disinvest in the weight she attaches to her professional identity. As a consequence, her supply of labor will start to decrease and in the new steady-state, both $\tilde{l}$ and $\tilde{n}_1$ will be lower than at their respective initial levels. To illustrate this graphically, observe first that at the

initial position where $l^w \ll \bar{l}_1^w$ and $\bar{L}_1^w \ll \bar{l}_1^w$, the RHS of equation (33) will be negative and relatively large in absolute value (especially if the parameter capturing social pressure, β, is large). In this situation, the increase in $\bar{l}_1^w$ will produce a large inward shift of the LLN function, as illustrated in *Figure 8a*, where the long-run outcome is point C where both labor supply and the weight attached to the working norm are reduced. Observe in particular the sharp contrast between the short-run response on labor supply (point B) and the long-run effect for the woman (point C). The short-run effect is positive (given by the vertical distance between points A and B in *Figure 8a*) whereas the long-run norm induced effect is negative (given by the vertical distance between points A and C). Note also that the long-run effect on labor supply will be radically different for this woman with a 'modern' personal working norm compared to the woman discussed previously who has a traditional personal working norm. This result suggests that for 'modern' women living in 'traditional' societies, it may be optimal to conform to the prevailing social norms, both in terms of behavior, but also internally in terms of downplaying the divergent aspect of their personality.

Finally, let us consider a woman violating the social working norm in a 'modern' society where the traditional male-only breadwinner norm has been replaced by a social working norm which requires women to do the same amount of market work as men, i.e. working full-time ($\bar{L}_1^w = 8$). Here, we assume that the woman at hand does not believe in this 'modern' working norm but instead has a personal working norm which requires her to work less, say half-time ($\bar{l}_1^w = 4$). However, assume that the social pressure is sufficiently strong so as to force her to conform with the social working norm, that is she will work approximately full-time ($l^w \approx \bar{L}_1^w = 8$). Note that, in this case we can no longer guarantee that the slope of the LLN and SLN function is positive. However, let us assume that this is the case.[24] If $l^w - \bar{l}_1^w > 0$ and $\bar{l}_1^w - \bar{L}_1^w < 0$, this implies that the RHS of equation (33) is positive. In this situation, an increase in $\bar{l}_1^w$ will shift the LLN

[24] If $\bar{l}_2^w < \bar{l}_1^w < l^w$ then the sign of a_{21} is no longer unambiguous. If $a_{21} > 0$ both the SLN and the LLN curve become negatively sloped. However, one can easily see that in the 'normal' case the results from the above hold.

locus to the right, as illustrated in *Figure 8b*, in which case the new steady-state is at point C where both n_1 and l have increased. To explain this, note that an increase in $\bar{l}_1^w$ from a position where $\bar{l}_1^w < l^w$ and $\bar{l}_1^w < \bar{L}_1^w$ hold initially will, on one hand make it easier to conform with the personal working norm and on the other hand reduce the psychological cost associated with the external pressure. Both effects stimulate the woman to invest in n_1, a process which continues until point C is reached.

Let us summarize the comparative static properties of an increase in the personal working norm by applying Cramer's rule in equation (24) to derive the following results;

Proposition 4: *Consider an increase in the personal working norm,* $\bar{l}_1$. *The long-run effects on the weight attached to the working norm and on labor supply are given by*

$$\frac{\partial \tilde{n}_1}{\partial \bar{l}_1} = \frac{n_1 \cdot a_{21} + b_2 \cdot a_{11}}{a_{11} \cdot a_{22} - a_{12} \cdot a_{21}} \tag{34}$$

$$\frac{\partial \tilde{l}}{\partial \bar{l}_1} = -\frac{n_1 \cdot a_{22} + b_2 \cdot a_{12}}{a_{11} \cdot a_{22} - a_{12} \cdot a_{21}} \tag{35}$$

3.3 An Increase in the Social Working Norm

The analysis above has indicated that the average social working norm plays a key role for the long-run development of labor supply and the weight attached to the personal working norm. Let us, therefore, conclude by analyzing the effects of a change in the social attitudes towards market work. As before, we base the interpretations on the assumption that labor supply is in the interval $\bar{l}_2 < l < \bar{l}_1$.

