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The demand for savings, credit and insurance in a simple dynamic framework

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Abstract

We present in this note a simple theoretical model, suitable to study the simultaneous demand for savings, credit and insurance by poor agricultural households. Simulations are reported for various prices of the three different financial instruments. They highlight a very low demand for insurance and suggest a complementarity between credit and insurance.

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Presentation

Early models adopted by microfinance actors were centered on providing microcredit to poor households. More recently, the attention is shifting towards a more global approach that encompasses facilitating access to savings and developing micro-insurance products in addition to offering credit.

On the micro-insurance side, many projects involving the development of an index-based policy have been implemented in the past ten years. Most of them have met with low demand despite their attractive price and properties. This would be a puzzle if households do not have other risk coping options at their disposal.

The role of savings and credit as suitable financial instruments to alleviate the effect of shocks has long been emphasized by the development economics literature. The precautionary motive for savings as well as the demand for credit in response to negative shocks suggest that both instruments can be used in the global risk coping strategy of poor households (see Karlan and Morduch, 2009, for a synthetic presentation).

In this context, and because there are some reasons to believe that credit, savings and insurance demands are interdependent, it seems crucial to complement the analysis centered on a single product by a more holistic approach and to analyze simultaneously the demand for the three types of financial instruments.

In addition, it has been recognized recently that taking into account self-control problems is important in order to understand the financial behavior of households in developing as well as in developed countries (e.g. Mullainathan and Shafir, 2009).

We present in this note some preliminary work in this direction. Having in mind the situation of a poor agricultural household in a developing country, we study the demand for the different instruments that a micro-finance institution may offer. We develop a simple dynamic model in which there is (a) a consumption smoothing role for insurance, (b) a precautionary motive for savings, (c) the possibility to borrow ex post to cope with a negative shock and (d) a self-control problem on the agent's side.

Simulations for a wide range of prices highlight the fact that in the presence of savings and credit opportunities, the demand for insurance is low when income shocks are expected to be frequent and symmetric. When shocks are asymmetric (big negative shocks occurring with low probabilities), savings are not very effective to smooth income and the demand for insurance is higher. Our model also suggests important complementarities between credit and insurance, as agents borrow to pay for insurance and therefore buy more insurance if they have a better access to credit. Finally, sophisticated present-biased agents tend to take up insurance more often than standard exponential discounters.

The Model

We build a simple dynamic model in order to study the simultaneous demand for savings, credit and insurance at the individual level. The main features of the model are the following.

1) There are three periods (labeled 0,1,2) in the model,
2) The agent receives an income in each period. The expected value of this income is constant across periods.
3) The income is fixed in period 0 and period 2 with value w but stochastic in period 1 where it takes value $w+(1-\pi)\varepsilon$ or $w-\pi\varepsilon$ with probability π and $(1-\pi)$ respectively.
4) The agent's preferences are represented by a time-separable utility function with constant relative risk aversion, a discount factor and a present bias.

This simple setting is sufficiently rich to generate interesting patterns of the demand for savings, credit and insurance. The single shock at period 1 justifies the need for different financial instruments. Without those instruments, the agent would not be able to smooth consumption at all and would suffer from a drastic reduction of consumption in period 1 in case he is hit by the negative shock (the bad state). The three financial instruments considered are different means to transfer some revenue to this bad state in period 1.

The hypothesis made on risk aversion is standard in the empirical and/or experimental literature. We discuss the calibration of the corresponding parameter in the next section.

Importantly, we consider that agents are present biased and have quasi-hyperbolic preferences. This behavioral hypothesis is a convenient way to model self-control problems. Several patterns of observed behavior such as the simultaneous use of credit and savings (Atkinson et al., 2011) or the difficulties to rebuild buffer stocks after a shock are difficult to understand without such a hypothesis.

The three financial instruments, i.e. savings, credit and insurance, are introduced in this basic framework as follows.

The decision to save is taken in period 0 and in the two states of period 1. There is no possible savings in period 2 since it is the last period of the model. For each decision, the amount saved by the agent is a continuous variable and savings become available, for consumption or any other use, the next period. The precise amount that the agent then has at his disposal depends on the rate of return on savings which is given by a parameter r.

