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# Principal-agent Problems in the Purchase of Durables: Evidence from Motorcycles in Nepal

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## Abstract

We investigate the existence of a principal-agent problem between parents and financially dependent adult children within households on the purchase of a durable (such as a vehicle). We theoretically argue that children will select more expensive durables if parents contribute more towards its purchase, however this effect is weaker for altruistic children. We test this empirically using unique data collected on motorcycle purchases of university students in Kathmandu Valley, Nepal. We confirm the first hypothesis, however we show that altruism does not influence this relationship. Policy implications relate to the effects on household finances, and on possible environmental impacts.

**JEL Classification:** D1, D8; Q4; Q5

**Keywords:** Principal-agent problems; Intra-household decision-making; Durable adoption; Motorcycle; Nepal

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# 1 Introduction

Households can be considered to be pivotal economic entities, who often need to make significant economic and financial decisions. In traditional economic models, the household is assumed to act as one decision-making unit (Becker, 1974, 1991), and household decision-makers take decisions on behalf of all household members. However, households are composed of several members having different tastes and preferences, as well as varying financial means. For example, non-adult children (and sometimes, even adult children) in a family may not have their own financial resources, but they usually have tastes and preferences that define which goods they would like to buy. Therefore, they need to discuss with their parents, especially before purchasing relatively expensive durable goods (such as modes of private transport like cars or motorcycles), and may need their approval, in particular if their parents agree to contribute to its purchase. In general, the theoretical and empirical literature suggests that intra-family decision-making can be more complicated than the decision of a single household member, if this interplay is accounted for (Bertocchi et al., 2014). As an alternative to the one decision-making unit model, scholars have proposed so-called "collective" approaches to household behavior (Chiappori, 1988). In these models, household decisions result from a Pareto-efficient bargaining process, with each member maximizing their utility based on their own preferences.

In the intra-family decision-making process, children can have direct influence on the choice of goods that they will also use. For instance, Deaton and Paxson (1998) suggested that children's age, gender, and socioeconomic status can influence family spending patterns; Martensen and Grønholdt (2008) showed that children can influence a family's choice of drinks, cereal, and clothes. Dauphin et al. (2011) also argued that children aged between 16 to 21 can be decision-makers within the family decision process. Children can also sway the household decision-making process regarding the purchase of expensive durable goods which are used by all or some of the household members, such as electronics, and vehicles. In many urban areas of developing countries, this decision involves the purchase of motorcycles, for example (in Nepal, for example, motorcycles comprise about 80% of the total vehicle fleet).

In many countries, households with children of driving age are faced with deciding whether to buy vehicles for their child of driving age. This is a pivotal decision for the household as, in many cases, the child still does not have enough means to be able to buy the vehicle independently. It is, therefore, a decision that is usually taken considering the child's preferences and accounting for the family budget. Typically the child plays a critical role in this decision-making process by selecting and proposing motorcycle models that he/she likes to the parents, and then the parents decide whether to pay for the purchase of the vehicle, and if yes, how much to contribute. In the context of motorcycle purchases, more expensive vehicles tend to be relatively more powerful and technically superior, and may thus be more appealing to children.

Buying a vehicle, such as a motorcycle, for a child can be conceived of as a typical principal-agent type situation, wherein the child is the agent and the parents act as the principal. In this situation, as in all other principal-agent situations, one party (the principal) delegates to another party (the agent) to act on its behalf. In the context of buying motorcycles, the child chooses the model he/she wants to buy, and the parents, who usually don't have complete information on vehicle attributes (such as engine power, price, and quality) pay for its purchase cost, or at least a part of it. For example, in the empirical part of this study, we show that in

most cases, the decision regarding the purchase of a motorcycle is left to the children. This large autonomy in the decision-making creates the potential for a principal-agent problem, which can engender inefficiencies in the choice of motorcycles.

For instance, the child may provide only partial, or even incorrect, information to his/her parents so as to get them to buy fancy and more expensive models and not relatively cheaper (and likely, more fuel-efficient) motorcycles. To overcome such information-based problems that may result in the choice of expensive, unaffordable, or even inefficient vehicles, parents could ask their child to contribute towards paying the cost of the motorcycle. Furthermore, we can expect that the child's general level of altruistic behavior could mitigate the extent of the principal-agent problem. Children who are altruistic, i.e. perform actions that are motivated by a concern for the well-being of others, may in turn consider the financial burden on their parents and, therefore buy less expensive motorcycles.

In developing countries, this type of principal-agent problem can have negative economic and welfare effects on households. For example, to buy an average-sized and relatively affordable motorcycle, a representative Nepali household living in the Kathmandu Valley may need to spend up to two-three times their average monthly income, whereas in industrialized countries, vehicles such as motorcycles cost a fraction of average household monthly income.

The principal-agent relationship framework has already been applied to studying family relationships, particularly between parents and children. In the literature, studies have used non-cooperative models to analyze parent-child interactions while deriving conditions for the optimal behavior of the child ([Burton et al. \(2002\)](#) and [Lundberg et al. \(2009\)](#)). In these papers, given limited resources and information and the demand for autonomy from the child, the parents need to decide the optimal level of behavioral control, and this is modeled in a principal-agent framework.

In this paper, we first sketch a theoretical model based on the principal-agent framework, where parents control the total spending on motorcycle by the child by deciding in advance to only pay a fraction of purchase cost of the motorcycle that the child decides to buy. Our theoretical model also allows us to understand the decision-making of children potentially exhibiting different degrees of altruism towards parents; in particular, we can distinguish two types of children: those who care about the impact of their decisions on their parents'/household's financial health (altruistic behavior), and those who don't. Thus, we derive conditions in the model that help us answer two research questions. First, how does the parent's share of motorcycle costs influence the purchase decision of children, i.e., is there a principle-agent problem? Secondly, how does this relationship vary for altruistic children?

In our empirical application, we utilize novel survey data collected from 1937 college-going students in Kathmandu Valley, Nepal in which we asked students about the motorcycles they already owned, along with several questions on decision-making within the household. These students were either partially or fully dependent on their parents to finance their motorcycle purchases. We use the price of the motorcycle purchased as the dependent variable. The price of the motorcycle can be thought of as representing its value to the children in terms of its visible attributes such as design, appearance, and other technical specifications. Importantly, expensive motorcycles also tend to have powerful engines, and normally consume more energy, and are therefore also likely to be less fuel-efficient, which has policy implications.

