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In this paper, we examine the old-age security hypothesis according to which parents rear children because they expect the latter to care for them in their later years. In developing countries where there are no perfect capital markets, children are usually viewed as a potential source of income and as a time-related support in old age. However, investing in children remains risky. By focusing on uncertainty about the parental consumption during old age, we show that there exists a precautionary motive for the demand for children so that fertility of prudent parents is expected to increase.

1. Introduction

In an economic environment such as poor developing countries where capital markets are next to non-existent, two main strands of reproductive motivations are usually used to analyse population growth (Dasgupta, 1993). In the first one, children are viewed as durable consumer goods in the sense that they are desirable in themselves and carry on the family lineage. In the second one, children are considered as insurance goods in which case the reproductive motivation stems from the old-age security that children can provide. Previously explored by Leibenstein (1957), the old-age security hypothesis postulates that in a setting where parents face uncertainty about their ability to support themselves during old age, they rear children in the expectation of receiving assistance from their children in their later years (Neher, 1971; Willis, 1980; Nerlove *et al.* 1987). The underlying transfer mechanism is one of direct reciprocity, where parents give first and children give later, without any intergenerational conflict: children are implicitly considered as passive agents under the control of parents, who honour the contract loan by reimbursing their parents during their old-age.[1]

The old-age security hypothesis has been strongly supported by various empirical studies in rural areas of developing countries, either in Africa or in Asia (Nugent, 1985). For example, in Malaysia, Raut (1996) shows that parents have longer birth

[1] As shown by Cremer and Pestieau (1991), the demand for children is strongly affected by the type of child-parent interaction. For example, the strategic bequest solution induces the number of children to be as large as possible to extract a greater amount of old-age support.

intervals when they have a sufficient stock of wealth to support themselves during old-age. Likewise, he shows that the probability that respondents will rely on their children when they are old is lower for couples with high income, with better access to private pensions and other financial assets. Jensen (1990) finds evidence in favour of the lexicographic safety-first model developed by Cain (1981), according to which there exists a minimal number of children for hedging against future disability risks when fertility decisions arise from old-age security. More surprisingly, one observes that child benefits also have a positive and significant effect on fertility rate in developed countries (Ermisch, 1988; Barmby and Cigno, 1990). Using time series-data covering the post-war years, Cigno and Rosati (1992, 1996) show that both in Europe and in the United States, saving and fertility would be jointly determined by self-interested parents. All of these results are fully consistent with the old-age security hypothesis (see also Rendall and Bahchieva, 1998).

An important issue for policy implications concerns the role of financial capital markets in influencing demand for children in developing countries. When parents consider children as assets, the development of social security schemes or an increase in the rate of returns of financial assets are expected to lower fertility, thus partly explaining the demographic transition (Willis, 1982; Cigno, 1992). The usual argument to explain this effect relies on an assumption of imperfect capital markets.[2] The idea that social security may act as a substitute for children is empirically supported. In particular, Nugent and Gillaspy (1983) find a significant decrease in fertility rate over time in a rural area of Mexico when farmers are given access to a social security coverage and Entwisle and Winegarden (1984) show that the demand for children is negatively related to the level of public pension programs. However, it has been suggested that incentives to having children are not necessarily reduced with the development of financial credit markets (Nerlove *et al.*, 1987; Razin and Sadka, 1995). On the one hand, capital markets represent a substitute form of investment for old-age support. On the other hand, capital markets allow a greater amount of borrowing against future high returns in order to finance the current costs of children in terms of education. In this framework, a crucial but neglected issue concerns the level of risk associated to each form of investment for old-age support, either buying financial assets or investing in children.

The idea that children and financial markets are competing assets for support in old-age has been extensively discussed by Cigno (1991; 1993) in a three-period overlapping generations model without altruism and also by Bergstrom (1996) in the context of the demonstration effect theory of transfers, in which adults take care of their parents in order to elicit symmetric future behaviour from their children. In this setting, the demand for children is exogenous and adults who exhibit a high

[2] Nevertheless, as shown by Wildasin (1990), the capital market imperfections are not necessary for this result provided that the social security program is underfunded.

degree of risk aversion prefer to invest in less risky assets by saving in the financial market rather than relying on the familial network.[3] As one considers models of intergenerational redistribution with endogenous fertility, the demand for children for old-age support has been linked to the existence of the uncertainty related to expected transfers by Appelbaum and Katz (1991) and Rosati (1996). The family reacts to this uncertainty by spreading risk across children. By assuming that children are not necessarily able to repay the support they received earlier in their life course, Rosati (1996) shows that in a non-altruistic setting, a reduction of uncertainty exerts an ambiguous effect on the number of children; when parents are sufficiently risk adverse, social security is expected to decrease fertility.