The decision to borrow is taken in period 0 and in the two states of period 1. Again, there is no possible borrowing in period 2 since it is the last period of the model. For each decision, the amount borrowed by the agent is a continuous variable. This amount, multiplied by one plus the interest rate R, must be reimbursed the next period.

The possibility to buy insurance is offered to the agent in period 0 only. The quantity of insurance that the agent buys is a continuous variable. When he buys one unit of insurance, the agent is entitled to receive one unit of wealth in period 1 in the bad state, i.e. when he receives the income w-ε. Insurance does not pay anything in the good state, i.e. when he receives the income w+ε. One unit of insurance costs $\frac{1}{2}(1+\lambda)$ where λ is a loading factor capturing the markup of the insurance company over the actuarially fair price. The price of insurance must be paid in period 0, while the benefits are perceived in period 1.

Calibration

We then calibrate and simulate our model in order to compare the households' demand for insurance and welfare levels under different scenarios. We normalize to 1 the per-period income and explore the influence of the other parameters, in particular the price of the three financial products. Our benchmark values for the discount rate and the present bias parameters are respectively 0.96 and 0.7. Relative risk aversion is set equal to 3. These correspond to annual discounting and risk aversion patterns typically measured in laboratory and field experiments (e.g. Angeletos et al., 2001; Laibson et al., 2007; Duflo et al. 2011; de Nicola et al., 2012). The other parameter values are set in order to favor a positive demand for insurance: a large shock in period 1 and a loading factor which corresponds to a lower bound of what is observed in real-world index-based micro-insurance contracts (see for instance Cole et al., 2013).

The shock in period one is such that agents can lose half of their income in the bad state, whose probability of occurrence is successively set to 50% (symmetric shock) and 20 % (asymmetric shock). Borrowing interest rates vary from 1000% to 30% annually. The upper value is set in order to simulate the absence of a credit market, while the lower value is below the interest rates that are usually charged by moneylenders in developing countries. Concerning savings, rate of return ranges between -0.5 and +0.1%. The lower value corresponds to a situation in which there is no formal savings market; resources can be kept at home and transferred to the next period but they lose half of their value due to the combined effect of inflation, storage or transaction costs and external pressures by relatives, friends or thieves. The upper value is a very optimistic scenario in which formal savings accounts are remunerated at a 10% annual interest rate.

Results

Table 1 presents the results of the simulation when agents have present bias and can lose or win half of their income in period 1 with equal probability. Each row represents a different condition of the local financial markets, given by r, R and λ, and gives the optimal financial decisions of the agents as well as the achieved utility level. The amounts of insurance, credit and savings are respectively denoted by i, b and s, while the subscripts 0 and 1 refer to the first and second periods and the superscripts + and - refer to the occurrence of a positive or negative income shock respectively. The utility is evaluated in period 0, both taking into account the agents' present bias $(U_{\beta\delta})$ and under classical exponential discounting (U_{δ}). Case 1 represents the "autarchic" benchmark: agents have no access to credit and can only engage in costly home savings. We then gradually improve the savings and credit conditions, and compute the utility gain with respect to case 1. In rows 2 and 3, we observe that giving access to a better savings technology has a large effect on welfare, as it allows a much better smoothing of the large shock that occurs in period 1. By contrast, having access to expensive credit has little effect and can even reduce welfare, as present-biased agents tend to over borrow in face of the shock. Even as the price of credit decreases to 200% annually, it does not allow reaching significantly higher utility levels than in the total absence of credit. It is only when credit becomes fairly cheap, with an interest rate at 50% annually, that we observe significant improvements, thanks to the optimal combination of savings and credit. Demand for insurance remains zero in all those cases. Indeed, it appears clearly that present-biased agents need cheap credit (from 30% in our simulation) to buy insurance, in order to keep a sufficiently high level of consumption in period 0. When they do, they reach much higher utility levels, with gains up to 17% with respect to autarchy. Yet, the demand for insurance appears very price-sensitive, as a small increase of the premium, generated by a 10 p.p. increase of the loading factor, decreases the demand for insurance by 40% when saving is very costly, and eliminates it completely when the savings interest rate is at -0.1 or 0.1. The price elasticity of insurance is slightly lower when credit is very cheap (20%), in which case the demand remains positive when λ=3. Finally, we observe that the optimal insurance coverage varies between about 50 and 115%.

