What is the Price Elasticity of Waiting Time for Taxis in Yaoundé, Cameroon?

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Abstract:

One tool used to allocate resources in markets is the auction. If this mechanism is applied in a situation characterized by large numbers of buyers and sellers (to avoid the possibility of single agent having the power to impact prices) then efficient allocation of resources should result, with important implications for welfare maximization. This paper looks at the essentially-deregulated taxi system in place in Yaoundé, Cameroon, which has endogenously developed around a bidding system. The "large number" criterion holds, as does that of a relatively low degree of informational asymmetry between buyer and seller, making the city an interesting case study for the effectiveness of the auction mechanism. Using original survey data collected on taxi trips, I estimate the Price Elasticity of Waiting Time in Yaoundé. These results may inform current understandings of efficient allocation structures of transportation industries and beyond.

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Introduction

Transportation is an essential sector in the urban environment, allowing the operation and development of the city itself. Without a means by which one may effectively move around in urban space, the benefits of urbanism are reduced or lost. The world today is becoming increasingly urbanized, particularly in developing countries.

The taxi system in the city of Yaoundé, Cameroon is an interesting case study of an urban transit system due to several characteristics that distinguish it from systems found in the United States. The intangible quality that defines the system is the premise on which it was formed and operates: efficient use of scare resources. Cameroonians say that they have simply applied the “African” way of doing business to the problem of modern urban public transportation. Their solution is perhaps best described as paid, negotiable hitch-hiking.

To ensure wider relevance of any results, I situate this study within the framework of auctions as market organization mechanisms. I look at a taxi system (or any urban transit, for that matter) as a means to increase productive time. Time spent standing around and waiting is wasted time. Time wasted can be considered harmful anywhere. This is particularly relevant in places where there is much that needs to be done. I seek to discover how well the auction mechanism works in reducing wasted time.

I ask the question: *What is the Price Elasticity of Waiting Time?*

Yaoundé also works well as a case study of taxi market deregulation: benefits and drawbacks found in Yaoundé offer ammunition to both sides of the debate over regulation. One of the supposed benefits of a deregulated system should be increased control over one's transit experience. In Yaoundé, everything is in theory negotiable: the price, the destination, the route, the comfort, etc. The city therefore provides an opportunity to measure the supposed benefits. The ability to increase your overall trip speed (through a reduction in the time spent waiting) by offering more money should be one of the major benefits of a highly deregulated system.

This paper can serve as a starting point for measuring these benefits. The Price Elasticity of Waiting Time on the demand side is a necessary piece of information in measuring overall gains to society. In order to discover the potential drawbacks (or gains) stemming from regulation, we need to know what welfare gains are possible. With information on these gains stemming from the functioning (or non-functioning) of the taxi-ride auction we can make more informed decisions about both urban transit problems and other situations in which market mechanisms may be changed or improved.

The section after this introduction is the literature review, followed by the theory. Next is my analysis section, in which I unpack more fully the Yaoundé case study. Finishing up the paper will be the conclusion.

Literature Review

Transportation Literature

Most authors take a holistic approach to measuring or grading urban transportation systems. This is done because by its nature transportation demands a multi-faceted approach; there is no one overriding concern. There are several concerns that are widely considered to be important, appearing frequently in the literature. The first is quality service for the customers. This can be measured through waiting time, traveling speed, cost, variety of options (choice), or accessibility to service. The second is a focus on the producers and their livelihoods; is the job a viable form of employment? The third is a focus on safety for everyone; driver, customer, bystander, and other drivers. Most studies touch upon these concerns, with varying degrees of depth.

The big debate is over regulation, reflected in both academia and the public policy sphere (Frankena and Pautler; 1984). Do regulated transit solutions or free-market solutions provide more compelling answers to the concerns above? Most believe that the answer lies in between the two; both extremes have their benefits and drawbacks. This section of the literature review will cover (1) the pro-regulation side of the debate and (2) the pro-free-market side of the debate.

Pro-Regulation in Urban Transit

The arguments for regulation consist of theoretical approaches and case studies. Shreiber (1981) writes that in free-market situations where there are many taxis, the increased supply should encourage operators to lower prices to attract more customers. On the flip side, the fact that customers cannot distinguish between cheap and expensive taxis (asymmetric information) means that there is essentially no incentive for operators to actually lower prices. Thus only an increase in fares will increase profits for the taximen; the incentive is to keep on raising prices. More taxis and more unprofessional drivers will enter the market in light of these profits and traffic and pollution will result from the increase in vehicles. The accumulating externalities will lead to a net social loss.

The general point is that a free-market solution both leads to unsustainably high prices and negative social externalities, all of which can only be overcome through regulation.

Chavez (1992) supports Shreiber in her analysis of the taxis in Lima, Peru. She finds support for her hypothesis that “the free market…does not guarantee satisfactory service and it is therefore indispensable to elaborate control measures that will provide a minimum of security, for both the driver and the user” (247). The *palancas*, or pirate taxis, are found to charge high prices (when they can), have unprofessional drivers, and be dangerous, amongst other bad things. Schkolnik (1992) finds mixed results in Chile with overall support for Shreiber. Liberalization policies there in the late 1970s did increase the numbers of taxis and thus decrease the waiting time for customers. However, the predicted rise in prices never happened and so customers benefited *twice*, at the cost of the living standards of the operators. Schkolnik finds that the neither the regulated nor the free-market approach cannot be done piecemeal; combining free-entry and exit in Chile with mostly fixed prices had unintended negative consequences.

Pro Free-Market in Urban Transit

The same mix of theory and case-study is found in the free-market literature. Klein, Moore, and Reja (1997) provide a critique of traditional (regulated) urban transit with a heavy nod towards Hayek’s theory of time and place knowledge. They note that top-down transportation planning can never, by design, achieve as high a level of this sort of knowledge as can individual competing entrepreneurs. They imply that as the role of regulations, government agencies and centralized planning grows within a system, the incentive to provide the good (safe, fast, reliable, accessible) service that customers demand fades and is distorted.

Johnson, Reiley, and Munoz (2005) compare two co-existing, and competing, bus systems in Santiago, Chile. The two systems differ in terms of driver compensation. One system runs on a fixed-wage system (prevalent in the US) and the other compensates drivers based on the number of passengers they transport (thus providing incentives to carry as many passengers as is possible). They find that the incentive-based system provides faster and more efficient service, but at the same time is less comfortable and less safe.

The common quality that exists in most of these papers is their holistic and somewhat undisciplined approach to grading regulated versus deregulated urban transit. This paper is intended to begin a welfare oriented approach: by looking at the gains to society one can more clearly understand the implications of different types of regulations. I look at the gains to society in terms of time, which these papers do not do

The problem with looking at regulated systems and their particular mechanisms of regulation (as some of these papers do) is that you cannot measure welfare losses resulting from said regulations because you do not know what the potential welfare gains are. Vernon Smith (1962) defined "allocative efficiency of markets as the total profit actually earned by all the traders divided by the maximum total profit that could have been earned by all the traders (i.e. the sum of producer and consumer surplus)" (in Gode and Sunder; 1993). In order to achieve some reasonable level of allocative efficiency, the mechanism organizing a market must be well-suited for the task. I continue this literature review with a discussion of the mechanism driving forward my case study: the auction.

Auction Theory Literature

There has been a great deal of discussion and thought in economics concerning the mechanisms through which we ought to organize allocation of resources. Neoclassical economics tells us that under certain assumptions the unrestrained market in a state of perfect competition is generally the way to optimize producer and consumer surpluses and thus optimize societal welfare.

The price mechanism comes with a question: how do we arrive at a certain price? Much commerce today is conducted, in admittedly imperfect markets, with prices fixed by producers. The major alternative to fixed prices is negotiable pricing. Auction theory plays a major role in the literature concerning negotiable pricing; it covers the various means by which price negotiations can occur and the theoretical results. The taxi market in Yaoundé can be fitted into the wider framework of auction theory. Despite the short time frame in which negotiations occur, an auction mechanism is essentially at work in determining the allocation of resources.