The purpose of our paper is to explore the consequences of uncertainty about parental old-age consumption on the demand for children when financial capital markets do not exist. Using a dynamic model where parents consider children as assets, we show that the fertility rate is strongly affected in an uncertain environment. Our concerns are close to the ideas developed in Appelbaum and Katz (1991) and Rosati (1996). Indeed, these studies have shown that a change in the variance of the random shock does influence the fertility decisions. However, the purpose of our contribution is not to study the factors determining the magnitude of the effects of risk, but to examine how parents are expected to respond to the risk by making adjustments that help to reduce the expected cost of the risk. Thus, we prove that changes in fertility behaviour are not explained by the concept of risk aversion, but that they are related to the measure of parental prudence (Kimball, 1990, 1992).[4] To the best of our knowledge, there are no previous studies dealing with the role of prudence in models of fertility decisions. Our main result is that the more prudent are parents, the stronger the precautionary motive for having children.

The remainder of the paper is organized as follows. In Section 2, we present a two-period model for old-age support, which allows us to derive the demand for children under certainty. In Section 3, we make the assumption that parental consumption in old age is a random variable and we derive the necessary condition for an interior maximum. In Section 4, we compare the two levels of fertility and we provide formal proof that the demand for children under uncertainty depends on the prudence of parents. Concluding remarks are found in Section 5.

[3] In order to secure for old-age support, parents may either save in the financial market with a sure return of saving or engage in risky demonstration-effect transfers whose rate of return depends on the probability to be imitated by children in the future (Jellal and Wolff, 2000). The level of upstream transfers made by adults is an increasing function of the rate of return of the demonstration effect.

[4] Both in Appelbaum and Katz (1991) and Rosati (1996), any demand for children is solely based on parental risk aversion. In our model, a change in the riskiness affects fertility behaviour when parents are prudent in the presence of risk. As detailed in Kimball (1990; 1992), the decision of how to avoid a risk is governed by risk aversion, while prudence concerns the decision of how to prepare in the face of uncertainty.

2. A model of old-age support

For the presentation, we consider a household composed of parents and children that maximizes utility over two periods, subject to budget constraints operating in each period. In the model, ties between family members do not result from altruistic feelings and transfers are part of an intertemporal exchange between the generations.[5] Concerning fertility decisions, we assume that parents are able to control their own fertility without any cost, as family planning programs are promoted by governments in many developing countries. The timing of the model is as follow: parents first choose the number of children and they invest in their children's human capital a fixed amount of resources; then they are paid back, through money and services, during their later years, so that intergenerational transfers between family members are like a portfolio-choice operation.

We consider the case where there is no financial capital market, as it may be found in rural areas of developing countries. Indeed, our study deals with the consequences of the existence of uncertainty on the demand for children and not with the effects of a social security program on fertility (see Rosati, 1996). Therefore, children are the only means of consumption smoothing. In fact, this hypothesis of imperfect capital markets is not as restrictive as it may seen and the model could be easily extended to the case of developed countries. An alternative interpretation concerns the form of the reimbursement made by children for old-age support. One can imagine that parents expect services and attention from their children that have no close market substitutes, rather than cash gifts.[6] In this setting, parents would be compelled to invest in their progeny if they wanted to receive attention and affection in return in old age (Ehrlich and Lui, 1991).

Following Nerlove *et al.* (1987), we make the assumption that parents are purely selfish, in the sense that they derive satisfaction from their own lifetime income stream only. Hence, parents seek to maximize the utility function $U(C_1, C_2)$, where C_1 and C_2 are the levels of parental consumption respectively in the first and second period of their life. We suppose that U is a three-time continuously differentiable, quasi-concave utility function. Let U_i be the partial derivative of $U(C_1, C_2)$ with respect to the i argument in U, so that we have $U_1 > 0$, $U_2 > 0$, and $U_{11} < 0$, $U_{22} < 0$. Besides, for the second-order condition, we suppose that the condition $U_{11}U_{22} - U_{12}^2 > 0$ is satisfied.