We empirically investigate the presence of a principal-agent problem: specifically, we first assess

whether children chose to buy relatively more expensive motorcycles, if their parents paid for a larger share of the purchase costs. Related to this, we then also evaluate the effect of the level of altruism of the child on the relationship between the share of costs paid, and the price of the motorcycle purchased. Secondly, we examine whether parents paying anything towards the purchase cost also has an effect on the price of the motorcycles. Lastly, we analyse the impact of the level of autonomy children had in the decision-making on the price of the motorcycle purchased.

We use two econometric approaches: the ordinary least squares, as well as the instrumental variable two-stage least squares methodology. To account for possible endogeneity of our explanatory variables, in the latter approach we instrument our main explanatory variables (the principal-agent measures) by the product of the birth order of the student's mother and father within their respectively family. Birth order has been shown to be an important determinant of a person's personality (Black et al., 2018; Rohrer et al., 2015), human capital development and educational attainment (De Haan et al., 2014; Silles, 2010), nutritional status (Horton, 1988), as well as behavioral development (Silles, 2010). Importantly, birth order has been found to have an effect on personality traits such as leadership ability, openness, emotional stability as well as conscientiousness which may all play a role in determining the ability of parents to bargain with their children (Black et al., 2018). Our identifying assumption is that the birth orders of the parents are likely to influence decisions relating to the price of the motorcycle purchased by the child, only through its effect on the contribution made by the parents towards the purchase of the motorcycle.

Our findings suggest the existence of principal-agent problems in the parent-child relationship with respect to the purchase of motorcycles. In particular, we find that an increase in parents' share of the purchase cost of the motorcycle is associated with the increase in their prices of the motorcycles eventually opted for by the students. This finding is also confirmed by considering the decision of the parents to contribute anything towards the purchase cost of the motorcycle, and by the autonomy/bargaining power of the students in the buying decision. In other words, relatively more expensive motorcycles are bought when a significant portion of the cost of motorcycle is borne by the parents, when students have the upper hand in the bargaining process, and in fact as long as the parents contribute something towards paying for its purchase. The presence of a principal-agent problem may be explained, as suggested by (Lundberg et al., 2009), by the inability of parents to monitor and exert influence on the purchase decision. This result also suggests that in low-income countries, such as Nepal where durable purchases may constitute a relatively large share of monthly household income, the presence of a principal-agent problem could exacerbate household finances (and may also have negative environmental implications, as previously discussed).

To the best of our knowledge, the paper's main contribution is to provide the first theoretical and empirical analysis of the presence of a principal-agent problem in an intra-household decision-making process related to the adoption of durable goods. Moreover, this paper makes an intriguing contribution by carrying out an empirical analysis using data from developing countries. This is crucial because in such countries, households' economic and financial struggles can be exacerbated by such principal-agent problems.

Thus, this study has important policy implications, both on household financial conditions, as well as on societal welfare (given that more expensive motorcycles tend to be less efficient). This may be particularly relevant in developing countries such as Nepal, where many households

face liquidity constraints, and thus durable purchase is likely to be an pivotal investment decision. Furthermore, urban areas of developing countries are often plagued by problems of air pollution, which has health as well as environmental consequences. Thus, the impact of family decision-making on motorcycle choice has spillovers on society.

This study is organized as follows. Section 2 presents the theoretical model. Section 3 presents the data and empirical strategy used in the study. Section 4 reports and discusses the main results. Section 5 concludes the paper.

## 2 Theoretical Model

This section describes a simple theoretical model that explains the intra-household decision process related to purchasing a durable item, such as a motorcycle, used by a child.

As previously discussed, we are assuming the existence of a principal-agent problem. In this scenario, a child wants to buy a motorcycle using money provided by parents who may not be well-informed about the types and prices of motorcycles in the market (or may not be able or willing to make the buying decision for the child). This possible information gap allows the child to take advantage of the situation and purchase an expensive motorcycle. To address this principal-agent problem, the parents consider a cost-sharing approach, where the child contributes their own money towards the cost of the new motorcycle. The basic hypothesis is that children who do not share the cost of buying motorcycles will have weaker incentives to buy relatively cheaper motorcycles.

The theoretical model proposed in this paper assumes a specific interaction or game of complete information between parents and their children. Initially, the parents decide and declare the fraction of the motorcycle price that they will cover, and then the child decides the motorcycle to be purchased. We also allow for altruistic behavior of the children towards parents. Intuitively, children with a low level of altruism are less likely to account for the effect of their buying decisions on household finances.

In this simple model, a non-cooperative game is played between child and the parents. This situation fundamentally differs from the game between couples where the couples are in symmetric positions with respect to each other. In contrast, the game between the parents and child is not symmetric. To model this, we make two digressions (from the models proposed by [McElroy and Horney \(1981\)](#) and [Chiappori \(1988\)](#)). First, although both the child and parents maximize utility subject to a budget constraint, their utilities are a function of different consumption goods and consequently their decision variables are different as well. Secondly, instead of assuming simultaneous move game we model the situation as dynamic game where parents decide first and then the child moves.

From the theoretical model, we derive an expression that postulates the impact of a change in the cost-sharing level on the price of the chosen motorcycle for children having different degrees of altruism, namely those who are altruistic concerning their parents, and those who are not. The optimization results suggest that larger the parents' contribution towards the purchase costs, higher is the price of a motorcycle chosen by a child, but that altruistic children choose motorcycles with lower prices than children who are not altruistic, i.e., the presence of altruistic children weakens this relationship.

Before we proceed to the formal presentation of the model, the following caveats are important to mention. We assume that parents do not pay for the full purchase cost of the motorcycle, if the child does not display any altruism. This is because a non-altruistic child will then spend an "infinite" amount on the motorcycle. Thus, it will be optimal for parents to put a cap on the amount that can be spent on the motorcycle, and the child will always reach this cap. This is equivalent to parents directly deciding how much to spend on the motorcycle, rendering the situation that we want to model irrelevant.

The situation will be slightly different in case of an altruistic child. In this case, the child will not spend an infinite amount on motorcycle because the marginal utility from increasing parent's consumption is non-zero (due to altruism), and the child's marginal utility from own consumption will be declining. If the child is altruistic enough that he/she decides to spend less than the amount that parents want to spend, then that amount will denote the child's expenditure on the motorcycle. If however, the child wants to spend more than the amount that parents want to spend, then again parents will impose an upper cap on the amount spent by parents, and the child's decision becomes irrelevant again. These two examples suggest that altruism of the child also plays a role in this situation. Consequently, we include altruism as a determinant of the purchase price of the motorcycle in both our theoretical and empirical model as well.