Within the context of this model, a change in the social attitudes towards market work is captured by changing the parameter φ_1 in equations (22) and (23). An increase in φ_1, from $\varphi_1 = 1$, captures a simultaneous increase in the personal

working norm $\bar{l}_i^j$ among the N individuals in the society.[25] This will influence an agent's decision both in the short-run, shifting the SLN function, and in the long-run, shifting the LLN function. The direct short-run effect arises because if more hours of work are prescribed by the social working norm, the agent will respond to this by increasing his/her supply of labor. This will cause an upward shift of the SLN function.

The LLN function will shift because the increase in φ_1 will have a positive effect on $\bar{L}_1$ (see equation 4) which, in turn affects MUC via the term $\partial C_1/\partial i_1 = \beta \cdot n_1 \cdot \left(\bar{l}_1 - \bar{L}_1\right)^2$. The direct effect on MUC is given by

$$\frac{\partial MUC}{\partial \bar{L}_1} = \frac{\partial^2 C_1}{\partial i_1 \partial \bar{L}_1} = -2 \cdot \beta \cdot \left(\bar{l}_1 - \bar{L}_1\right) \cdot \frac{n_1}{N} \cdot \sum_{j=1}^{N} \bar{l}_1^j \tag{36}$$

If $\bar{l}_1 > \bar{L}_1$ initially, MUC will decrease which will shift the LLN function to the right. *Figure 8b* in section 3.2 can be used to illustrate the long-run outcome in this situation. If, on the other hand, $\bar{l}_1 < \bar{L}_1$ initially, MUC will increase and this will shift the LLN function to the left. *Figure 8a* in section 3.2 can serve as an illustration for this scenario. Finally, if $\bar{l}_1 = \bar{L}_1$ initially, MUC is not affected and the LLN function will be unchanged.

Now, consider a woman who lives in a society where the traditional male-only breadwinner norm is strong but who herself does not believe in this norm. Instead, her personal norm $\bar{l}_1^w$ is larger than the average working norm prescribed by the society, $\bar{L}_1^w$, that is $\bar{l}_1^w > \bar{L}_1^w$. For this woman, the RHS of equation (36) will be negative. In this situation, her psychological cost associated with the external pressure will decrease when $\bar{L}_1^w$ increases because the difference between her personal working norm, $\bar{l}_1^w$, and the average working norm in society, $\bar{L}_1^w$, is now lower. This will cause an outward shift of the LLN function, as illustrated in

[25] Of course, one can also envisage that the personal working norm increases within a fraction of the population in the society but as long as this fraction is not infinitesimally small in relation to N, the effects will produce effects that are qualitatively identical to the effects derived in this section.

Figure 8b, which causes both labor supply and the weight attached to the personal working norm to increase in the long-run.

In contrast, for an agent with traditional beliefs living in a relatively 'modern' society an increase in $\bar{L}_1^w$ may actually backfire in terms of reducing both labor supply and the relative weight of the working norm. In other words, if the discrepancy between society's and the individual's values becomes substantial, this traditional individual may become reactionary. To see this, note that in this case $\bar{l}_1^w < \bar{L}_1^w$ initially and when $\bar{L}_1^w$ increases, so does the discrepancy between the agent's personal norm and society's expectations. Although social pressure initially creates incentives to conform by increasing labor supply, the individual in will the long-run have incentives to devalue the importance of the social group promoting this social norm. Hence, in the long-run, for such an individual, an increase in $\bar{L}_1^w$ may actually reduce labor supply.

We summarize the comparative static properties of an increase in the social working norm by applying Cramer's rule in equation (24) to derive the following results:

Proposition 5: *Consider an increase in* φ_1. *The long-run effects on the weight attached to the working norm and on labor supply are given by*

$$\frac{\partial \tilde{n}_1}{\partial \varphi_1} = \frac{b_3 \cdot a_{11} - b_1 \cdot a_{21}}{a_{11} \cdot a_{22} - a_{12} \cdot a_{21}} \tag{37}$$

$$\frac{\partial \tilde{l}}{\partial \varphi_1} = -\frac{b_1 \cdot a_{22} - b_3 \cdot a_{12}}{a_{11} \cdot a_{22} - a_{12} \cdot a_{21}} \tag{38}$$

4. Analysis of the evolution of female labor supply

The model presented in this paper offers an interesting framework for analyzing the changes in female labor supply that has taken place in the era after the World Wars. In addition, our results offer a potential explanation to the persisting differences in, and attitudes towards, female LFP between countries

and to women's domination of part-time labor. Let us therefore linger around the implications of the model.