This paper is based on the premise that the taxis in Yaoundé have organized their business around the concept of a double auction. [1] The buyer, trying to secure an offer of a taxi ride in the shortest amount of time possible, adjusts her bid. The seller, trying to

[1] The most common perception of the auction is that buyers compete with each other and thus bid up the price. This is called a demand auction. By contrast, an auction in which *producers* compete with each other to offer the lowest price is called a supply (or reverse) auction. An auction in which both producers and consumers move is called a double auction.

secure business while minimizing their opportunity costs of searching time, adjusts what is essentially an unspoken reserve price.

There has been both theoretical and experiment-based research on double auctions. Sutterthwaite and Williams (2002) prove that, in what they call "least favorable trading conditions" and even with a finite number of traders, the double auction mechanism is the *least in*efficient of all possible mechanisms. Jackson and Swinkels (2005) show that as the number of traders increases (and theoretically approaches infinity), positive-quantity trade equilibrium exists.

There are debates over the nature of the double auction. Gode and Sunder (1993) asserted that the continuous double auction generates "efficient allocations" even if there is *no* rationality on the part of traders. Gjerstad and Shachat (2007) take issue with the budget-constraint assumption made by Gode and Sunder, claiming that in making an impractical assumption that the "buyer's currency never exceed her value for the commodity", they in effect "force rationality" onto their supposed "Zero-Intelligence" traders.

Much of the research has been based on controlled experiments. List (2004) runs controlled tests on naturally occurring sports card and collector pin markets. He finds that particularly in mature double auction markets, agreed-upon contracted prices and quantities rapidly achieve levels that would be predicted by neoclassical theory in a state of perfect competition. Secondly, he finds that market composition impacts rent results: the gender of the traders matters, for example. Finally, he finds that experience of the individual trader is an important factor in determining the distribution of rents: experienced agents earn more. In other words, one can learn to play the game.

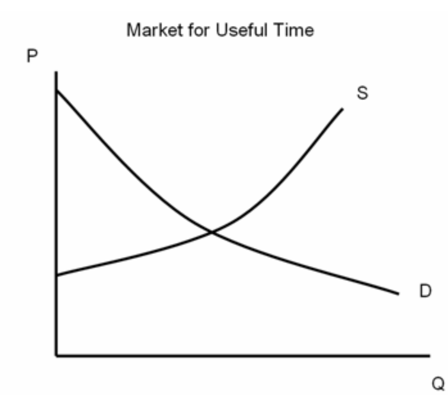
Shubik (2003) discusses results from classroom experiments run at Yale in which he tested inexperienced traders (students) in a simple double auction game. He noted, after 20 years of repeated experiments, that “it has been a source of wonder as to how this simple mechanism forms a price that is quickly close to the theoretical competitive price” (3). He also found that the quantity traded was often *lower* than theory would predict.

Theory

Building off of the theoretical results and propositions in the literature, I treat the completely deregulated taxi market as a double auction for useful, productive time. Buyers (customers) want to reduce their waiting time and are willing to pay more money to do so. Sellers (taximen) want to reduce their idle time or spare capacity (which both come with certain opportunity costs) and are willing to accept less money for their services to do so.

The literature proposes that, even on a small scale, double auctions are the mechanism best suited for creating markets exhibiting the characteristics of perfect competition. Therefore I begin with a neoclassical market for useful time.

Figure 1



With certain pieces of information, we can *measure* the overall gains to society in terms of useful time that result from this double auction market structure. If we assume demand and supply preferences (in the form of information on their elasticities) to be relatively constant and we know information about the equilibrium point (which, as per Jackson and Swinkels (2005), *exists* for double auctions), we can plot out the exact supply and demand curves.

We will be then able to calculate the respective producer and supplier surpluses (in the blue and yellow areas in **Figure 2**) and sum them to find the overall gains to society that result from the double auction structure.

Figure 2

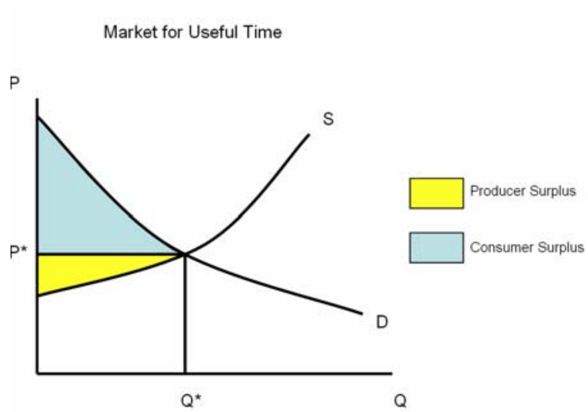
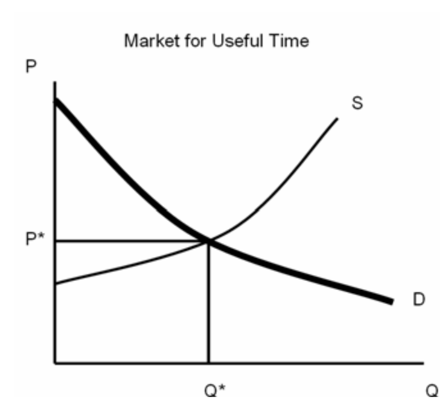


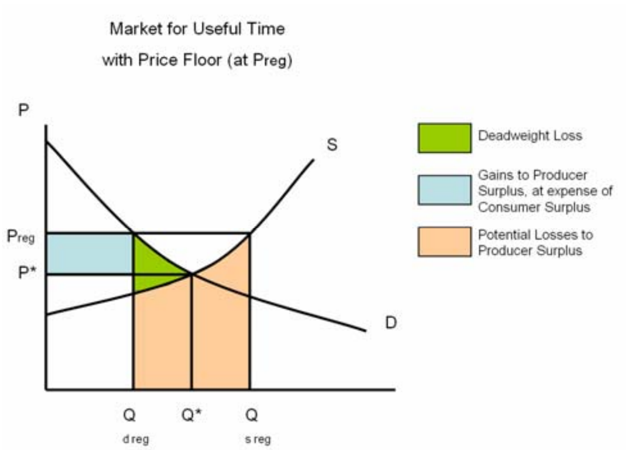
Figure 3



This paper begins this process by finding *one* of the necessary pieces of information: the elasticity information on the demand side (highlighted in **Figure 3**). If we were to know (additionally) the elasticity information for the supply side (for example, through a controlled experiment such as those in List (2004) or Shubik (2003)) and we were to know the equilibrium point (the "useful time at stake" at any moment and the average price) we could estimate the total gains to society.

At this point it would be possible to run simulations to find what kind of losses would be incurred through various distortions and forms of regulation.

Figure 4



For example, a very common form of regulation in developed country markets is the price floor or set price (plus tip). This is often done to protect producers or to create a "living wage." However, in this market it results in a surplus of available useful time, as well as deadweight loss split between the producers and consumers. **Figure 4** shows the deadweight loss (in green) resulting from such a form of regulation, as well as the transfer of surplus from consumer to producer (in blue). It also shows the potential loses to the producer surplus (in orange) that may result depending on the production decisions made. We cannot, however, measure these losses in *any* market without knowing *first* the possible total surpluses, as shown above in **Figure 2**.

While the theoretical approach of applying neoclassical markets and regulation simulations in terms of useful time offers a more disciplined method of measuring regulation and deregulation effects in terms of societal welfare, it is not perfect. Negative externalities are not taken into account, such as pollution and smog resulting from the vehicles, nor are the frustration and inefficiencies that traffic congestion can cause.

Analysis – Yaoundé Case Study

Background Information

An understanding of the Yaoundé taxis must go hand in hand with an understanding of the context in which they operate. Cameroon is a low-income country with a human development index of 0.532 (UNDP; 2008). The GDP/capita with Purchasing Power Parity is $2,060 US; without PPP, it hovers around $990 (World Bank; 2008). The capital city reflects well situations and trends evident in the rest of the country. Many of Yaoundé's characteristics must seem vaguely "African" to outsiders: huge, sprawling, dusty, black and poor. Set in a hilly, cool region in the center of the country, Yaoundé is a city of over one and a half million inhabitants living mostly in slum or near-slum conditions that has been growing at a large 6.8 % each year (Communauté Urbaine de Yaoundé; 2001). In the dry season the dust causes health problems and in the rainy season there are frequent floods. Residents are more concerned with problems such as this flooding than they are with public transportation. A citywide survey in 2002 found that 17% of complaints were related to a lack of security and 11% were related to flooding; in contrast, only 2% were directed at the "quality of public transport" (INS; 2002). This implies that *relative* to other services in the city, transport seems to work.