The following section gives the formal presentation of the model. We start with the child's problem of choosing the motorcycle, given that parents have already announced what portion of the motorcycle price they are going to pay. The section after that looks at the parent's problem of deciding what share of the motorcycle cost to pay, i.e., the game is solved by backward induction.

## 2.1 Child's Problem

The utility of the child depends on the spending on other goods and on the motorcycle. The level of financial restriction depends on the income/pocket money of the child, and on the share of the price of the motorcycle covered by the parents. The optimization problem of the child can be described as follows:

$$\begin{aligned} \max_{B,g} U(B, g) + V(x) \\ s.t. B + g = M + \delta B \end{aligned} \tag{1}$$

where  $B$  is spending on the motorcycle,  $g$  is the spending on other goods by child and  $x$  denotes parents' consumption. Thus,  $V$  is the function that captures the child's altruism towards the consumption of the parents.  $M$  is the pocket money/income of the child and  $\delta$  is the share of the motorcycle price paid by the parents. We make standard assumptions on  $U$  and  $V$  that they are increasing at decreasing rate in all their arguments. This ensures that constrained optimization leads to maximization of utility.

Let the disposable income of the parents be given by  $W$ . The above problem can be reformulated as follows:

$$\begin{aligned} \max_{B,g} U(B, g) + V(W - \delta B) \\ \text{s.t. } (1 - \delta)B + g = M \end{aligned} \quad (2)$$

Where  $W - \delta B$  is the remaining income of the parents after paying for the motorcycle. We are interested in the equilibrium value of  $B$ . The equilibrium condition is given as follows.

$$\frac{U'_B - V'\delta}{U'_g} = (1 - \delta) \quad (3)$$

The condition is similar to the utility maximization condition, except that there is a negative term  $V'\delta$  in the numerator. This term indicates an adjustment in marginal utility due to altruism towards parental consumption. In other words, the marginal happiness from buying an expensive motorcycle is dampened by the 'sadness' due to a reduction in parent's consumption.

Solving the above equation along with the constraint will give the value of  $B$  as a function of  $\delta, M, V'$ , i.e.  $B^C = B(\delta, M, V')$  We can find  $\frac{\partial B}{\partial \delta}$  given as follows -

$$\frac{\partial B}{\partial \delta} = \frac{1}{|A|} [U_g + B(U''_{Bg} - U''_{gg}(1 - \delta)) - V' + V''\delta^2 B] \quad (4)$$

Here  $-|A| = (U''_{BB} + V''\delta^2) - 2U''_{Bg}(1 - \delta) + U''_{gg}(1 - \delta)^2$  is the negative of the determinant of the bordered hessian matrix. The sufficiency of maxima ensures that  $|A|$  is positive.<sup>1</sup> The expression in the numerator is positive except for  $[-V' + V''\delta^2 B]$ . Thus, if the altruism factor is sufficiently small, then there is positive relation between  $\delta$  and  $B$ . The altruism factor just weakens this positive relation. Thus, increase in spending on motorcycle response to increase in parent's share is smaller for altruistic child than non-altruistic child.

$$\frac{\partial B_{non-altru}}{\partial \delta} > \frac{\partial B_{altru}}{\partial \delta} \quad (5)$$

Also, since altruism enters in the partial derivative of the motorcycle price with respect to the parent's share, this means that in the empirical analysis, we will introduce an interaction term to capture this impact on the price of motorcycle purchased.

As an example to make the intuition clearer, we consider a simple case where the child's personal utility function is Cobb-Douglas of the form  $U(B, g) = Bg$ . In this case,  $B$  is given as follows.

$$B = \frac{M - V'\delta}{2(1 - \delta)} \quad (6)$$

Here  $\delta$  enters both in numerator and in denominator with the same sign thus have two opposing impacts on the price of motorcycle purchased. First, consider  $\delta$  in the denominator; an increase

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<sup>1</sup>In the Appendix we present the derivation of this expression

in  $\delta$  would make the denominator small and thus tend to increase  $B$ . This effect pushes  $B$  up, because paying higher shares means a smaller burden on the child, and thus they tend to buy relatively more expensive motorcycles.  $\delta$  in the numerator has the opposite impact, as it reduces the numerator by a factor of  $V'$ , and thus  $B$  decreases. This is because an increase in  $\delta$  increases payment by parent,s and reduces the resources available to them. This leads to a decline in total utility of an altruistic child, and thus they tend to lower the expense on motorcycle. The higher the marginal altruistic utility, the more the negative impact.

Equation 4 is the main result of our theoretical model that shows how the change in parent's share of the motorcycle costs borne affects the spending on the motorcycle by the child. In the next section, we present how parents decide their contribution towards the motorcycle purchase costs, i.e., the first stage of the dynamic game of complete information between parent and child. Thus, parents know the solution to the child's optimization problem, and decide the share of costs to pay, so as to optimize their utility.

## 2.2 Parent's Problem

Parents solve their own optimization problem and decide the optimum amount that should be spent on the motorcycle, given the total family resources  $W + M$ .

$$\begin{aligned} \max_{B,x} U^P(B, x) \\ s.t. B + px = W + M \end{aligned} \quad (7)$$

Suppose  $B^P$  is the equilibrium expenditure on the motorcycle obtained from the parents' optimization problem. Then, parents can spend this optimal amount on motorcycles by solving the following equation for  $\delta$ .

$$B^P = B(\delta, M, V') \quad (8)$$

Here,  $B(\delta, M, V')$  is the child's decision about the motorcycle obtained by solving the problem in the previous section. Thus, given  $B^P$  if  $B$  rises rapidly with  $\delta$  then the equilibrium level of  $\delta$  will be at a lower level compared to the case where  $B$  rises slowly in response to  $\delta$ . We also know that marginal altruistic utility has a dampening impact on the increase in  $B$  in response to  $\delta$ . Thus, a higher share of the motorcycle price will be paid by the parents who have a more altruistic child, assuming everything else is constant.