In the first period, parents earn an exogenous income Y_1. Let h be the fixed amount of child-rearing costs, which includes both the monetary cost of schooling and the basic subsistence costs such as expenditures on food and medicine. The number of children chosen by parents is denoted by n, so that an amount of

[5] By focusing on the recent economic explanations of changes in fertility behaviour, Cigno (1992) points out the main role of incentives connected with motives for private transfer income within the family.

[6] There exist two main types of child services: participation in home-production; and care-giving activities, contact, and visits. While parents can do without material transfers from the children by saving in the presence of a perfect capital market, there is no market alternative to contact and affection.

financial resources hn is devoted to investments in the young generation. In the second period, we suppose that parents also get a personal but smaller income Y_2, which is used to finance part of their old-age consumption. Even if this assumption is not necessary for the model, we think that in developing countries it is more realistic to consider that elderly parents still participate in agricultural production because of farm-specific experience. For example, one can consider that parents who were previously land-owning peasants may get personal resources by selling part of a self-produced agricultural crop or by leasing out some of their land.

Another possible source of income consists in upstream intergenerational transfers. Indeed, parents rely on the support of their n children, who have to reimburse the parental investments received during their schooling. For simplicity, we make the assumption that each child within the family provides the same amount of repayment for the loan made one period earlier. Let t be the fixed amount of transfer that each child pays back to his parents. A justification for this assumption is found in the existence of family rules yielding a Pareto-efficient consumption over the life cycle of each generation. In a three-generational framework, Cigno (1991, 1993) proves the existence of a self-enforcing family constitution where all family members are interested in going on with the amounts of transfers prescribed by the family rule.[7] The repayment of the debt depends on the total number of children and tn denotes the sum of the personal child contributions. Formally, the budget constraints for the parents in the two periods are

$$C_1 = Y_1 - hn \tag{1}$$

$$C_2 = Y_2 + tn \tag{2}$$

In this section, we are interested in the standard case where the second-period consumption of parents is known with certainty. Implicitly, the meaning of this assumption is that one expects each child to honour his commitments and to repay the parental loans. Why will children not default on the repayment? In Cigno (1993), the family constitution prescribes at each date the amounts of intergenerational transfers. If a child does not transfer money to his parents, his own children will be exempted from transferring upstream resources in the next period. The family constitution is self-fulfilling under certain conditions. In this mutuality model, all generations are interested in going on with the chain. The set of strategies such that any generations will comply with the family rules if and only if parents repaid their own debt is a Nash-equilibrium.[8]

[7] Rather than having fixed gifts, Rosati (1996) considers the case where the intra-family interest rate of loans is fixed by the family constitution.

[8] Other mechanisms relying on self-interested explanations may guarantee the effectiveness of such an intertemporal exchange (see Laferrère, 1999). According to Becker (1993), parents who are worried about old-age support attempt to inculcate in their children a feeling of culpability and guilt if the latter do not comply with the desired behaviour. Cox and Stark (1996) and Jellal and Wolff (2000) argue in favour of a demonstration effect, which induces parents to shape the children's preferences by setting an example. Parents care for their elders as they would like to be treated themselves later by their progeny.

Substituting the two budget constraints into $U(C_1, C_2)$, parents choose the number of children n to maximize

$$\max_n U(Y_1 - hn, Y_2 + tn) \tag{3}$$

We can now determine the optimal demand for children under certainty, denoted by $n^\star$. According to the first-order necessary condition for an interior maximum

$$-hU_1(C_1^\star, C_2^\star) + tU_2(C_1^\star, C_2^\star) = 0 \tag{4}$$

the marginal cost of raising children in terms of a decrease in first-period consumption and the marginal benefit from assistance receipt in old-age are equalized at the optimum. From (4), we get the usual arbitrage condition $U_1/U_2 = t/h$ for shifting consumption between the first and second periods.