And transport really *needs* to work in Yaoundé. With an area of 252 square kilometers (Communauté Urbaine de Yaoundé; 2001) built on hills, the city is not a "walking city". Thus it is appropriate that cars provides most cross-town transport; urban sprawl is strongly connected to the use of automobiles (Glaeser and Kahn; 2003). Furthermore, capable drivers and private vehicles are rare: only 11.6% of households owned vehicles and there were just over 15,000 drivers licenses granted in the year 2000 for the entire Centre Province, which Yaoundé demographically dominates (INS; 2002).

The average (and poor) resident of Yaoundé needs some means to traverse the city. The consequences of public transport failures have been documented to a degree in similar urban situations: a strong potential exists for a poverty trap characterized by lack of physical *and* social mobility (Diaz Olvera, Plat, and Pochet; 2003). Yaoundé citizens are *relatively satisfied* with their options, as noted earlier.

The average resident of the city needs to walk approximately five to eight minutes to reach a paved road more regularly served by transit options (INS; 2002). Ngandeu (2006) finds that 82% of residents in one borough of the city regularly make this walk, from residence to roadside gathering point; furthermore, he finds that the state of these paved roads are often mediocre at best, lacking government investment in upkeep. The transit options available at the roadside vary widely. There is a new fixed-price bus system (run by an American company) with several routes in the Central Business District. On the city outskirts and on the bad roads, motorcycle taxis provide service (operating using a double auction mechanism). Commuters from the suburban areas to the Central Business District are served by *Cars Périphériques*, crowded minivans running on fixed routes with fixed pricing structures (Ngandeu; 2006).

By and large, however, it is the taxis which move people around Yaoundé.[2]

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[2] I have no official statistics on this; instead I draw inferences based on a) awareness of lack of personal means of transport (as per INS statistics), b) awareness of small scale of bus and motorcycle operations and c) personal experience in the city.

Customers stand on the side of the road and yell out a proposal to passing taximen (the drivers are always male), who momentarily slow down to hear the bid. If they accept, the car is stopped for a few seconds to allow the customer to enter and situate themselves amongst the other passengers (generally speaking, customers share the cab). If the taximan rejects the bid, he simply speeds up again to the next potential customer.

The proposals contain three pieces of information: destination, number of seats required and overall price offered. To reduce their price and waiting time, the customers work to manipulate the situation in ways beneficial to them.[3] They will walk further in order to wait at locations with the best chance of a quick pickup (which could be affected by the road-to-be-traveled, other potential customers, etc.). Children and thin people will squeeze several bodies into one seat to reduce their payments.

Riders often congregate at certain spots along the main roads. This grouping facilitates the system in two ways. Firstly, it makes it easier on the taximen; as it reduces the number of times they must slow down to hear bids. Secondly, the likelihood increases that a passenger will find a taxi willing to take him; the taximen prefer to slow down if they know that they will hear a larger number of bids. At the same time, because the system is entirely composed of individuals making their own decisions and not bound by any restraints from above, the flexibility exists to hail a taxi from any location. The taximen are less likely, however, to dedicate the effort and time required to slow their vehicle down to hear the lone bid. See **Appendix A** for a map of the city and **Photo 1** for an image of people lined up to bid.

[3] It is important to note that, once the agreement has been reached between taximan and customer, there is an element of *lack* of post-seating control on the part of the customer. *En route*, decisions made by the taximan regarding new customers and route choices may disrupt any pre-seating calculations (on price and time) done by the customer.

Photo 1

All taxis in the city are used, manual-transmission cars that have been painted yellow. Toyotas from the early 1990s have the lion's share; there are also a good number of Starlets and Nissans from the same time period. Typically, the used cars are well-used: 200 to 600 thousand kilometers (from 120 to well over 300 thousand miles) on each is not unusual. The condition of the cars ranges from fair to poor. See Photo 2 for an image of a typical taxi. Dents and major cracks in the windshield are not considered major problems. Door handles oftentimes either do not work or exist. Sometimes, full windows are missing; when it rains, water enters the cabin rapidly. To deal with this problem, sheets of plastic are stretched across and taped to the window, with varying degrees of effectiveness. Neither maintenance costs nor depreciation costs are built into the business model of most taxi operators. They are instead focused on breaking even for the day; drivers speak of frustration stemming from their inability to operate with a longer time horizon (Gilmartin; 2007). This situation is not unique to Yaoundé; studies of informal taxi markets elsewhere document similar attitudes towards depreciation (Chavez; 1992).

Photo 2

According to interviews with various taximen and taxi owners, ownership structures vary. Most taximen operate in a simple daily-rental framework. They pay the owner a fee, usually about 10,000 CFA francs per day, for use of the car (with an exchange rate of 500 CFA to the dollar). They must pay this regardless of their earnings throughout the day. On top of the fee, they must pay for their gas (estimated around 15,000 CFA per day) and any damages incurred. They ferry passengers in 12 hour shifts under the framework described previously: any earnings above total costs is theirs to keep, in addition to a small salary they are paid each month. Some taximen own their vehicles or rent at a reduced rate from a relative. Others are in a buying agreement in which they will, after a certain amount of time of renting the car from the current owner, become the new owner (Gilmartin; 2007).

The market can be summarized as follows: there is relatively quick and free entry and exit from the market (sometimes exhibited in the form of *clandos*, unofficial and often spontaneous share taxis that are run by drivers normally outside the taxi system). The product as discussed in the theory (useful time) is homogenous. Informational asymmetry is low: neither drivers nor customers are well informed as to traffic conditions and both are usually equally informed about road conditions, particularly passengers tracing regular routes. There are a large number of traders on both sides.

Model

As stipulated earlier, the goal for this paper is to estimate demand-side elasticity information. This information is necessary for estimating total gains to society, which is in turn necessary for evaluating various regulations in urban transport markets. The first step is to develop a simple regression model. Drawing on Shaller (1999) who estimates the fare elasticities for taxicabs in New York City, the elasticity that I aim to estimate is similar to what is in his paper called "fare elasticity of availability" Shaller uses a log-log model and a dependant variable measuring the "availability of cabs."[4] I look instead at the demand side, examining the time spent waiting by the customers.

Useful time gained is a function of the waiting time experienced by the customer, which is in turn a function of the price offered, controlling for other factors which may influence the taximan's decision to pick them up:

Useful Time = f (Waiting Time)

Waiting Time = f (Price, Control Variables)

These control variables can vary widely. I use three principal models, differentiated by the number of control variables included:

Wait = f (Price per Mile, Traffic Conditions, Road Quality, Space in Car)

[4] This variable is measured with the number of miles spent cruising for passengers (this implies that he is working more on the supply side, measuring the opportunity costs of drivers). Because Shaller is dealing within a regulated framework, a (presumably exogenous) fare increase increases "availability" because few customers are willing to pay the higher cost for the taxi trip.