Before we proceed to the empirical part of our paper, a few remarks are in order. In this model, we are interested in the impact of principle-agent nature of this parents-child interaction on purchase expenditure. We recognize that operating cost considerations are generally present while buying any kind of durable. However, these considerations will not impact the main conclusion of our paper as long as operating cost considerations are absent from child's problem, or both parents and child have common beliefs about the present value of the discounted operating costs of the motorcycle. Thus, abstracting from operating cost considerations keeps our model focused on the principal-agent nature of decision making.

Given this stylized model, we will use the empirical analysis in the next section to test our main hypothesis, represented by equation (??). As we will discuss in further detail in the next section, the parents' share of purchase costs is one of the main measures we use to verify the existence of the principal-agent problem in this context. Moreover, our data gives us the possibility to have a proxy for the level of altruism of a child. Therefore, the empirical part will also be able to provide a test on the effect of altruism on the choice of the motorcycle.

### 3 Model Specifications and Data

In this section, we first provide details on the survey and the data used in the study. Next, we discuss the identification strategy adopted to test for the presence of principal-agent (PA) problems between parents and children.

#### 3.1 Data

The data used in this study is based on the field survey conducted in 2021 in Kathmandu valley. With the help of a local survey partner and using a computer-assisted personal interview (CAPI) framework, the field survey was targeted to recruit university students who had bought a motorcycle within the last seven years, and were also its main users (within their household). The time span was limited to seven years primarily to minimize the recall bias in responding to the questions relating to the purchase of the motorcycle, and the decision-making process during its purchase.

motorcycles are popular means of local transportation among teenagers and university students in Nepal.<sup>2</sup> The minimum legal age to drive a motorcycle in Nepal is 16 years. We surveyed students belonging to the 18-35 age group since bachelor's-level university students usually start their courses after they complete their upper secondary schooling at the age of 17 or 18 years. The choice of this age group is also driven by the fact that some students start working at this age<sup>3</sup>; this allows us to test the existence of the PA problem, as discussed in the theoretical model, by allowing variation in the proportion of cost-sharing between the parents and the students in the purchase of motorcycles. The main explanatory and dependent variables, as well as the demographic and socioeconomic characteristics of the respondents, are described below, and summary statistics are presented in the table 1.

##### 3.1.1 Principal-agent related variables and their measurement

As also discussed in the theoretical section, our goal is to test for the presence of principal-agent problems related to the purchase price of the motorcycle. In this study, we define three main explanatory variables that we use to evaluate the existence of a PA problem in parent-student relationships.

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<sup>2</sup>A survey carried out in four districts of Bagmati province including Kathmandu reports that nearly 82% of the users of the motorcycles have bachelor's or Master's degrees and 87% of them are in 16-35 age-group (Thapa, 2021)

<sup>3</sup>The minimum legal age to work in Nepal is 18 years old.

- Parents' share of purchase cost: This variable represents the proportion of the total purchase cost of the motorcycle borne by the parents. This variable is expressed as a share/fraction.
- Whether parents paid anything for the purchase: This variable is expressed as a binary variable which is equal to one if the students reported that their parents at least partly paid for the purchase of the motorcycle, or if the parents or the student took a loan for its purchase, and is equal to zero otherwise, i.e., if the student paid for the full cost of the purchase from their income/savings.

During the survey we also collected information on the intra-household decision-making process adopted by the students and their parents in deciding which motorcycle to buy. For this purpose, students were asked to pick the most relevant statement that best described this process back at the time of purchase of the motorcycle. The possible answers were:

- (Statement A) You selected the motorcycle, and your family/parents paid the purchase price for whatever model you choose.
- (Statement B) You selected some motorcycles that you liked and discussed with your family/parents about which one to buy, and they may have offered their opinion, but the final decision was yours.
- (Statement C) You selected some motorcycles that you liked and discussed with your family/parents about which one to buy, and they may have strongly encouraged you to buy certain models. The final decision was theirs.
- (Statement D) Your parents/family first made some recommendations to you based on budget or performance, and you chose the motorcycle that you wanted to buy out of that selection.
- (Statement E) Your parents/family told you which model they wanted you to buy, and you bought that model.
- (Statement F) You decided on the budget and the type of motorcycle yourself. Your parents/family were not involved in this process in any way.

Our third measure of the principal-agent problem is a continuous index that captures this decision-making process, coded from 1 (Statement A) to 6 (Statement F). Higher values of this index denote a weaker principal-agent problem, with Statement F suggesting a complete lack of parental involvement in decision-making.

Finally, to measure the level of altruism of the student, we use answers to the following question: "Have you ever volunteered for a cause (for e.g., after a natural disaster like the earthquake), either individually or as a part of a group? The possible answer choices included 'Yes a lot', 'Yes a few times', 'Not too often', and 'Never'. We create a binary variable, equalling one if students provided a positive answer (either 'Yes a lot', or 'Yes a few times') to this question, and use this to proxy for altruistic behavior.

### 3.1.2 Covariates

In the survey, we asked the respondents to provide information on several relevant motorcycle-related variables (such as details on the make and model of the vehicle and on the principal-agent measures described in the previous section), as well as on socioeconomic variables (the survey questionnaire used is provided in the Appendix). While we also collected some information on the the share of fuel costs paid by the parents at the time of the survey, this information does not necessarily reflect the share of operating costs that the parents agreed to pay at the time of purchase, which is our main interest in this study. Moreover, as argued in the theoretical framework, we are more interested in understanding the principal-agent problem from the perspective of the purchase of the motorcycle. For these reasons, we do not include this measure in our models.

We also collected information on a set of demographic and socioeconomic variables that may be relevant determinants of the price of durables such as motorcycles purchased in the Nepalese context, such as the age and gender of the students, whether they still lived with their parents, as well as whether they were enrolled in a Bachelor's or Master's program. Furthermore, we asked the respondents for household-level information, such as the household size, income, and whether the household received remittances. We also acquired information on the demographic composition of the family, particularly on the birth order of the student, as well as on the birth orders of the parents. Lastly, we have information on the type of motorcycle owned by the students, such as the brand, model, engine size, fuel economy as well as when they purchased the motorcycle.