For comparison, table 2 presents the optimal choices in the absence of present bias. Without detailing all cases, we observe that agents borrow less, leading to higher utility levels. Interestingly, the demand for insurance appears to go down in some instances, because agents do not need to curb over-borrowing in face of the shock anymore.

Table 1: Summary of simulations of the baseline model with present bias, symmetric shock and different financial prices ($\beta = 0.7, \delta = 0.96, \rho = 3, \epsilon = 1, \pi = 0.5$)

#	r	R	λ	i_0	b_0	s_0	b_1^+	s_1^+	b_1^-	s_1^-	$U_{\beta\delta}$	$\Delta_{\beta\delta}$†	U_δ	Δ_δ†
1.	-0.5	10	0.2	0	0	0.0585	0	0.0528	0	0	-1.5553	0	-1.9801	0
2.	-0.1	10	0.2	0	0	0.1210	0	0.2066	0	0	-1.4616	6	-1.8107	8.6
3.	0.1	10	0.2	0	0	0.1326	0	0.2435	0	0	-1.4143	9.1	-1.7357	12.3
4.	-0.5	5	0.2	0	0	0.0532	0	0.0513	0.0213	0	-1.5599	-0.3	-1.9894	-0.5
5.	-0.1	5	0.2	0	0	0.1300	0	0.2105	0.0024	0	-1.4634	5.9	-1.8075	8.7
6.	0.1	5	0.2	0	0	0.1326	0	0.2435	0	0	-1.4143	9.1	-1.7357	12.3
7.	-0.5	2	0.2	0	0	0.0012	0	0.0362	0.0862	0	-1.5165	2.5	-1.9516	1.4
8.	-0.1	2	0.2	0	0	0.1007	0	0.1977	0.0595	0	-1.4575	6.3	-1.8172	8.2
9.	0.1	2	0.2	0	0	0.1225	0	0.2385	0.0465	0	-1.4165	8.9	-1.7453	11.9
10.	-0.5	0.5	0.2	0	0	0	0	0.0358	0.1993	0	-1.4057	9.6	-1.7939	9.4
11.	-0.1	0.5	0.2	0	0	0.0330	0	0.1682	0.1874	0	-1.3857	10.9	-1.7505	11.6
12.	0.1	0.5	0.2	0	0	0.0666	0	0.2108	0.1699	0	-1.3653	12.2	-1.7045	13.9
13.	-0.5	0.3	0.2	0.4735	0.2347	0	0	0	0.1601	0	-1.3342	14.2	-1.6689	15.7
14.	-0.1	0.3	0.2	0.3242	0.1335	0	0	0.0698	0.1676	0	-1.3308	14.4	-1.6581	16.3
15.	0.1	0.3	0.2	0.2821	0.1049	0	0	0.1162	0.1697	0	-1.3241	14.9	-1.6467	16.8
16.	-0.5	0.2	0.2	0.5789	0.3276	0	0	0	0.1697	0	-1.3026	16.2	-1.6379	17.3
17.	-0.1	0.2	0.2	0.5789	0.3276	0	0	0	0.1697	0	-1.3026	16.2	-1.6379	17.3
18.	0.1	0.2	0.2	0.4631	0.2463	0	0	0.0444	0.1777	0	-1.3003	16.4	-1.6291	17.7
19.	-0.5	0.3	0.3	0.2872	0.1295	0	0	0	0.1810	0	-1.3569	12.8	-1.6974	14.3
20.	-0.1	0.3	0.3	0	0	0.0123	0	0.1592	0.2267	0	-1.3607	12.5	-1.7243	12.9
21.	0.1	0.3	0.3	0	0	0.0492	0	0.2022	0.2085	0	-1.3453	13.5	-1.6848	14.9
22.	-0.5	0.2	0.3	0.4436	0.2596	0	0	0	0.1932	0	-1.3302	14.5	-1.6732	15.5
23.	-0.1	0.2	0.3	0.3002	0.1547	0	0	0.0639	0.2008	0	-1.3273	14.7	-1.6634	16.0
24.	0.1	0.2	0.3	0.2573	0.1233	0	0	0.1110	0.2031	0	-1.3207	15.1	-1.6523	16.6

† Indicate the percentage increase in utility with respect to the autarchic case.