Consider first the effects of the absence of male labor during the World Wars. This structural change clearly implied that society's need for female labor increased and therefore potentially that the social norms related to female market work became more positive. The results summarized in proposition 5 suggest that if society at large became more accepting towards female market work, this may have affected female labor supply both in the short- and long-run. In the short-run, women with personal aspirations to be something more than a housewife became freer to choose market work over household work. However, if these women initially also defined themselves in terms of their role as mothers/wives to some extent, the increase in LFP may have had a negative side effect in terms of guilt of not being a 'good' housemother. Consequently, working women may have felt inclined to downplay the relative importance of living up to the 'household' norm for a positive self-image, and this in turn may have increased incentives to pursue a career. Note also that, since an increase in the socially prescribed hours of market work for women reduces the perceived future social cost of being a female breadwinner, the change in social norms may have facilitated the transition. It is also interesting to note that the relatively high growth in GDP, that took place during the post war era, may have amplified the effect. Proposition 3 suggests that, if this growth in GDP was reflected in higher wages for market work, we should expect female labor supply to increase in the short-run but also an enforced effect in the long-run due to an increase in the perceived importance of being successful at work for having a positive self-image.

Now, for women with no or small aspirations to have a career outside of the households, the model predicts that short-run effects of the war-induced structural changes should have been the same as for women with professional aspirations. However, the long run effects are expected to have differed. For these women, an increase in the socially prescribed hours of market work and in the wage increases incentives to supply work in the short-run. However, although

this behavior is likely to have created incentives to upgrade the importance of being a 'working woman', the divergence between these women's personal prescriptions and society's expectations may have created a sense of not living up to the expectations at the labor market (a failure as a professional) and therefore to have created incentives to downplay the importance of pursuing a career. Indeed, the presence of conflicting identities and expected future costs of diverging too much from society's expectations imply that, if society did not change completely after the World Wars, so that women were expected to completely abandon their responsibility within the household, we may expect that the role as mothers/wives may have persisted as having a significant share in women's identities and therefore that women's participation in the labor market will continue to be part-time for a relatively large share of the population.

Let us also briefly discuss the implications of Proposition 4. The results presented in equations (34) and (35) suggest that, although the differences in personal preferences for market and household work are likely to be as high within countries as they are between countries, we may expect to observe a homogenization of attitudes within countries over time. This is so because women with 'high ambitions' in societies where social norms still prescribe a traditional distribution of work may find it optimal to adjust to these norms, both in behavior but also in the long run by downplaying the importance of making a career for their overall self-image. Even if their personal aspirations to have a career are initially relatively high, the fear of being and becoming an outsider in society may provide these women with incentives to upgrade the relative importance of being a 'good' housemother. Hence, the overrepresentation of women who agree with the traditional gender norm in some countries presented in *Table 1*, may not be so surprising: it is simply a consequence of our need to maintain mental peace and a positive self-image.

5. Summary and implications for future research

Drawing on ideas from psychology, which emphasizes that individuals define themselves in terms of a set of different identities, we have formulated a model that relates the importance an individual attaches to different personal identities to his/her long-run supply of labor. A key assumption is that different identities may prescribe different types of behavior, in which case the identities are in conflict with each other. This will provide an agent with an incentive to revise the importance he/she attaches to the different identities in the long-run. Applying this approach to a model of female labor supply, the potential conflict between identities is between a traditional household norm prescribing little (possibly zero) hours of work and a working norm which prescribes the woman to work, say, full-time. The main results are that (i) the long-run effects of a higher wage on labor supply may be underestimated if we do not recognize that the weights attached to different social identities are endogenous, (ii) an increase in the hours of work prescribed by a woman's personal working norm need not necessarily lead to an increase in her supply of labor in the long-run, and (iii) a change towards more gender-neural social norms facilitates the transition of women with professional aspirations from housewives to breadwinners.