### 3.1.3 Descriptive statistics

The descriptive statistics for the overall sample are presented in Table 1. In the upper part of the Table, we report statistics on the three main principal-agent measures that we use in our study. We can observe that on average, parents paid about 70% of the purchase cost of the motorcycle, and about 79% of respondents said that their parents paid at least something towards its purchase. With regards to the decision-making index, we observe that the majority of students (about 36%) stated that they selected the motorcycle that they wanted, and their parents agreed to pay for its cost (i.e., they selected Statement A as the answer to this question). Statement B, which also reflects the existence of considerable decision-making autonomy with the students, was selected by a large share of respondents (about 25%). The sum of two shares clearly indicates the potential presence of a principal-agent problem, given that these statements indicate the students 'calling the shots' with the purchase decision. On the other hand, for about 5.56% of students, their parents imposed the motorcycle model that they should purchase, i.e., these were authoritarian parents.

Table 1 also shows that about 30% of the respondents were female, and that the average age of the respondents in the sample was about 23.8 years, and about 28.31% of the population has a high income (of more than Rs. 80,000 per month), while a fairly large share of respondents reported that their family received remittances from abroad (about 61%).<sup>4</sup> 38.9% of the students lived with their parents at the time of the survey, and on average, the number of

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<sup>4</sup>According to the World Bank estimates, the GDP per capita income was USD 4260.84 (equivalent to Rs. 498,262.60 per annum or Rs. 41521.88 per month) in the year 2021.

**Table 1: Summary Statistics**

Variable	Mean	Std. Dev.	Min.	Max.	Obs.
<b>Principal-agent problem measures</b>					
Parent's share paid of purchase cost	0.696	0.407	0	1	1600
Whether parents paid anything for purchase cost	0.789	0.408	0	1	1600
<i>Decision-making before motorcycle purchase</i>					
		Share (in %)			1600
Statement A		35.62			570
Statement B		24.88			398
Statement C		11.75			188
Statement D		13.25			212
Statement E		5.56			89
Statement F		8.94			143
<b>Socioeconomic variables</b>					
<i>Monthly household income (Rs.)</i>					
		Share (in %)			1600
Less than Rs. 20,000		9.06			145
Rs. 20,000-40,000		14.38			230
Rs. 40,000-60,000		15			240
Rs. 60,000-80,000		33.25			532
Rs. 80,000-100,000		21.56			345
More than Rs. 100,000		6.75			108
Enrolled in Masters program	0.267	0.442	0	1	1600
Live with parents dummy	0.388	0.487	0	1	1600
Female	0.298	0.458	0	1	1600
Age (years)	23.75	2.85	18	35	1600
Received remittances	0.607	0.489	0	1	1600
Number of children including self	3.72	1.114	2	8	1600
First-born child dummy	0.327	0.469	0	1	1600
Second-born child dummy	0.416	0.493	0	1	1600
Birth order of father	1.933	1.030	1	6	1559
Birth order of mother	1.981	1.000	1	6	1562
<i>Volunteered for a cause</i>					
		Share (in %)			1600
Yes a lot		14.56			233
Yes a few times		49.44			791
Not too often		26.44			423
Never		9.56			153
<b>Motorcycle attributes</b>					
Price (in Rs.)	277616.1	97585.06	117900	810000	1600
<i>Engine category</i>					
		Share (in %)			1600
Less than or equal to 125 cc		37.06			593
126-180cc		34.56			553
181-300cc		25.19			403
Above 300 cc		3.19			51
<i>Year bought</i>					
		Share (in %)			1600
2015		1.41			21
2016		1.94			31
2017		4.44			71
2018		15.31			245
2019		24.38			390
2020		29.31			469
2021		23.31			373

*Notes:* This table reports the summary statistics (mean, standard deviation, minimum and maximum) for the dependent and independent variables in the data sample used for the models of columns (1), (3) and (5) of Table 2. The sample size is 1600 observations.

children in the household (including the respondent) was about 4. About 27% of respondents were enrolled in a Masters program for their study.

Approximately 15% of the students volunteered a lot for a general cause such as a natural disaster like the earthquake, either individually or as a part of a group, whereas about 49% students stated that they volunteered at least a few times. We club these two categories together in creating our binary measure of altruism.

Our main dependent variable is the price of the motorcycle. For respondents in our sample, the mean price of the motorcycle that they already own is Rs.277616.10. Most respondents own motorcycles that are relatively small with an engine size smaller than 125 cc (37.06%), and which were purchased in the three years prior to 2021, when the survey was undertaken.

### 3.2 Empirical strategy

The first empirical specification that we use to evaluate both the existence as well as the magnitude of the principal-agent problem in the purchase of motorcycles is estimated using the ordinary least squares (OLS) methodology, and is specified below:

$$lprice_{i,j} = \alpha + \beta PA_i + \gamma X_i + \delta B_j + \epsilon_{i,j} \quad (9)$$

where,  $lprice_{i,j}$  is the natural log of the price of the motorcycle  $j$  purchased by individual  $i$ .  $PA_i$  denotes one of three PA-related measures that we described in subsection 3.1.1 and in Table 1, namely the share of the purchase costs paid by the parents, a dummy variable indicating whether the parents paid anything towards the purchase of the motorcycle, as well as the decision index.  $X_i$  represents a vector of individual  $i$ -specific covariates, whereas  $B_j$  includes controls for motorcycle attributes. As mentioned earlier, we control for both engine size category of the motorcycle, the brand and the year when it was purchased.  $\epsilon_{i,j}$  is the unobserved residual.

On using the first two principal-agent problem measures, a positive and significant value of the  $\beta$  coefficient will confirm the hypothesis derived in equations (4) and (5), i.e., that an increase in the share paid by the parents will positively affect the price of the motorcycle purchased by students, and thus confirm the existence of a principal-agent problem. With the decision-making index, a negative and significant value of  $\beta$  will validate the presence of a principal-agent problem.

To test for differential effects on altruistic children, we also estimate a slight variant of model specification (9) in which we introduce an interaction variable between one of the PA variables, i.e., the share of the purchase costs paid by the parents, and the level of altruism of the student for the parents, measured as a binary variable. A significant (and negative) effect on the interaction term would suggest that the relationship between the share of purchase costs paid and the price of the motorcycle selected is weaker for altruistic children.