3. Uncertainty about the old-age consumption

Following Rosati (1996), we now relax the prevalent assumption that the old-age level of consumption C_2 is known with certainty.[9] We consider the case where the second-period consumption is a random variable denoted by $\tilde{C}_2$ such that

$$\tilde{C}_2 = Y_2 + tn + \varepsilon \tag{5}$$

In this setting, we assume that the variable ε is an additive random term defined on the state space Ω and characterized by the distribution function $F(\varepsilon)$. We make the additional hypothesis that $E(\varepsilon) = 0$ and $V(\varepsilon) = \sigma^2 > 0$.

Given the old-age resource constraint $\tilde{C}_2 = Y_2 + tn + \varepsilon$, the introduction of uncertainty in our model may be interpreted in two different ways. On the one hand, one can consider that parents receive an uncertain income because of the presence of risk in an agrarian environment, for example owing to uncertainties in agricultural yields and the prices of inputs and outputs ($\tilde{Y}_2 = Y_2 + \varepsilon$). On the other hand, investing in children is a risky operation since children may be unable to repay their parents in old age and $\tilde{t}n = tn + \varepsilon$. The riskiness of familial loans is a central problem for agrarian communities where there exist a variety of individual-specific risks such as illness, infection or fire damage and agricultural risks with production failure and poor harvest. The risk of a repayment default from children has two possible explanations (see Rosati, 1996): it may arise either from the uncertainty of the survival probability of the children or from the uncertainty of their level of income when children are old enough to honour their debt. With low agricultural yields due to poor climatic conditions, adult children may not get enough resources to repay their debt. It seems useful to note that these two previous factors are also operating in developed countries. The probability that children reach adulthood remains necessarily lower than one and children are often subject to labour risk such as unemployment.

[9] Using a three-generational non-altruistic model of transfers, Rosati (1996) accounts for the existence of uncertainty relative to the survival of children from youth to middle-age.

Formally, given the existence of uncertainty about the second-period consumption, the maximization program for parents is now

$$\max_n \int_\Omega U(Y_1 - hn, Y_2 + tn + \varepsilon)\, \mathrm{d}F(\varepsilon) \tag{6}$$

The first-order necessary condition for an interior maximum is hence

$$\int_\Omega [-hU_1(\tilde{C}_1, \tilde{C}_2) + tU_2(\tilde{C}_1, \tilde{C}_2)]\, \mathrm{d}F(\varepsilon) = 0 \tag{7}$$

where the budget constraints $\tilde{C}_1 = Y_1 - h\tilde{n}$ and $\tilde{C}_2 = Y_2 + t\tilde{n} + \varepsilon$, and $\tilde{n}$ indicates the demand for children under uncertainty. In this framework, we wonder whether the randomness of the parental old-age consumption increases or decreases the optimal rate of fertility in developing countries.

4. The demand for children under uncertainty

To compare the optimal values for $n^\star$ and $\tilde{n}$, we define the following function $\Psi(\varepsilon)$ given the first-order condition (7)

$$\Psi(\varepsilon) = -hU_1(\tilde{C}_1, \tilde{C}_2) + tU_2(\tilde{C}_1, \tilde{C}_2)$$

Hence, we can write the demand for children under uncertainty in the following way

$$\int_\Omega \Psi(\varepsilon)|_{n=\tilde{n}}\, \mathrm{d}F(\varepsilon) = 0$$

so that a necessary and sufficient condition to examine the incidence of uncertainty on the fertility rate is to study the sign of the integral $\int_\Omega \Psi(\varepsilon)|_{n=n^*}\, \mathrm{d}F(\varepsilon)$. The main result of our paper is summarized in Proposition 1 below.

Proposition 1 The demand for children under uncertainty is such that

$$n^\star > (<)\tilde{n} \Leftrightarrow -hU_{122}(C_1^\star, C_2^\star) + tU_{222}(C_1^\star, C_2^\star) < (>)0$$

Proof From the definition of $\tilde{n}$ such that $\int_\Omega \Psi(\varepsilon)|_{n=\tilde{n}}\, \mathrm{d}F(\varepsilon) = 0$, we arrive at the result that $n^\star$ is greater (respectively lower) than $\tilde{n}$ if the term $\int_\Omega \Psi(\varepsilon)|_{n=n^*}\, \mathrm{d}F(\varepsilon)$ is negative (respectively positive). From the definition of Ψ, the demand for children $n^\star$ when there is no risk of non-repayment satisfies the condition

$$\Psi(E(\varepsilon)) = -hU_1(C_1^\star, C_2^\star) + tU_2(C_1^\star, C_2^\star)$$

Hence, from Jensen's inequality, we deduce that $n^\star > \tilde{n}$ if and only if the condition $\int_\Omega \Psi(\varepsilon)|_{n=n^*}\, \mathrm{d}F(\varepsilon) < \Psi(E(\varepsilon))$ is satisfied (the converse holds for $\tilde{n} > n^\star$), so that the comparison between the values of $n^\star$ and $\tilde{n}$ depends on the convexity of the function $\Psi(\varepsilon)$.