This paper may serve as a stepping stone for further research in the area of personal and social norms. Since the model presented in this paper deals with behavior at the individual level, the natural next step is to use this framework to analyze how the interaction between agents at the individual level sum up and determine the social pressure associated with a given norm. By doing this, one would be able to endogenize the weights attached to the different social identities at the social level. This would enable an analysis of how the interaction between agents drives the importance of different norms in the long-run. Another issue for future research would be to endogenize the behavior prescribed by the personal norms. By doing this, it would be possible to analyze how the importance of norms and the defined behavior of these norms simultaneously

change over time. The latter is interesting because the definition of the breadwinner seems to change over time and between countries.

Appendix

The $dn_1/dt = 0$ locus

To derive the equation for the $dn_1/dt = 0$ locus, observe first that necessary conditions (15) and (17) are written as

$$0 = \mu - \kappa \cdot i_1 - \beta \cdot \left[n_1 \cdot \left(\bar{l}_1 - \bar{L}_1 \right)^2 - n_2(n_1) \cdot \left(\bar{l}_2 - \bar{L}_2 \right)^2 \right] \tag{A.1}$$

$$\begin{aligned} \frac{d\mu}{dt} - \theta \cdot \mu = \beta \cdot i_1 \cdot \left[\left(\bar{l}_1 - \bar{L}_1 \right)^2 - \frac{dn_2(n_1)}{dn_1} \cdot \left(\bar{l}_2 - \bar{L}_2 \right)^2 \right] \\ - \left[\alpha_1 - \frac{1}{2} \cdot \left(l - \bar{l}_1 \right)^2 \right] - \frac{dn_2(n_1)}{dn_1} \cdot \left[\alpha_2 - \frac{1}{2} \cdot \left(l - \bar{l}_2 \right)^2 \right] \end{aligned} \tag{A.2}$$

Next, differentiate (A.1) w.r.t. time and rearrange

$$\frac{d\mu}{dt} = \kappa \cdot \frac{di_1}{dt} + \beta \cdot \left[\left(\bar{l}_1 - \bar{L}_1 \right)^2 - \frac{dn_2(n_1)}{dn_1} \cdot \left(\bar{l}_2 - \bar{L}_2 \right)^2 \right] \cdot \frac{dn_1}{dt} \tag{A.3}$$

If we now use (A.1) and (A.3) to substitute for μ and $d\mu/dt$ in (A.2), and use that $dn_1/dt = i_1$, we obtain equation (21) in the text.

Proof of Existence of Steady-State

From equation (21), it follows that the $di_1/dt = 0$ locus can be written as

$$\begin{aligned} \theta \cdot i_1 = \frac{1}{\kappa} \cdot \left[\alpha_1 - \frac{1}{2} \cdot \left(l - \bar{l}_1 \right)^2 \right] + \frac{1}{\kappa} \cdot \frac{dn_2(n_1)}{dn_1} \\ \cdot \left[\alpha_2 - \frac{1}{2} \cdot \left(l - \bar{l}_2 \right)^2 \right] \end{aligned} \tag{A.4}$$

$$-\frac{\theta}{\kappa}\cdot\beta\cdot\left[n_1\cdot\left(\bar{l}_1-\bar{L}_1\right)^2-n_2(n_1)\cdot\left(\bar{l}_2-\bar{L}_2\right)^2\right]$$

By using that equation (20) implies $l(n_1)$, it follows that the $di_1/dt=0$ locus defines a relationship between i_1 and n_1. Let us now evaluate the RHS of equation (A.4) as $n_1\to\infty$. First, since $lim_{n_1\to\infty}\ l(n_1)=\bar{l}_1$ it follows that the first term on the RHS of (A.4) approaches α_1/κ; a finite value. Second, the properties of the norm function specified in section 2.1 implies

$$\lim_{n_1\to\infty}\ \frac{dn_2(n_1)}{dn_1}=0 \tag{A.5}$$

which means that the second term on the RHS of (A.4) approaches zero. Third, since the first term inside square brackets in the second row of equation (A.4) approaches infinity whereas the second term inside square brackets approach zero as $n_1\to\infty$, it follows that the RHS of equation (A.4) approaches $-\infty$ as $n_1\to\infty$ which, in turn, implies that $i_1\to-\infty$. This means that the $di_1/dt=0$ locus will eventually be situated below the horizontal axis in (n_1,i_1) space as $n_1\to\infty$.