The OLS methodology can provide insights on the correlation between our PA problem measures and the price of motorcycles selected by the students. However, estimates derived using this approach are likely to be endogenous due to omitted variable bias, as well as potential reverse causality. For example, if the influence of decision-making by the students depends on their

ability to negotiate with their parents, a measure we do not have information on,  $\epsilon_{i,j}$  will be negatively correlated with  $PA_i$  variable and positively correlated with the dependent variable  $\logprice_{i,j}$ . This will induce the coefficient estimates  $\hat{\beta}$  to be downward-biased. Another possible source of endogeneity is reverse causality: parents may decide on the share of the purchase cost that they want to pay based on the price of the motorcycle. For example, parents may be willing to bear a significant proportion of the cost only when relatively cheaper motorcycles are bought.

To address these potential sources of endogeneity in estimating  $\beta$ , we employ an instrumental variable two-stage least squares (IV-2SLS) approach. Following the literature in applied microeconomics, we identified the birth order of the parents of the respondents as a possible instrument. Our main instrumental variable is the product of the birth order of the mother and the father of the respondent in their respective families. The general idea is that the childhood experiences of the parents, particularly those that manifested as a result of their birth order in their households, are likely to influence their decision-making with respect to their own children as adults. Some studies have shown that birth order influences adult outcomes such as educational attainment, earnings, as well as health ([Black et al., 2016](#); [Kantarevic and Mechoulan, 2006](#)).

For instance, it has been shown in this literature that first-born children are more likely to not only have higher levels of educational attainment, but they are also more likely to earn more than later-born children. Thus, our identifying assumption is that the product of the birth orders of the parents directly determines the contribution of the parents to the purchase of costs of durables such as motorcycles (or their willingness to contribute), and the decision-making process between them and their children regarding the choice of motorcycle, while it can affect the actual choice of motorcycle only indirectly through its effect on this decision-making process.

## 4 Results

In this section, we present the regression results in Table 2 based on the empirical model outlined in subsection 3.2 above.

Table 2 presents the coefficient estimates of the results in which we analyze the impact of three different principal-agent problem measures on the log of the price of the motorcycle the student owned: the share of purchase costs paid by the parents, a dummy variable for the parents having paid at least a part of the purchase cost, and the decision index. Columns (1) and (2) present the results using the share of purchase costs paid by the parents, columns (3) and (4) include the results in which we incorporate a variable capturing altruistic behaviour by the student and its interaction with the share of purchase costs, in columns (5) and (6) we use a dummy variable indicating if the parents at least partially cover the purchase costs, and lastly, in columns (7) and (8) we use the decision index as our main explanatory variable. The odd-numbered columns present the OLS results, whereas in the even-numbered columns, we report the IV-2SLS results using the instrumental variable discussed in the previous section. In all IV-2SLS models, the principal-agent problem measure is the endogenous variable, whereas in column (4), we treat the interaction between the share of purchase costs and the indicator for an altruistic child as an endogenous variable too. Our preferred specification uses the share

**Table 2: Main Regression Results**

Dependent variable Principal-agent measure	Price of motorcycles (in logs)							
	Parent's share of the purchase cost				Dummy variable: parents contribute		Decision index	
Models	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Principal-agent variables								
Parents' share of purchase cost	0.021** (0.010)	0.199* (0.113)	0.020** (0.010)	0.261* (0.151)				
Altruistic child			0.002 (0.013)	0.146 (0.113)				
Parents' share*Altruistic child			0.003 (0.018)	-0.219 (0.167)				
Parents paid at least a part of purchase cost					0.019** (0.009)	0.209* (0.121)		
Decision Index							-0.003* (0.002)	-0.057** (0.028)
Covariates								
Student: first-born child	-0.011 (0.011)	-0.015 (0.012)	-0.011 (0.011)	-0.012 (0.013)	-0.011 (0.011)	-0.018 (0.013)	-0.009 (0.010)	-0.022 (0.014)
Student: second-born child	-0.009 (0.009)	-0.012 (0.010)	-0.009 (0.009)	-0.007 (0.011)	-0.009 (0.009)	-0.016 (0.010)	-0.010 (0.009)	-0.024** (0.012)
No. of children including student	-0.003 (0.004)	0.002 (0.005)	-0.003 (0.004)	0.004 (0.006)	-0.004 (0.004)	-0.003 (0.004)	-0.006 (0.004)	-0.005 (0.004)
Household monthly income								
Rs. 20,000-40,000	0.019 (0.013)	0.044* (0.023)	0.019 (0.013)	0.050* (0.027)	0.018 (0.013)	0.041* (0.022)	0.017 (0.012)	0.030* (0.017)
Rs. 40,000-60,000	0.027** (0.013)	0.073** (0.034)	0.026** (0.013)	0.088** (0.043)	0.025** (0.013)	0.063** (0.030)	0.025** (0.012)	0.088** (0.037)
Rs. 60,000- 80,000	0.037*** (0.012)	0.067*** (0.024)	0.037*** (0.012)	0.076*** (0.029)	0.036*** (0.012)	0.055*** (0.019)	0.039*** (0.011)	0.093*** (0.032)
Rs. 80,000- 100,000	0.037*** (0.013)	0.070*** (0.025)	0.036*** (0.013)	0.084*** (0.032)	0.035*** (0.013)	0.052*** (0.018)	0.040 (0.013)	0.096*** (0.032)
More than Rs. 100,000	0.055*** (0.018)	0.112*** (0.040)	0.054*** (0.018)	0.126** (0.050)	0.053*** (0.018)	0.090*** (0.031)	0.055*** (0.018)	0.128*** (0.044)
Student: Female	0.026** (0.012)	0.012 (0.015)	0.026** (0.012)	0.008 (0.017)	0.025** (0.012)	0.003 (0.018)	0.025** (0.012)	0.002 (0.018)
Student: lives with parents	0.011 (0.007)	-0.006 (0.014)	0.011 (0.007)	-0.015 (0.018)	0.012* (0.007)	0.004 (0.010)	0.009 (0.007)	0.0005 (0.009)
Student: age	0.003* (0.002)	0.015* (0.008)	0.003* (0.002)	0.016* (0.009)	0.003* (0.002)	0.014* (0.008)	0.003 (0.002)	0.009** (0.004)
Receive remittances	-0.007 (0.007)	-0.046* (0.025)	-0.007 (0.007)	-0.051* (0.029)	-0.007 (0.007)	0.045* (0.025)	-0.003 (0.007)	-0.041* (0.021)
Enrolled in Master's program	-0.014 (0.010)	-0.012 (0.011)	-0.014 (0.010)	-0.015 (0.012)	-0.013 (0.010)	-0.006 (0.012)	-0.014 (0.010)	-0.013 (0.012)
Maximum range of motorcycle	0.0001 (0.0001)	0.0002** (0.0001)	0.0001* (0.0001)	0.0002** (0.0001)	0.0001** (0.0001)	0.0002** (0.0001)	0.0001** (0.0001)	0.0002*** (0.0001)
Manual transmission	0.096*** (0.028)	0.079*** (0.030)	0.096*** (0.028)	0.070** (0.032)	0.095*** (0.028)	0.073** (0.031)	0.090*** (0.026)	0.049 (0.033)
Fuel economy (km/l)	-0.014*** (0.001)	-0.015*** (0.001)	-0.014*** (0.001)	-0.015*** (0.001)	-0.015*** (0.001)	-0.015*** (0.001)	-0.015*** (0.001)	-0.015*** (0.001)
Engine size fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brand fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year bought fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1600	1522	1600	1522	1600	1522	1678	1600
Kleibergen-Paap F-Statistic		17.495		5.57		12.665		9.816