Wait = f (Price per Mile, Traffic Conditions, Road Quality, Space in Car, Nationality, Day of Week)

Wait = f (Price per Mile, Traffic Conditions, Road Quality, Space in Car, Nationality, Day of Week, Size of Group Traveling)

For specification, the primary concern is to find a presumably constant elasticity measuring the relationship between price and wait time. Therefore a semi-log model seems to be the most suitable specification form to use:

$$\ln WAIT = \alpha + \beta_1 \ln PRICEMILE + \beta_2 TRAFFIC + \beta_3 ROAD + \beta_4 PPLTAKEN \quad \textbf{(1)}$$

$$\ln WAIT = \alpha + \beta_1 \ln PRICEMILE + \beta_2 TRAFFIC + \beta_3 ROAD + \beta_4 PPLTAKEN + \beta_5 AMERICAN + \beta_6 OTHNONCAM + \beta_7 MON + \beta_8 TUES + \beta_9 WED + \beta_{10} THURS + \beta_{11} FRI + \beta_{12} SAT \quad \textbf{(2)}$$

$$\ln WAIT = \alpha + \beta_1 \ln PRICEMILE + \beta_2 TRAFFIC + \beta_3 ROAD + \beta_4 PPLTAKEN + \beta_5 AMERICAN + \beta_6 OTHNONCAM + \beta_7 MON + \beta_8 TUES + \beta_9 WED + \beta_{10} THURS + \beta_{11} FRI + \beta_{12} SAT + \beta_{13} GROUP \quad \textbf{(3)}$$

The estimation of these models with OLS should yield, importantly, the price elasticity of waiting time. Table 1 summarizes the expected signs on the coefficients on all models. The β_1 coefficient is the one which primarily interests us: theory predicts that it be negative to show that as price offered goes up, wait time goes down. The second two coefficients, β_2 and β_3, are predicted to be positive. Both are subjective “grades” given to those exogenous conditions during the trip, on a scale from 1 to 5 (1 being the best). Thus as their numbers go up, we would expect waiting time to go up. The coefficient on “people taken already by taximan,” β_4, ought to be positive as well. This variable offers a measurement of the space in the cab. The higher the number, the *less* space in the cab and so the *less* likely the taximan is to pick up a new customer.

Models two and three are less parsimonious but may nevertheless offer insights into our subject. β_5 and β_6 are intercept dummies for nationalities other than Cameroonian. These variables are designed to capture some of the effects of operating in familiar territory and looking like a local. Their predicted signs, particularly on β_5 (the American dummy), would be negative as, *controlling for price* (which we would expect to be higher on average), such passengers might stand out more than most Cameroonians and therefore offer a diversion (for example, a promise of an interesting conversation or the possibility of a tip) to the taxi drivers. β_7 through β_{12} are intercept dummies relative to Sunday and their expected signs are unknown: one might speculate that weekdays are busier (in terms of other traders, traffic, etc.) and thus might be associated with longer wait times. β_{13} should be negative: a larger group size combined with the price offered per mile (per person) means larger overall revenue for the driver for the service. One would expect the drivers to seek to maximize the number of people they are carrying at all times; taking groups of customers offers an easy way to do that.

Table 1

Expected Signs:

β1	(-)	as more money is offered, less wait time
β2	(+)	as traffic gets worse, waiting times increase: cars move slowly
β3	(+)	if the road to-be-traveled is bad, taximen will avoid it
β4	(+)	the more empty seats, the more likely cab is to pick one up
β5-β6	(-)	controlling for price, possibility of tip or conversation
β7-β12	(?)	unknown effect, possibly negative on weekends
β13	(-)	the bigger the group traveling, the more potential one-time revenue for cab

Summary Statistics

The data were collected through a survey distributed primarily at the University of Yaoundé I during the week of May 8th through the 16th, 2007. George Fonkeng, a research methods professor at the University of Yaoundé I, graciously allowed use of his Tuesday and Wednesday morning classes. Trip information survey forms were distributed and explanations given in French and English to about 350 students in the two classes. These classes, combined with the Dickinson-in-Cameroon study abroad program members, made for a data set comprising 750 trip observations from 316 participants representing six nationalities (but overwhelmingly Cameroonian). The average age of the respondents was 26.3 years old and the vast majority were Francophone (French being the contact language of the city). Relevant statistics are reproduced below in **Table 2**, containing number of observations, means, standard deviations and ranges.

Ideally, it would be possible to collect data on all possible factors influencing the taximan's decision to pick up a passenger. The taximan's particular knowledge of the city is one such factor. Does he even know of the proposed destination? If not, he will reject. The weather, the quality of the taximan's vehicle and existence of police checkpoints along the route (with varying degrees of potential hassle) would all be relevant and useful for the model. The popularity of the destination would be important; the taximen certainly take into account the possibility of *future* customers when they make their decisions. The data used in this paper is limited to 1) what was possible to place on the survey and to be reasonably filled out while in a taxi and 2) the quality of the resulting data. For example, the survey did try to capture the "popularity" effect but the results were unreliable (some participants used a ranking system while others guessed at a number of potential customers).

The average price per mile agreed-upon by both parties (buyer and seller) was 71.5 CFA francs (a little less than 15 cents per mile), with a high standard deviation of 47 CFA francs. The average wait time was about 13 minutes, again with a high standard deviation of around 12 minutes. The average traffic grade was 2.3 and the average road condition grade was 1.7. The participants tended to find about 2 other customers in the car upon entry. For more information on the survey (as well as histograms for the key variables), please see **Appendix B**.

Table 2

Variable	Observations	Mean	Std. Dev.	Min	Max	Expected Sign
WAIT	734	13.35831	12.365	1	78	
REJECTIONS	750	5.270667	6.610068	0	55	
PRICEMILE	547	71.51384	47.08789	20.40816	405.4054	-
TRAFFIC	695	2.327338	1.450817	1	5	+
ROAD	698	1.722063	1.189432	1	5	+
PPLTAKEN	598	1.996656	1.222345	0	6	+
AMERICAN	592	0.0625	0.2422662	0	1	-
OTHNONCAM	592	0.0185811	0.1351543	0	1	-
SUN	620	0.066129	0.2487082	0	1	?
MON	620	0.0903226	0.2868748	0	1	?
TUES	620	0.1548387	0.3620429	0	1	?
WED	620	0.2	0.400323	0	1	?
THURS	620	0.2080645	0.406251	0	1	?
FRI	620	0.1483871	0.3557703	0	1	?
SAT	620	0.1322581	0.3390446	0	1	?
GROUP	466	1.540773	0.896499	1	6	-

* All variables shown in linear form.

The WAIT variable is measured in minutes. REJECTIONS are the number of times a passing taximan rejected a proposal. The PRICEMILE variable is measured in

CFA units: in May 2007, the exchange rate was about 500 CFA to 1 US dollar. TRAFFIC and ROAD are subjective grades from 1 to 5, with a score of 1 being the best. TRAFFIC of 5 implies terrible traffic; ROAD of 5 implies a bad road. PPLTAKEN are the number of people that were already in the taxi car at the time the survey participant entered.

AMERICAN and OTHNONCAM are intercept dummy variables containing information about the participant's nationality. An OTHNONCAM value of 1 represents a other non-Cameroonian participant (not an American). MON, TUES, etc. are intercept dummy variables representing the day of the week on which the trip was taken. GROUP is the size of the group traveling.

One issue in the data comes with the bidding system. A price elasticity of waiting time is *implied* in the existence of the system and so the customers in Yaoundé frequently *change* their bids after a number of rejections in order to increase their chances of being picked up. Customers attempt to *exploit* the price elasticity of waiting time by changing their bids; in the survey, in 27% of the recorded trips the participants increased their bid after one or more rejection. I have recorded data on the different proposals and the corresponding number of rejections for each. The challenge is to come up with a good way to measure the degree to which the customer attempts to exploit the elasticity. For the time being, this problem is circumvented by restricting the data set (with a corresponding reduction in number of observations) to those trips in which the first and last proposals have the same value: the customer held their ground in the bidding and "did not budge".

Results

The results for estimating regression (1) provide us with the price elasticity of waiting time. All of the signs are as theory predicts. The most important independent variable, lnPRICEMILE, is highly statistically significant and has a coefficient value of (-0.31), implying a 0.31% drop in minutes of waiting time for every 1% increase in the price offered per mile. Of the control variables, TRAFFIC is significant while ROAD and PPLTAKEN are not; all three have the predicted signs.

The results for regressions (2) and (3) are widely statistically insignificant. Only TRAFFIC and AMERICAN are statistically significant at the 95% level. In fact, the 95% confidence intervals for each of the coefficients on every other independent variable include zero. A major possible reason for this lack of statistical significance is a specification error in terms of independent variable choice. It is not clear that the specific day of the week affects the operation of the market. It is also not clear that taximen believe that large one-time revenue hauls are the best way to maximize their rents.