The demand for children under uncertainty is lower than $n^\star$ if $\Psi(\varepsilon)$ is a concave function of ε, a condition which is satisfied for $\Psi'(\varepsilon) = -hU_{12} + tU_{22} > 0$ and $\Psi''(\varepsilon) = -hU_{122} + tU_{222} < 0$. Conversely, the inequality $n^\star < \tilde{n}$ holds when $\Psi(\varepsilon)$ is a convex function of ε, which requires the condition $\Psi''(\varepsilon) > 0$. □

In this very simple framework, one can see that the concept of risk aversion remains insufficient to explain the changes in fertility behaviour induced by the uncertain old-age consumption. In rural areas of developing countries where a great deal of individual and environmental risks are found among agricultural communities, our theoretical results reveal the presence of a precautionary motive for having children, whose strength is measured through the concept of absolute prudence introduced by Kimball (1990) and expressed by $P(w) = -U'''(w)/U''(w)$ for any initial wealth w. As one considers that households are characterized by non-separable preferences $E[U(C_1, \tilde{C}_2)]$ with $U_i > 0$ and $U_{ii} < 0$, the measure of absolute prudence in the context of our problem is defined by

$$P(w) = \frac{-hU_{122} + tU_{222}}{hU_{12} - tU_{22}}$$

where the denominator $hU_{12} - tU_{22}$ is positive since the first-period consumption C_1 is a normal good (Drèze and Modigliani, 1972; Kimball, 1990). In our setting, the sign of the measure of absolute prudence is just given by the sign of the numerator $-hU_{122} + tU_{222}$, which brings the two following additional results.

Corollary 1 Given the uncertainty about old-age consumption, prudent households are expected to face an increase in fertility rate.

Indeed, we have shown that the inequality $\tilde{n} > n^\star$ holds if $-hU_{122} + tU_{222} > 0$. Provided that $\text{sgn}(-hU_{122} + tU_{222}) = \text{sgn}P$ and that a positive value of P corresponds to a prudent behaviour, Corollary 1 indicates that prudence gives rise to a precautionary motive for having children in an uncertain environment. This means that the prospect of the random old-age consumption will increase the demand for children relative to the situation where the level of income received by the young generation is high enough to repay the debt owed to parents.

Corollary 2 When preferences are separable, the comparison between $n^\star$ and $\tilde{n}$ depends on the sign of U_{222}.

Under the assumption of separability, we know that the utility function of parents is defined by $E[U(C_1, \tilde{C}_2)] = U(C_1) + E[U(\tilde{C}_2)]$, so that we get $-hU_{122} + tU_{222} = tU_{222}$ since $U_{12} = 0$. In that case, the measure of absolute prudence that gives the strength of the precautionary motive for having children is simply $P = -U_{222}/U_{22}$; as the second-order derivative U_{22} is negative, we get $\text{sgn}\, P = \text{sgn}\, U_{222}$.[10]

So, prudent parents are expected to hedge against an increased risk of consumption in old age by having more children. From an empirical perspective, it

[10] If we consider the case of an isoelastic utility function U, as usual in studies exploring consumption behaviour in connection with fertility choice, it is easy to see that the first-derivative U_2 is a strictly convex function and hence $U_{222} > 0$.

seems useful to identify variables that are likely to influence the prudence of the households. However, there are few empirical studies dealing with the impact of individual characteristics on the degree of prudence. For our purpose, we discuss selected empirical evidence on the precautionary saving motive. Several recent attempts test whether the precautionary motive is an important force in consumer behaviour, with conflicting results (for a survey, see Browning and Lusardi, 1996). Individual choices are quite heterogeneous.[11]