The table presents the results of the OLS (columns (1), (3), (5) and (7)) and IV-2SLS (columns (2), (4), (6) and (8)) results estimating the impact of three different measures of the principal-agent problem on the log of the price of motorcycle owned by the students. The instrumental variable in columns (2), (6) and (8) is the product of the birth order of the mother and the father of the student in their respective families, whereas in column (4) we use the interaction of this product with a dummy variable for being an altruistic child additional instrumental variable. \*, \*\* and \*\*\* respectively denote significance at 10%, 5% and 1% levels. Robust standard errors are reported in parentheses. The constant on the coefficient is not reported.

of the purchase costs paid by the parents as an explanatory variable and employs an IV-2SLS methodology, i.e., the results of columns (2) and (4).

In column (1), the model in which we do not control for altruistic behaviour by the student, we find that a 10 percentage point increase in the share of purchase costs paid by parents results in an approximately 0.21% increase in the price of the two-wheeler purchased by the respondents. The IV-2SLS results of column (2) also suggest a positive effect for the share of purchase cost paid by parents on the price of the motorcycle; if the share of purchase costs paid by parents increases by 0.1 (a 10 percentage point increase), then the price of the motorcycle increases by about 2%. From the results of columns (3) and (4), we learn that there is no significant difference in the share of purchase costs paid by parents of children who are more altruistic in nature, compared to the parents of non-altruistic children (the interaction terms between altruism and the share are insignificant in both columns). Thus, we do not find evidence in our data that altruistic children can mitigate the positive relationship between the share of the parents' payment and the price of the motorcycle, as was proposed to be a possibility in the theoretical model. The indicator for altruistic children is also insignificant in both estimations. However, we acknowledge that there is likely to be a weak instrument problem in the IV-2SLS results of column (4), given an F-statistic of 5.57 with two endogenous variables.

This suggests that in our setting, while the principal-agent problem appears to be present, its magnitude remains unaffected by whether children exhibit altruistic behaviour, or not. Thus, the principal-agent problem with regards to the purchase of motorcycles appears to be strong.

We find similar results on using a dummy variable capturing whether the parents anything towards the motorcycle purchase as an explanatory variable in columns (5) and (6). In column (5), we provide evidence that in households where parents paid for these costs at least partially, students owned motorcycles that were about 1.9% more expensive than households where students paid fully for these costs. The effect size is comparatively larger, at about 23.24%, in column (6), possibly due to omitted variable bias or measurement error with the OLS estimates in column (5).

Lastly, in columns (7) and (8), we introduce an index for decision-making as an explanatory variable capturing the possibility of a principal-agent problem. Lower values of the index denote the existence of a stronger principal-agent problem. We find that the coefficients on this index are negative, namely that students who were able to 'call the shots' more and whose parents paid for the purchase of any motorcycle that they wished to select, ended up buying more expensive motorcycles. We are able to confirm this finding using both methodologies, with a unit increase in the index associated with a 5.7% reduction in the price of the motorcycle purchased by respondents in column (8).

Thus, the results of columns (1) to (8) support the existence of a principal-agent problem in this setting, and confirm the positive relationship between the share of the purchase costs paid by parents, and the price of the motorcycle bought, as highlighted in expression (4) of the theoretical model.

In all model specifications we control for several individual-specific socioeconomic variables (including income, gender, family size and age) as well as for some characteristics of the motorcycles, such as the brand, engine size and fuel economy. We find that many socioeconomic variables are insignificant in several specifications, indicating that these variables may have a limited role to play in determining the price range of the motorcycle purchased. We find

significant and positive effects of income, with higher income levels associated with more expensive motorcycles being purchased, in line with intuition. Also, we find that the gender of the respondents is a significant covariate in many models. For example, in column (1) we learn that female respondents purchased motorcycles that were about 2.6% more expensive than those owned by male students, controlling for engine size, however the variable is only significant in the OLS specifications. In general, female respondents in our data own smaller motorcycles compared to male respondents: 74.09% of the female riders own motorcycles with an engine size of less than 126 cc. Thus, conditioning on engine size, our result implies that female students may have selected motorcycles that were more advanced or fancier on other dimensions (e.g. style, technical functions, etc.).

We also find a significant and positive effect for age, with older students having purchased more expensive motorcycles than younger ones. This is likely driven by the fact that older students are more likely to be married and/or have families of their own, which could then drive different choices. Lastly, students whose households received remittances were likely to own relatively cheaper motorcycles (as confirmed in the IV-2SLS results of columns (2), (4), (6) and (8)): households that receive remittances are likely to be poorer in this context, and this result reflects this finding. On the other hand, we do not find significant effects for household size or for the birth order of the student.

Regarding the motorcycle attributes, as expected, fuel economy is strongly (and negatively) associated with the price of motorcycles. An increase in fuel economy by 1 km/l is associated with a reduction in the price of the motorcycle by 1.5% in column (2). This suggests that fuel-efficient motorcycles are relatively cheaper, on controlling for engine size and brand. We also find a positive association between the maximum range and the price of the vehicle, and relatively higher prices for motorcycles with a manual transmission (as opposed to an automatic one). This can be explained by the fact that motorcycles generally have a manual transmission, whereas scooters (which we also include in the category of 'motorcycles' in this paper) are generally automatic, and they also tend to be cheaper than motorcycles. These vehicle-specific variables enable us to control for several technical features that can explain variation in prices in our sample.