For robustness checks, I run the regression (1) in non-logged linear specification three times. The first time, I have WAIT as the dependant variable. The second time, REJECTIONS is the dependant variable. REJECTIONS theoretically is strongly and positively correlated with WAIT. As rejections increase in number, so should wait time. The third time, REJECTIONS is again the dependant variable, but TRAFFIC is taken out to reflect the possibility that it does not theoretically cause more rejections. I also test regressions (2) and (3) linearly using WAIT as the dependant variable. In all of these regressions, the expected signs stay the same.

$$WAIT = \alpha + \beta_1 PRICEMILE + \beta_2 TRAFFIC + \beta_3 ROAD + \beta_4 PPLTAKEN \quad \textbf{(4)}$$

$$REJECTIONS = \alpha + \beta_1 PRICEMILE + \beta_2 TRAFFIC + \beta_3 ROAD + \beta_4 PPLTAKEN \quad \textbf{(5)}$$

$$REJECTIONS = \alpha + \beta_1 PRICEMILE + \beta_2 ROAD + \beta_3 PPLTAKEN \quad \textbf{(6)}$$

$$WAIT = \alpha + \beta_1 PRICEMILE + \beta_2 TRAFFIC + \beta_3 ROAD + \beta_4 PPLTAKEN + \beta_5 AMERICAN + \beta_6 OTHNONCAM + \beta_7 MON + \beta_8 TUES + \beta_9 WED + \beta_{10} THURS + \beta_{11} FRI + \beta_{12} SAT \quad \textbf{(7)}$$

$$WAIT = \alpha + \beta_1 PRICEMILE + \beta_2 TRAFFIC + \beta_3 ROAD + \beta_4 PPLTAKEN + \beta_5 AMERICAN + \beta_6 OTHNONCAM + \beta_7 MON + \beta_8 TUES + \beta_9 WED + \beta_{10} THURS + \beta_{11} FRI + \beta_{12} SAT + \beta_{13} GROUP \quad \textbf{(8)}$$

The three robustness checks on (1) all seem to indicate the validity of the results. Across the board, the signs are as theory predicts (with the exception of the statistically insignificant coefficients on ROAD in regressions (5) and (6)). PRICEMILE is *always* significant, which seems to be promising support for the theory put forward. TRAFFIC is similarly significant in all regressions, and PPLTAKEN becomes significant at a lower level in regression (6) when TRAFFIC is removed. The F statistics in all cases provides little reason to worry (except perhaps in the case of (6), when it was a lower 6.18). Again across the board, VIF and correlation tests indicate little need to worry about multicollinearity. The results of the regressions are provided in **Table 3** and residual graphs are provided in **Appendix C**.

Table 3

Regression	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependant Variable	lnWAIT	lnWAIT	lnWAIT	WAIT	REJECTIONS	REJECTIONS	WAIT	WAIT
Independent Variables			Estimated Coefficients and (t-scores)					
lnPRICEMILE	-0.31	-0.22	-0.10					
	(-3.08)**	(-0.18)**	(-0.64)					
PRICEMILE				-0.032	-0.018	-0.019	-0.033	-0.014
				(-2.72)**	(-3.62)**	(-3.84)**	(-1.97)**	(-0.72)
TRAFFIC	0.23	0.25	0.21	2.29	0.74		2.66	2.01
	(6.72)**	(6.74)**	(4.71)**	(5.83)**	(4.26)**		(6.25)**	(4.32)**
ROAD	0.18	0.024	0.022	0.10	-0.21	-0.07	0.25	0.27
	(0.45)	(0.49)	(0.40)	(0.21)	(-1.01)	(-0.36)	(0.46)	(0.46)
PPLTAKEN	0.055	0.030	-0.003	0.64	0.20	0.37	0.35	-0.08
	(1.42)	(0.72)	(-0.05)	(1.43)	(0.99)	(1.91)*	(0.74)	(-0.14)
AMERICAN		-0.55	-0.60				-3.66	-3.66
		(-2.77)**	(-2.92)**				(-1.62)	(-1.69)
OTHNONCAM		-0.34	(dropped)				-6.53	(dropped)
		(-0.80)					(-1.38)	
MON		-0.006	0.16				-0.33	0.83
		(-0.02)	(0.53)				(-0.11)	(0.27)
TUES		0.27	0.34				1.88	2.93
		(1.15)	(1.24)				(-0.71)	(1.03)
WED		-0.007	-0.035				0.47	0.14
		(-0.03)	(-0.14)				(0.19)	(0.05)
THURS		-0.10	-0.049				-1.18	-0.43
		(-0.45)	(-0.19)				(-0.47)	(-0.16)
FRI		0.37	0.25				3.14	1.47
		(1.59)	(0.89)				(1.18)	(0.49)
SAT		-0.010	-0.009				0.36	-1.07
		(-0.04)	(-0.03)				(0.13)	(-0.34)
GROUP			0.073					0.85
			(-0.88)					(0.97)
Constant	2.64	2.19	1.68	7.38	3.57	4.62	6.24	5.05
	(6.05)**	(3.73)**	(2.30)**	(4.60)**	(5.05)**	(7.04)**	(2.14)**	(1.38)
n	403	320	226	403	410	421	320	226
adj r-squared	0.1303	0.1803	0.1283	0.1018	0.0734	0.0357	0.1364	0.0807
f statistic	16.05	6.85	3.76	12.39	9.11	6.18	5.2	2.65

* significant at 94% level

** significant at 99% level

Conclusions and Future Research

The results of my regression analysis thus far provide support for the existence of a statistically significant price elasticity of waiting time. Focusing on the results of regression (1), I estimate the elasticity of waiting time to be -0.31, implying that waiting time decreases by 31% when the price proposed is doubled. This is the first step in estimating the overall gains to society stemming from Yaoundé's adaptation of a double auction pricing mechanism. It also seems to be quite low and potentially has strong implications for the policy debate outlined in this paper.

On one hand, this elasticity of -0.31 would lend support to proponents of free-market systems: it provides a specific numerical estimate of the ability of customers to personally curtail the transportation service they desire. On the other hand, it is a strong indication of the poverty of the society; it implies that the demand curve flattens out quickly, which in turn implies a lack of flexibility on the demand side (most likely, not by choice). This elasticity also fills a gap in the literature mentioned by Frankena and Pautler (1984) when they lament the lack of waiting time elasticity estimates.

The most immediate and pressing direction for future research is in simulations. As outlined in my theory section, with information (derived from experiments/surveys or hypothetical figures) on the supply-side elasticities and on the equilibrium point, one could estimate the gains to society in terms of time resulting from Yaoundé's double auction market structure. The next step would be to run simulations on various forms of regulations in order to more accurately estimate and understand the changes and losses to welfare resulting from these deviations from the neoclassical model.

As mentioned earlier, a variable indicative of the extent to which a customer tries to exploit the assumed price elasticity of waiting time would be helpful and allow analysis of the full dataset available. Other aspects of the data set might also be added to the model and tested, such as time information. Perhaps there is some sort of "rush hour effect." It might also be interesting to expand the theoretical model and test the assumption that traveling time is out of ones control. To test the other side of the induced time split, traveling time (for which data exists) could be used as a dependent variable (as opposed to waiting time.) Of course, the resulting model and specification would have to be altered to reflect this change in focus.

Acknowledgements

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Sources

Chavez, Eliana. "Consequences of the Legal and Regulatory Framework in Peru's Taxi Market.". In *Beyond Regulation: The Informal Economy in Latin America.* Edited by Tokman, V. Lynne. Rienner Publishers. Boulder, CO. 1992. pp. 247-275.

Communauté Urbaine de Yaoundé. *Plan Guide de Yaoundé*. 2001.

Diaz Olvera, L.D., Plat, D. and Pochet, P. "Transportation Conditions and Access to Services in a Context of Urban Sprawl and Deregulation: The Case of Dar Es Salaam" Laboratoire d'Economie des Transports. 2003.

Frankena, Mark and Pautler, Paul. "An Economic Analysis of Taxicab Regulation." *Bureau of Economics Staff Report*. Federal Trade Commission. May 1984.

Gilmartin, Patrick with Blair Kauffmann. *Interviews with three taximan and a former owner (Edwin, Moise, Jean and Ako).* April 2007.

Gjerstad, Steven and Shachat, Jason. "Individual Rationality and Market Efficiency" Institute for Research in the Behavioral, Economic, and Management Sciences. Paper No. 1204. Purdue University, Indiana. August 2007.