It is not possible to evaluate the sign of the RHS of equation (A.4) as $n_1\to 0$ because the second term on the RHS approaches $-\infty$ whereas the second term inside square brackets in the second row of equation (A.4) approaches $+\infty$. To overcome this problem, we instead reformulate the maximization problem in terms of investing in n_2 instead of n_1 which means that the agent now chooses i_2 instead of i_1 and the norm function is now written $n_1(n_2)$. This problem is equivalent to the problem formulated in the paper. If we follow the same procedures as in the paper, we can derive a $di_2/dt=0$ locus which reads

$$\begin{aligned}\theta\cdot i_2=&\frac{1}{\kappa}\cdot\frac{dn_1(n_2)}{dn_2}\cdot\left[\alpha_1-\frac{1}{2}\cdot\left(l-\bar{l}_1\right)^2\right]+\frac{1}{\kappa}\cdot\left[\alpha_2-\frac{1}{2}\cdot\left(l-\bar{l}_2\right)^2\right]\\&-\frac{\theta}{\kappa}\cdot\beta\cdot\left[n_1(n_2)\cdot\left(\bar{l}_1-\bar{L}_1\right)^2-n_2\cdot\left(\bar{l}_2-\bar{L}_2\right)^2\right]\end{aligned} \tag{A.6}$$

Again using that equation (20) implies $l\big(n_1(n_2)\big)$, it follows that the $di_2/dt = 0$ locus defines a relationship between i_2 and n_2. Let us now evaluate the RHS of equation (A.6) as $n_2 \to \infty$. First, the properties of the norm function specified in section 2.1 implies

$$\lim_{n_2 \to \infty} \frac{dn_1(n_2)}{dn_2} = 0 \tag{A.7}$$

which means that the first term on the RHS of (A.6) approaches zero. Second, $lim_{n_2 \to \infty}\ l\big(n_1(n_2)\big) = \bar{l}_2$, which implies that the second term on the RHS of (A.6) approaches α_2/κ; a finite value. Third, since the first term inside square brackets in the second row of equation (A.6) approaches zero whereas the second term inside square brackets approach infinity as $n_2 \to \infty$, it follows that the RHS of equation (A.6) approaches $-\infty$ as $n_2 \to \infty$ which, in turn, implies that $i_2 \to -\infty$. Now, since a disinvestment in n_2 is equivalent with an investment in n_1, it follows that i_1 and i_2 will always have opposite signs. Hence, since $n_2 \to \infty$ corresponds to $n_1 \to 0$, and $i_2 \to -\infty$ corresponds to $i_1 \to \infty$, it follows that the $di_1/dt = 0$ locus will eventually be situated above the horizontal axis in (n_1, i_1) space as $n_1 \to 0$.

To sum up, since $i_1 \to \infty$ as $n_1 \to 0$, and since $i_1 \to -\infty$ as $n_1 \to \infty$, there must exists one point where the $di_1/dt = 0$ locus crosses the horizontal axis in (n_1, l) space. Since the horizontal axis corresponds to the $dn_1/dt = 0$ locus, that point will be a steady-state. If only one steady-state exists, the $di_1/dt = 0$ locus will cross the horizontal axis from above. If multiple steady-states exist, their numbers must be odd and each odd-numbered steady-state will be saddle-point stable because each time the $di_1/dt = 0$ locus crosses the horizontal axis from above, the steady-state will be saddle-point stable. This is proved next.

Saddle-Point Stability

To prove that when the $di_1/dt = 0$ locus crosses the horizontal axis from above, the steady is saddle-point stable, let us first observe that the dynamic

system is characterized by equations (21) and (8). The dynamic Jacobian, J, corresponding to this system is written

$$J = \begin{bmatrix} \frac{\partial\left(\frac{di_1}{dt}\right)}{\partial i_1} & \frac{\partial\left(\frac{di_1}{dt}\right)}{\partial n_1} \\ \frac{\partial\left(\frac{dn_1}{dt}\right)}{\partial i_1} & \frac{\partial\left(\frac{dn_1}{dt}\right)}{\partial n_1} \end{bmatrix} = \begin{bmatrix} \theta & \frac{\partial\left(\frac{di_1}{dt}\right)}{\partial n_1} \\ 1 & 0 \end{bmatrix} \tag{A.8}$$