A main difficulty for the problem is to have an accurate measure of risk faced by households, which may be given by variability in income, consumption variability, or subjective expectations about future income. Empirical findings suggest that prudence is mainly linked to occupation, income, and age of the household. In Skinner (1988), income uncertainty is proxied by occupation, but there may exist a self-selection of less risk-averse people into riskier occupations. Nevertheless, using panel data, Carroll and Samwick (1997, 1998) and Kazarosian (1997) find greater prudence for both the self-employed and farmers.[12] Conversely, workers in the public sector are expected to have a lower precautionary motive. Households that currently experience unemployment should be more prudent, as they are more likely to be unemployed in the future. In that case, transmission of social status also increases the probability that children become unemployed, leading to a greater uncertainty for the parental consumption in old age. The effect of education on prudence is not clear, since educational attainment may be correlated with the household's time preference rate (Dynan, 1993).

Gourinchas and Parker (2001) show that a precautionary motive is more likely at low wealth levels, meaning that parental prudence is greater for households with poor income and low wealth. Besides, households with more than one income earner are expected to face less income risk; risk pooling is likely among multiple earners. The precautionary term is also especially important at young age. Age is undoubtedly correlated with uncertainty, but it is also an individual taste shifter, especially as one examines fertility decisions. In fact, these joint factors should be associated to a greater prudence. Labour-income uncertainty is more important for young households, who are characterized by a low level of wealth. Finally, people with poor health are expected to be more prudent, since they have more uncertain health expenditures (especially in old age).[13]

[11] Studying the role of a precautionary motive requires the identification of some observable and exogenous source of risk that varies across the population.

[12] Since farmers are generally born into the profession rather than having chosen it, the self-selection argument is unlikely to apply (Kazarosian, 1997).

[13] Recent empirical studies have shown that the precautionary motive has some role to play in explaining saving behaviour. However, an underlying assumption is that family size is exogenous. Since having children is a form of investment, then the decision to have children affects the precautionary saving. The effect of greater uncertainty should be examined by accounting for both saving and fertility choices.

5. Concluding comments

In this paper, we have analysed the effect of uncertainty on fertility in a setting where family support is the only way of transferring resources between the generations. In many countries, numerous explanations make it necessary to account for uncertainty on the parental consumption in old age. In particular, children may be unable to repay their debt because mortality prevents them from reaching their productive period or because they do not succeed in acquiring a sufficient level of income. This randomness of the level of resources in old-age is obviously greater in developing countries within an agrarian environment, but the risk of default also exists in developed countries since parents have to rely on the support of their children if they are interested in receiving attention and affection that have no close market substitutes.

Hence, our paper highlights an aspect of the old-age security hypothesis that has been extensively discussed in the subsequent literature related to intergenerational transfers, namely that parents are not necessarily able to enforce children to give them some transfer when the latter are in their productive period; curiously, this problem has received little theoretical attention. Using a two-period model, the most important finding of our paper is that there may exist a precautionary motive for having children under uncertainty. The derivation of the conditions under which this result holds reveals that the fertility rate of prudent parents is expected to increase. Thus, the high levels of fertility that one still observes in agrarian communities may be interpreted as the response that prudent parents give rise to the risk that only some of their children would provide them resources in old-age. For example, from a longitudinal viewpoint, the study of Boongaarts and Cain (1981) exhibits a substantial replacement rate through increased fertility following the Bangladesh famine of 1974 (see also Cain, 1983).

A final comment deals with the policy issues raised by our model. When parents make child investments in exchange for the care they expect their children to provide for them in old age, an appropriate policy to reduce high fertility levels is to provide parents some alternatives to their own children as the only source of old-age support. The introduction of state insurance schemes for upstream transfers and health care lessens the incentives to perform these functions within the family. However, in spite of the effectiveness of public programs on women's schooling, child health, and family planning methods, these forms of social welfare legislation are often not a realistic option to decrease the demand for children in low-income developing countries because of their excessive costs compared to the available public funds. According to our theoretical results, a policy designed to decrease the level of environmental risk among agrarian communities may also be an effective way to reduce fertility. Public resources devoted to the pooling of agricultural risks, for example by improving food transportation and food exchanges across different regions, should contribute significantly to the decline in fertility in developing countries by lessening the precautionary motive for having children.

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