Glaeser, E.L. and Kahn, M.E. "Sprawl and Urban Growth" NBER Working Paper No. 9733. 2003.

Gode, Dhanajay K. and Sham Sunder. "Allocative Efficiency of Markets with Zero-Intelligence Traders: Market as a Partial Substitute for Individual Rationality," *Journal of Political Economy*. 1993. 101, pp. 119 – 137.

INS (Institute National de la Statistique). *Enquête sur le cadre de vie des populations de Yaoundé et de Douala en 2002 (CAVIE)*. Volume 2 A: Résultats pour la ville de Yaoundé. Juillet (July) 2003.

Jackson, Matthew and Swinkels, Jeroen. "Existence of Equilibrium in Single and Double Private Value Auctions" *Econometrica*. Vol. 73, No. 1. Jan. 2005. pp. 93-139.

Johnson, R., Reiley, D.H. and Munoz, J.C. "The War for the Fare: How driver compensation affects bus system performance." NBER Working Paper No. 11744. 2005.

Klein, DB, Moore, A and Reja, B. *Curb Rights: a foundation for free enterprise in urban transit*. The Brookings Institution. Washington, D.C. 1997.

List, John. "Testing Neoclassical Competitive Theory in Multilateral Decentralized Markets." *Journal of Political Economy*. The University of Chicago. Vol. 112, no. 5. 2004.

Ngandeu, Joseph. *La réalité actuelle des transports entre la commune d'arrondissement de Yaoundé VI et le centre-ville.* Mémoire de Maitrise de Géographie at the University of Yaoundé I. Under direction of Fodrouop, Kengne. May 2006.

Satterthwaite, Mark and Williams, Steven. "The Optimality of a Simple Market Mechanism." *Econometrica*, Vol. 70, No. 5. Sep. 2002. pp. 1841-1863.

Schkolnik, Mariana. "The Taxi Market in Chile: Regulation and Liberalization Policies, 1978-1987.. *Beyond Regulation: The Informal Economy in Latin America.* Edited by Tokman, V. Lynne. Rienner Publishers. Boulder, CO. 1992. pp.207-245.

Shaller, Bruce. "Elasticities for taxicab fares and service availability." *Transportation.* The Netherlands. November 1998.

Shreiber, C. "The economic reasons for price and entry regulation of taxicabs: A rejoinder." *Journal of Transports Economics and Policy*. School of Economics and Political Science. London. January 1981.

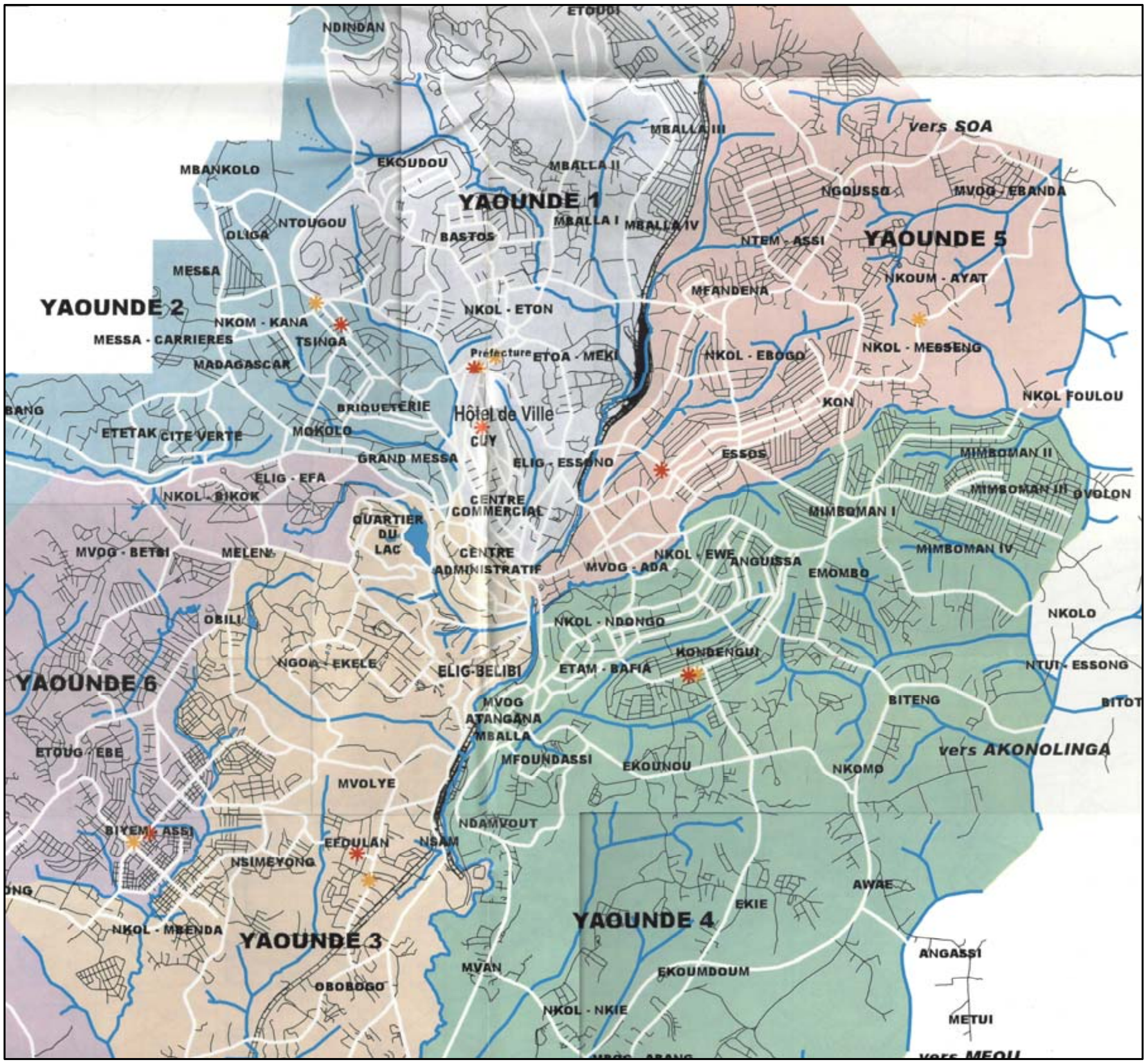
Shubik, Martin. "A Double Auction Market: Teaching, Experiment and Theory." Cowles Foundation for Research in Economics. Yale University, October 2003.

UNDP "Cameroon – The Human Development Index." United Nations Development Programme. 2005.

World Bank. "World Indicators – Cameroon Data Profile" The World Bank Group. 2006.

Appendix A

Map of Yaoundé



Appendix B

Survey Information

I compiled the data set in my last month in Yaoundé. I developed a survey form to distribute to members of the study abroad program which asked for rather detailed information on individual trips. I wanted to know where they were starting and where they were going to, at what times, their bidding history, information about the other passengers in the taxi, and various other bits of trip information. I decided to err on the side of asking for too much information as opposed to designing a very simple survey; after all, the more interesting variables I had to look at later, the better, and anyone who is willing to spend 30 seconds in a taxi filling out a form is probably willing to spend 45 seconds or a minute filling out a form.

At first the survey participants included members of the Dickinson-in-Cameroon program. I soon expanded this to include various people involved in the program or connected to it somehow; this came to include professors, families of professors, host families, etc. However, even with this expanded participant group, the survey was still being completed by a group that was overwhelmingly white, rich, and geographically centered in south Yaoundé. That's not to say it would not have been fun to play with, but the participant group came with certain baggage.