where

$$\frac{\partial\left(\frac{di_1}{dt}\right)}{\partial n_1} = a_{22} + a_{21} \cdot \left(-\frac{a_{12}}{a_{11}}\right) = \frac{1}{a_{11}} \cdot (a_{11} \cdot a_{22} - a_{12} \cdot a_{21}) \tag{A.9}$$

$$tr\, J = \theta, \;\; |J| = -\frac{\partial\left(\frac{di_1}{dt}\right)}{\partial n_1} \tag{A.10}$$

Now, observe that the slope of the $di_1/dt = 0$ locus in (n_1, i_1) space is given by

$$\frac{\partial i_1}{\partial n_1} = -\frac{\partial\left(\frac{di_1}{dt}\right)/\partial n_1}{\partial\left(\frac{di_1}{dt}\right)/\partial i_1} = -\frac{\partial\left(\frac{di_1}{dt}\right)/\partial n_1}{\theta} \tag{A.11}$$

When the $di_1/dt = 0$ locus crosses the horizontal axis from above, in which case the $di_1/dt = 0$ locus has a negative slope in steady-state, equation (A.11) implies that $\partial\left(\frac{di_1}{dt}\right)/\partial n_1 > 0$. From (A.10) it then follows that $|J| < 0$. This means that $tr\, J > 0$ and $|J| < 0$, and the discriminant $(tr\, J)^2 - 4 \cdot |J|$ is positive. Hence, the conditions for local saddle-point stability are satisfied.

If, instead, the $di_1/dt = 0$ locus crosses the horizontal axis from below, it follows that the linearized system around the steady-state will have positive characteristic roots, implying that the steady-state it is either an unstable node or a focus.

Observe also that since $\partial\left(\frac{di_1}{dt}\right)/\partial n_1 > 0$ in the saddle-point-stabe steady-state, equation (A.9) in turn implies that $a_{11} \cdot a_{22} - a_{12} \cdot a_{21} < 0$. In addition, since $a_{11} < 0$ and $a_{12} \cdot a_{21} < 0$, then $a_{11} \cdot a_{22} - a_{12} \cdot a_{21} < 0$ can only hold if $a_{22} > 0$.

Proof of Proposition 2

When either $\beta = 0$, or $\bar{l}_1 = \bar{L}_1$ and $\bar{l}_2 = \bar{L}_2$, the $di_1/dt = 0$ in (A.4) reduces to

$$\theta \cdot i_1 = \frac{1}{\kappa} \cdot \left[\alpha_1 - \frac{1}{2} \cdot \left(l - \bar{l}_1\right)^2\right] + \frac{1}{\kappa} \cdot \frac{dn_2(n_1)}{dn_1} \cdot \left[\alpha_2 - \frac{1}{2} \cdot \left(l - \bar{l}_2\right)^2\right] \tag{A.12}$$

Let us again use that equation (20) implies $l(n_1)$ and evaluate the RHS of equation (A.12) as $n_1 \to \infty$. First, $lim_{n_1 \to \infty}\ l(n_1) = \bar{l}_1$ which means that the first term on the RHS of (A.12) approaches $\alpha_1/\kappa > 0$; a finite positive value. Second, the properties of the norm function specified in section 2.1 implies

$$\lim_{n_1 \to \infty} \frac{dn_2(n_1)}{dn_1} = 0 \tag{A.13}$$

which means that the second term on the RHS of (A.12) approaches zero. Hence, the RHS of equation (A.12) approaches $\alpha_1/\kappa > 0$ as $n_1 \to \infty$ which, in turn, implies that $i_1 \to \alpha_1/\kappa > 0$. This means that the $di_1/dt = 0$ locus will eventually be situated above the horizontal axis in (n_1, i_1) space as $n_1 \to \infty$.