Table 2: Summary of simulations of the baseline model with no present bias, symmetric shock and different financial prices ($\beta = 1, \delta = 0.96, \rho = 3, \epsilon = 1, \pi = 0.5$)

#	r	R	λ	i_0	b_0	s_0	b_1^+	s_1^+	b_1^-	s_1^-	U_δ	Δ_δ†
1.	-0.5	5	0.2	0	0	0.1187	0	0.1722	0	0	-1.9613	0
2.	-0.1	5	0.2	0	0	0.1685	0	0.3094	0	0	-1.7929	8.6
3.	0.1	5	0.2	0	0	0.1766	0	0.3424	0	0	-1.7187	12.4
4.	-0.5	2	0.2	0	0	0.0738	0	0.1585	0.0534	0	-1.9224	2.0
5.	-0.1	2	0.2	0	0	0.1576	0	0.3043	0.0196	0	-1.7894	8.8
6.	0.1	2	0.2	0	0	0.1750	0	0.3416	0.0033	0	-1.7186	12.4
7.	-0.5	0.5	0.2	0	0	0	0	0.1360	0.1656	0	-1.7806	9.2
8.	-0.1	0.5	0.2	0	0	0.0989	0	0.2772	0.1274	0	-1.7226	12.2
9.	0.1	0.5	0.2	0	0	0.127	0	0.3162	0.1056	0	-1.6773	14.5
10.	-0.5	0.3	0.2	0.4821	0.1819	0	0	0	0.083	0	-1.6473	16
11.	-0.1	0.3	0.2	0.2746	0.0422	0	0	0.2032	0.0947	0	-1.6312	16.8
12.	0.1	0.3	0.2	0.2398	0.0187	0	0	0.2373	0.0966	0	-1.62	17.4
13.	-0.5	0.2	0.2	0.5961	0.2763	0	0	0	0.0883	0	-1.6169	17.6
14.	-0.1	0.2	0.2	0.4805	0.1959	0	0	0.1105	0.0973	0	-1.611	17.9
15.	0.1	0.2	0.2	0.4345	0.164	0	0	0.1544	0.1008	0	-1.6025	18.3
16.	-0.5	0.3	0.3	0	0	0	0	0.136	0.1943	0	-1.7413	11.2
17.	-0.1	0.3	0.3	0	0	0.0807	0	0.2688	0.1613	0	-1.6966	13.5
18.	0.1	0.3	0.3	0	0	0.1119	0	0.3082	0.1385	0	-1.6577	15.5
19.	-0.5	0.2	0.3	0.4535	0.2048	0	0	0	0.1148	0	-1.6514	15.8
20.	-0.1	0.2	0.3	0.2546	0.0604	0	0	0.1941	0.1267	0	-1.6363	16.6
21.	0.1	0.2	0.3	0.2187	0.0343	0	0	0.2292	0.1289	0	-1.6254	17.1

† Indicate the percentage increase in utility with respect to the autarchic case.

Table 3 presents the results of the simulation when agents have present bias and face an asymmetric shock in period 1, with a 20% probability to lose half of their income (and a 80% probability to get an extra income of 0.125). Utility gains derived from the availability of the three financial instruments are lower when income is less risky. Yet, we observe a positive demand for insurance more often when the shock is asymmetric, though optimal coverage is lower than in the symmetric case. This is because insurance is relatively more effective than savings to smooth income if shocks are asymmetric and with low probability. Demand for insurance is also much less price sensitive in this case, and remains positive at larger loading factors. We again find that sophisticated present-biased individuals tend to take up insurance more often than standard exponential discounters (not shown here).