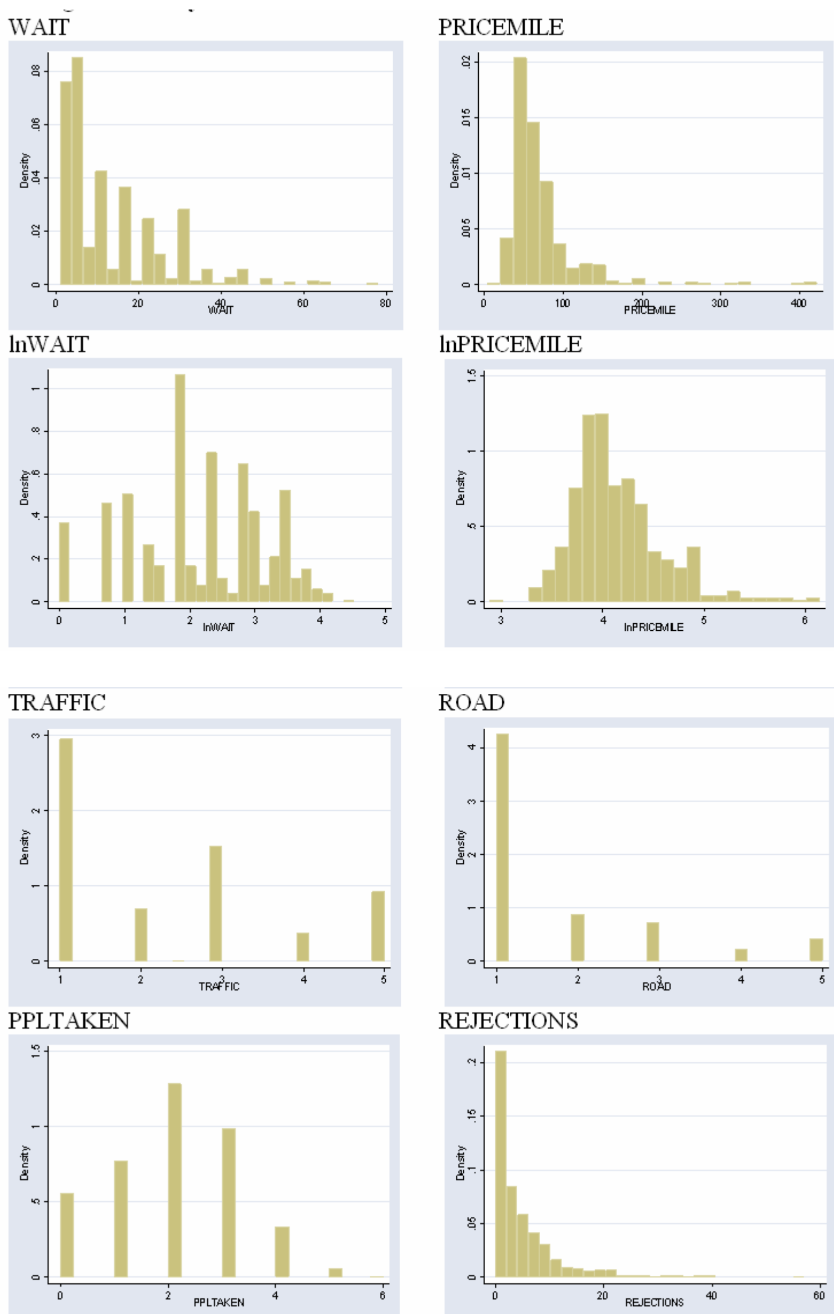
The break came when one of the program professors, George Fonkeng, offered to let me use some of his classes at the University of Yaoundé I as survey participants. I jumped at the chance…and headed over to the photocopier booths. On Tuesday, May 8th, I distributed around 150 of the surveys to his 8:00 AM Research Methods class, explaining the survey in both French and English. The following day, Wednesday May 9th, I did the same, with about 200 surveys, to at a noon English class, again with explanations (somewhat improved, I think) in French and English. Each time I told the class that I would return the following week to pick up the surveys.

One week later, on Tuesday and Wednesday respectively, I returned to the university to pick up my surveys. I was delighted with the good and enthusiastic response from the students, who on the whole filled out the forms diligently and correctly. On my trip to pick up the forms, I had the classes fill out another questionnaire with some information about themselves; name, age, residence, etc. And so it was that in mid-May I found myself with the responses from over 300 Yaoundé residents to my taxi survey.

Some Relevant Information

- 316 participants, 750 trip observations.
- Information on: Name, Age, First Language, Neighborhood of Residence, Nationality, Times, Date, Bidding History, Gendarme (Police) Checkpoints, Traffic rating, Road Condition rating, Comfort rating, Other Passengers, Any Other Information (accidents, weather, discussion in cab, etc.)
- Distance variable comes from Google Earth: path tool used on major roads.

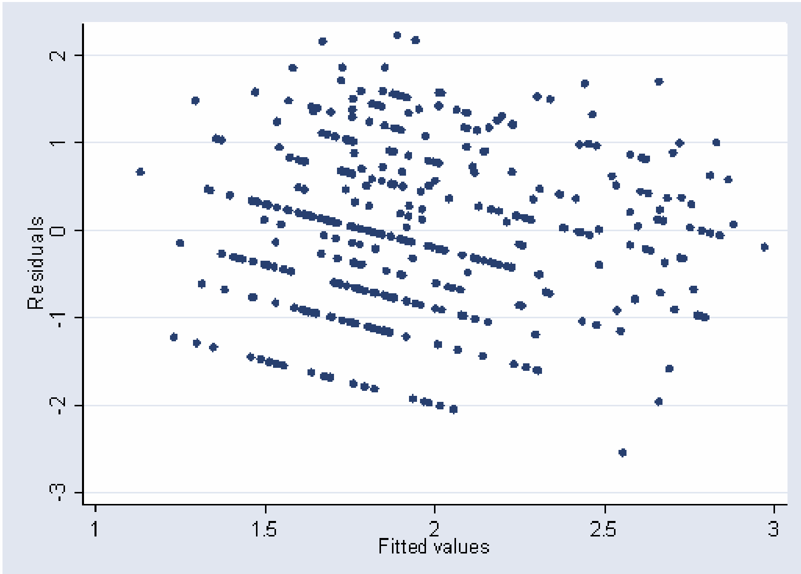
Histograms of Key Variables



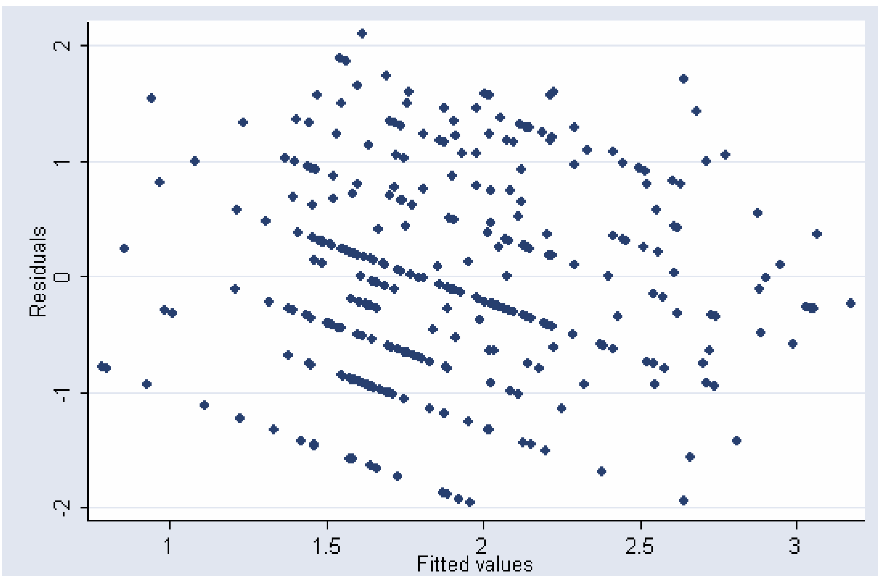
Appendix C

Regression Extras

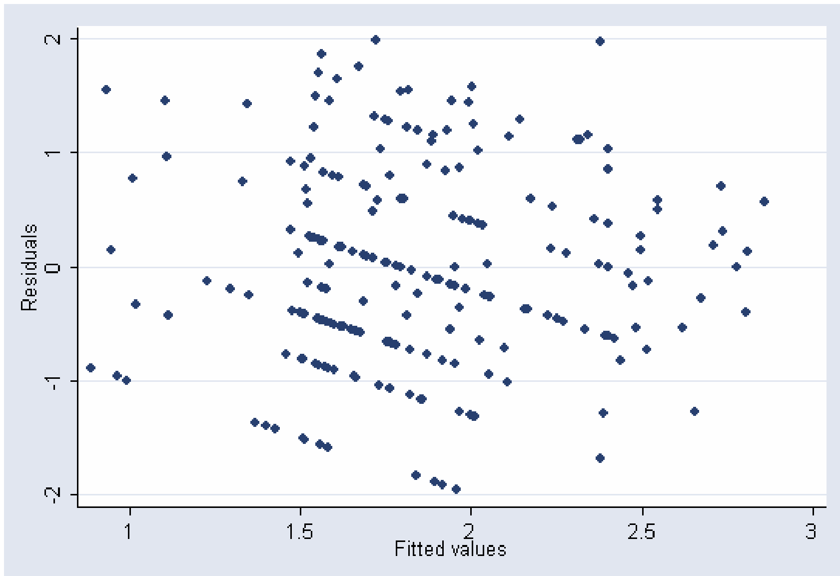
rvfplot – residuals from regression (1)