Next, let us evaluate the RHS of equation (A.12) as $n_1 \to 0$. First, as $l(n_1) = \bar{l}_2$, the first term on the RHS of (A.12) will converge to $\frac{1}{\kappa} \cdot \left[\alpha_1 - \frac{1}{2} \cdot \left(\bar{l}_2 - \bar{l}_1\right)^2\right]$, which is a finite number. Second, $lim_{n_1 \to 0}\ l(n_1) = \bar{l}_2$ which means that the term inside the second square bracket on the RHS of (A.12) approaches $\alpha_2/\kappa > 0$; a finite positive value. Third, the properties of the norm function specified in section 2.1 implies

$$\lim_{n_1 \to 0} \frac{dn_2(n_1)}{dn_1} \to -\infty \tag{A.14}$$

which means that the second term on the RHS of (A.12) approaches minus infinity. Hence, this last term will dominate and the RHS of equation (A.12) will approach minus infinity as $n_1 \dashrightarrow 0$ which, in turn, implies that $i_1 \to -\infty$. This means that the $di_1/dt = 0$ locus will eventually be situated below the horizontal axis in (n_1, i_1) space as $n_1 \to 0$.

Hence, since the $di_1/dt = 0$ locus will be situated below the horizontal axis when $n_1 \to 0$ but above the horizontal axis as $n_1 \to \infty$. Hence, there exists at least one point where the $di_1/dt = 0$ locus crosses the horizontal axis from below and this is a steady-state. From (A.10) and (A.11) it follows that when the $di_1/dt = 0$ locus has a positive slope, the determinant of the dynamic Jacobian, $|J| > 0$. Then, since that $tr\, J > 0$, the characteristic roots are either two positive real numbers or complex roots with a positive real part. In either case, the system will be unstable.

Proof that the LLN function is steeper than the SLN function

The difference in slopes between the LLN function and the SLN function is given by

$$\begin{aligned} \frac{dl}{dn_1}(LLN) - \frac{dl}{dn_1}(SLN) &= -\frac{a_{22}}{a_{21}} - \left(-\frac{a_{12}}{a_{11}}\right) \\ &= -\frac{a_{11} \cdot a_{22} - a_{12} \cdot a_{21}}{a_{11} a_{21}} > 0 \end{aligned} \tag{A.15}$$

where we have used that $a_{21} < 0$ as long as $\bar{l}_2 < l < \bar{l}_1$, and that $a_{11} \cdot a_{22} - a_{12} \cdot a_{21} < 0$. Since both the LLN function and the SLN function has a positive slope as long as $\bar{l}_2 < l < \bar{l}_1$, the inequality in (A.15) implies that the LLN function is steeper than the SLN function.

Proof that the long-run effect on labor supply of an increase in w exceeds the short-run effect

The short-run effect of an increased in w on l is obtained by differentiating the first-order condition for labor supply, equation (22), w.r.t. w and l. This produces

$$\frac{\partial \tilde{l}}{\partial w}(short) = -\frac{1}{a_{11}} > 0 \tag{A.16}$$

The long-run effect is given in equation (30) and restated here

$$\frac{\partial \tilde{l}}{\partial w}(long) = -\frac{a_{22}}{a_{11} \cdot a_{22} - a_{12} \cdot a_{21}} > 0 \tag{A.17}$$

To show that the long-run effect exceeds the short-run effect, observe first that the inverse effects are given by

$$\frac{\partial w}{\partial \tilde{l}}(short) = -a_{11} \tag{A.18}$$

$$\frac{\partial w}{\partial \tilde{l}}(long) = -\frac{a_{11} \cdot a_{22} - a_{12} \cdot a_{21}}{a_{22}} = \frac{a_{12} \cdot a_{21}}{a_{22}} - a_{11} \tag{A.19}$$

This implies

$$\begin{aligned} \frac{\partial w}{\partial \tilde{l}}(long) - \frac{\partial w}{\partial \tilde{l}}(short) &= \frac{a_{12} \cdot a_{21}}{a_{22}} - a_{11} - (-a_{11}) \\ &= \frac{a_{12} \cdot a_{21}}{a_{22}} < 0 \end{aligned} \tag{A.20}$$

The inequality in (A.20) must imply

$$\frac{\partial \tilde{l}}{\partial w}(long) - \frac{\partial \tilde{l}}{\partial w}(short) > 0 \tag{A.21}$$

Hence, the long-run effect on labor supply exceeds the short-run effect.

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