## 5 Conclusion and Policy Implications

A principal-agent problem in intra-family decision making may arise if the actions of children are misaligned with the intentions or goals of their parents. An interesting example of this phenomenon is the purchase of durable goods such as motorcycles that are primarily used by adult children within a household: given low (or no) income-earning opportunities of such children, parents are likely to pay a share of the cost of these durables. However, the benefits of owning this motorcycle are primarily borne by the children, who may have incentives to choose the most expensive durable that they can buy, perhaps because these goods are status symbols, or because the price of motorcycles may be correlated with other product attributes (such as technical performance, design, engine power, brand and reputation, etc.).

In this study, we develop a stylised model to analyse this possible divergence of interests between parents and children, and provide an empirical application of this problem, using unique survey data on motorcycles owned by university students in Kathmandu Valley, Nepal. Our theoretical

model suggests that *ceteris paribus*, the prices of motorcycles chosen by children are likely to be higher, if the parents pay a larger amount towards its purchase. We test this hypothesis using the empirical analysis, and our main results suggest that the price of motorcycles chosen by students is higher, the more their parents contribute towards the purchase costs, and the bigger the “say” the children have in the decision-making process. We are able to confirm this result using different empirical specifications, as well as accounting for possible endogeneity of our main explanatory variable.

Furthermore, we test the theoretical prediction that altruistic children weaken this relationship, i.e., that if the parents of altruistic children pay a larger share towards the purchase costs of the motorcycle, they are likely to choose motorcycles that are relatively cheaper than the types of motorcycles chosen by non-altruistic children. We do not find any support for this hypothesis in our data, i.e., we do not find a significant difference in the relationship between the share of costs borne by the parents, and the price of the motorcycle between altruistic and non-altruistic children. Thus, the principal-agent problem appears to be salient, and strong, in this setting.

The existence of the principal-agent problem can have a severe negative effect on household finances in the short- and medium-run. This effect can be expected to be worse, if households are resource-constrained, as is common in many developing countries. In fact, the price of durables in developing countries corresponds to a relatively large share of monthly household income, whereas in industrialized countries, it is only a fraction. When parents bear a significant portion of the purchase cost of durables such as motorcycles, children may not consider the effect of their buying decisions on household finances, either because of a low level of consciousness, or because they simply may not care.

The consequences of this problem are likely to be, thus, both significant for the household itself, but also likely to influence society. As mentioned in the Introduction section, relatively more expensive motorcycles generally also tend to be more powerful (i.e., have larger engine size) and tend to be less fuel-efficient. Hence, students may end up buying larger and potentially more polluting motorcycles, if their parents agree to pay more towards its purchase costs. This is a critical spillover of intra-household decision making on society, and it is particularly relevant in urban areas of developing countries, which tend to be more polluted and where the health-related costs of air pollution are high.

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## Appendix A

In this appendix, we derive the condition of the impact of an increase in the level of cost-sharing on the level of the bike price chosen by the child.

Lagrange:

$$L = U(B, g) + V(W - \delta B) + \lambda(M - (1 - \delta)B - g)$$

First-order conditions,

$$\frac{\partial L}{\partial B} = U'_B - V'\delta - \lambda(1 - \delta) \iff F_1(B, g, \lambda; M, \delta) = 0$$

$$F_2 = \frac{\partial L}{\partial g} = U'_g - \lambda \iff F_2(B, g, \lambda; M, \delta) = 0$$

$$F_3 = \frac{\partial L}{\partial \lambda} = M - (1 - \delta)B - g \iff F_3(B, g, \lambda; M, \delta) = 0$$

We are interested in the partial effect of  $\delta$  on  $B$ . This requires comparative statics, and the following calculations do that. Using the implicit function theorem, we can find  $\delta$  on  $B$  as follows:

$$\frac{\partial B}{\partial \delta} = -[A^{-1}c^\delta]_{1,1}$$

Here, the  $a_{ij} = \frac{\partial F_i}{\partial j}$ ,  $i \in \{1, 2, 3\}$ ,  $j \in \{B, g, \lambda\}$  is the entry in the  $i^{th}$  row and  $j^{th}$  column of the  $3 \times 3$  matrix  $A$ .  $c^\delta = \frac{\partial F_i}{\partial \delta}$ ,  $i \in \{1, 2, 3\}$  is the entry in the  $i^{th}$  row of the  $3 \times 1$  column vector  $c^\delta$ . The subscript 1, 1 denotes the first entry of the matrix. We need to find  $\frac{\partial B}{\partial \delta}$ .

$$A = \begin{bmatrix} U''_{BB} + V''\delta^2 & U''_{Bg} & -(1 - \delta) \\ U''_{Bg} & U''_{gg} & -1 \\ -(1 - \delta) & -1 & 0 \end{bmatrix}$$

$$c^\delta = \begin{bmatrix} U_g - V' + V''B \\ 0 \\ B \end{bmatrix}$$

$$A^{-1} = \frac{1}{T} \begin{bmatrix} 1 & -(1 - \delta) & U''_{Bg} - U''_{gg}(1 - \delta) \\ -(1 - \delta) & (1 - \delta)^2 & U''_{Bg}(1 - \delta) - (U''_{BB} + V''\delta^2) \\ U''_{Bg} - U''_{gg}(1 - \delta) & U''_{Bg}(1 - \delta) - (U''_{BB} + V''\delta^2) & U''_{Bg} - (U''_{BB} + V''\delta^2)U''_{gg} \end{bmatrix}$$

here  $T = -|A|$  where  $|A| = -[(U''_{BB} + V''\delta^2) - 2U''_{Bg}(1 - \delta) + U''_{gg}(1 - \delta)^2]$ , is determinant of  $A$ . Replacing these matrices in the equation above we find the following -

$$\frac{\partial B}{\partial \delta} = \frac{1}{|A|} [U_g + B(U''_{Bg} - U''_{gg}(1 - \delta)) - V' + V''\delta^2 B]$$

Sufficiency for maxima ensures that  $|A|$  is positive. The expression in the numerator is positive except for  $[-V' + V''\delta^2 B]$ . Thus, if the altruism factor is sufficiently small, then there is positive relation between  $\delta$  and  $B$ . The altruism factor just weakens this positive relation. Also, since altruism enters in the partial derivative of the bike price with respect to parent's share that means in empirical analysis an interaction term is needed in order to capture this impact on the price of bike purchased.

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