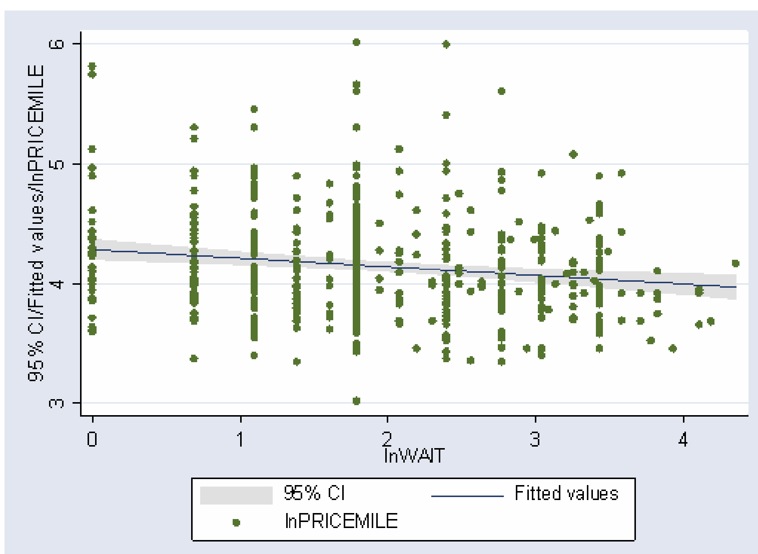
rvfplot – residuals from regression (2)



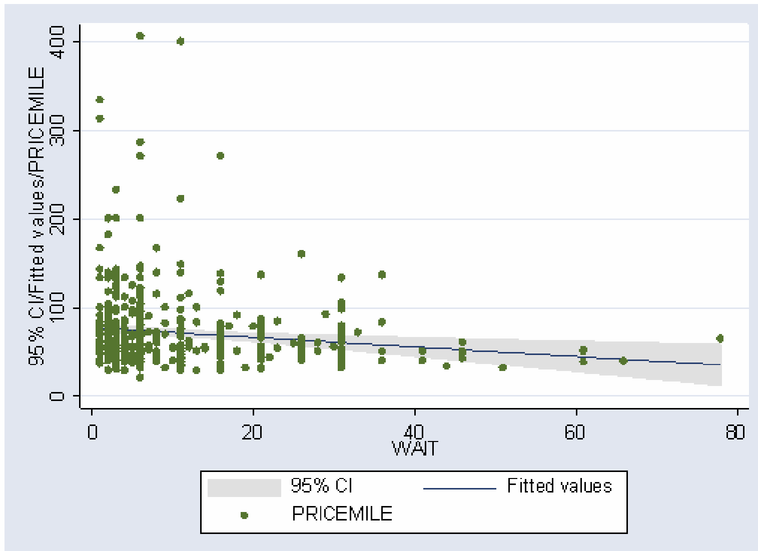
rvfplot – residuals from regression (3)



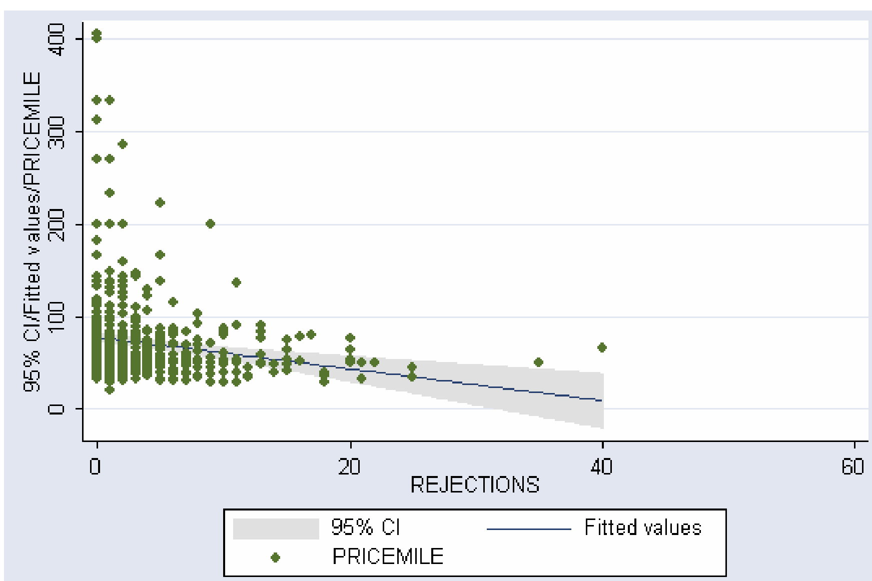
regression fitted plot – lnPRICEMILE and lnWAIT



regression fitted plot – PRICEMILE and WAIT



regression fitted plot – REJECTIONS and WAIT



Appendix D

Theory from the demand side

We begin with a utility function that stipulates that overall utility is derived from a function of speed in transportation and all other goods.

U = f (Speed, Everything Else)

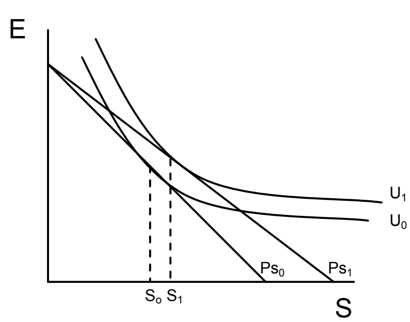
Then we move on to a budget constraint describing the allocation of available resources between speed and everything else. The possible distribution amongst the goods is visually represented by a budget constraint expressed as:

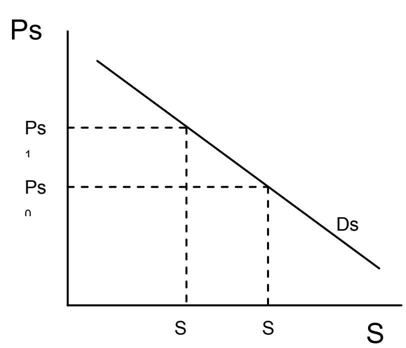
I = PsS + PeE

where I is income, S and E are "speed" and "everything else" respectively, and Ps and Pe are their respective prices. The income constraint can be rearranged to show the quantity of speed chosen at differing levels of income, everything else, and respective prices:

S = [I – PeE] / Ps

The consumer spends all income on the two goods because doing so is necessary to maximize his utility. If the price of speed (Ps) falls, the slope of the budget constraint falls, representing the increased purchasing power. From the changes in S resulting from the changes in Ps, we can derive the demand curve for S, the demand for speed:





To find the utility-maximizing conditions subject to the constraints at hand, we use the method of Lagrangian multipliers. The Lagrangian model takes into account our utility function as well as constraints:

L = U(S,E) - λ (PsS + PeE - I)

dL/dS = MUs (S,E) - λPs = 0

$dL/dE = MUe\ (S,E) - \lambda Pe = 0$

$dL/d\lambda = PsS + PeE - I = 0$

Thus we find several conditions that must hold at a utility maximizing state:

$MUs = \lambda\ Ps$

$MUe = \lambda\ Pe$

$PsS + PeE = I$

We find through the equal margin principle:

$MUs/Ps = MUe/Pe$

$MUsPe/MUe = Ps$

Substituting back into the budget constraint, we find the choice of speed based on everything else when utility is being maximized:

$S = (I - PeE) / (MUsPe/MUe)$