Table 3: Summary of simulations of the baseline model with present bias, asymmetric shock and different financial prices ($\beta = 0.7, \delta = 0.96, \rho = 3, \epsilon = 0.625, \pi = 0.8$)

#	r	R	λ	i_0	b_0	s_0	b_1^+	s_1^+	b_1^-	s_1^-	$U_{\beta\delta}$	$\Delta_{\beta\delta}$†	U_δ	Δ_δ†
1.	-0.5	10	0.2	0	0	0	0	0	0.002	0	-1.3045	*0*	-1.6494	*0*
2.	-0.1	10	0.2	0	0	0.0357	0	0	0	0	-1.2983	*0.5*	-1.6243	*1.5*
3.	0.1	10	0.2	0	0	0.0678	0	0.0422	0	0	-1.2798	*1.9*	-1.5816	*4.1*
4.	-0.5	5	0.2	0	0	0	0	0	0.0269	0	-1.3042	*0*	-1.6489	*0*
5.	-0.1	5	0.2	0	0	0.0329	0	0	0.0207	0	-1.3003	*0.3*	-1.6284	*1.3*
6.	0.1	5	0.2	0	0	0.0705	0	0.0436	0.0106	0	-1.2817	*1.7*	-1.5829	*4*
7.	-0.5	2	0.2	0	0	0	0	0	0.0864	0	-1.2834	*1.6*	-1.6192	*1.8*
8.	-0.1	2	0.2	0	0	0.0026	0	0	0.0857	0	-1.2834	*1.6*	-1.618	*1.9*
9.	0.1	2	0.2	0	0	0.0477	0	0.0322	0.0709	0	-1.274	*2.3*	-1.5837	*4*
10.	-0.5	0.5	0.2	0.3181	0.0494	0	0	0	0.1015	0	-1.2133	*7*	-1.5069	*8.6*
11.	-0.1	0.5	0.2	0.3181	0.0494	0	0	0	0.1015	0	-1.2133	*7*	-1.5069	*8.6*
12.	0.1	0.5	0.2	0.3181	0.0494	0	0	0	0.1015	0	-1.2133	*7*	-1.5069	*8.6*
13.	-0.5	0.2	0.2	0.352	0.0969	0	0.0287	0	0.1479	0	-1.1958	*8.3*	-1.4992	*9.1*
14.	-0.1	0.2	0.2	0.352	0.0969	0	0.0287	0	0.1479	0	-1.1958	*8.3*	-1.4992	*9.1*
15.	0.1	0.2	0.2	0.352	0.0969	0	0.0287	0	0.1479	0	-1.1958	*8.3*	-1.4992	*9.1*
16.	-0.5	0.5	0.3	0.2634	0.0395	0	0	0	0.1175	0	-1.2196	*6.5*	-1.515	*8.1*
17.	-0.1	0.5	0.3	0.2634	0.0395	0	0	0	0.1175	0	-1.2196	*6.5*	-1.515	*8.1*
18.	0.1	0.5	0.3	0.2634	0.0395	0	0	0	0.1175	0	-1.2196	*6.5*	-1.515	*8.1*
19.	-0.5	0.2	0.3	0.2907	0.0846	0	0.0222	0	0.1682	0	-1.202	*7.9*	-1.5066	*8.6*
20.	-0.1	0.2	0.3	0.2907	0.0846	0	0.0222	0	0.1682	0	-1.202	*7.9*	-1.5066	*8.6*
21.	0.1	0.2	0.3	0.2907	0.0846	0	0.0222	0	0.1682	0	-1.202	*7.9*	-1.5066	*8.6*
22.	-0.5	0.5	0.4	0.2114	0.0287	0	0	0	0.1318	0	-1.2248	*6.1*	-1.5217	*7.7*
23.	-0.1	0.5	0.4	0.2114	0.0287	0	0	0	0.1318	0	-1.2248	*6.1*	-1.5217	*7.7*
24.	0.1	0.5	0.4	0.2114	0.0287	0	0	0	0.1318	0	-1.2248	*6.1*	-1.5217	*7.7*

† Indicate the percentage increase in utility with respect to the autarchic case.

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