THE NATURE OF EXCESS:
USING RANDOMIZATION TO UNDERSTAND HOW MARKETS EQUILIBRATE

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ABSTRACT

How do prices adjust when markets are in disequilibrium? This paper investigates this question by comparing two models of price dynamics: the classic excess supply model developed by Leon Walras, and the excess rent model developed by Vernon Smith. Past investigations exploring how prices adjust rely upon naturally-occurring variation in the treatment variable (prevailing price) as opposed to experimental control via randomization. We explore price dynamics using laboratory experiments wherein we control the assignment mechanism of the key treatment variable. Across two distinct market institutions, double oral auctions and decentralized bilateral bargaining, our results provide strong support for Smith's excess rent model as the driver of price adjustments.

JEL Codes: D41, D43, D44, C78

Keywords: competitive equilibrium; Chamberlin market; double auction; bilateral bargaining

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1. INTRODUCTION

How do prices adjust when markets are in disequilibrium? Understanding price dynamics as markets equilibrate and adjust to external shocks is not just a foundational question in the discipline; it has become part of the public discourse. Everyone from economists to senior policymakers and public intellectuals regularly opine about how prices adjust to new circumstances. In the 1970s, commentators fixated on oil prices as OPEC disrupted global supply chains. In the new millennium, they have turned their attention to how working- and middle-class wages respond to phenomena such as international trade (Autor et al. 2016), migration (Chiquiar and Hanson 2005), and technological advancements (Acemoglu 1998). More recently, there is a vibrant discourse regarding the impact of sharing economy disruptors such as Airbnb and Uber on pricing in the markets in which they operate (Horn and Merante 2017).,[1] And, perhaps few questions have greater interest today than understanding how prices and wages will adjust during the recovery from a major worldwide shock and the volatility driven by a global pandemic.

Despite the importance of this question for understanding how markets operate, the majority of empirical work exploring price adjustments has centered around the fundamental work of Leon Walras (1874, 1877, 1889, 1896). Known as the "excess supply" model, Walras' analysis yields two testable predictions. First, when excess supply is positive, prices fall, as sellers rationed out of the market bid prices down to secure a trade (and the reverse is true for buyers when excess supply

[1] While the long-term comparative statics of exogenous changes to markets are important, economists also need to understand the short- and medium-term dynamics of prices as they adjust to new equilibria, especially in light of the adverse political impact that such disruptions have had through the rise of populist governments (Lacey, 2019).

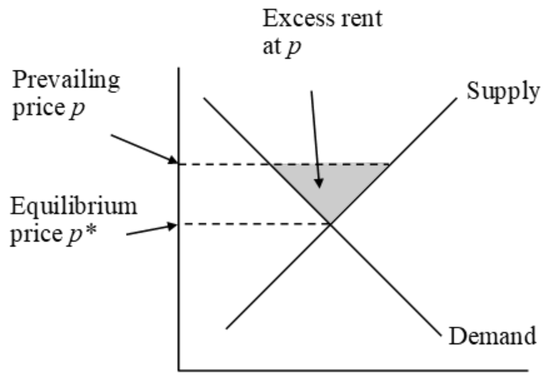
is negative). Second, the greater the absolute size of excess supply, the greater the imbalance and the level of rationing, and thus the greater the absolute rate of change of prices.[2]

As part of his seminal experimental program, Smith (1962, 1965) introduced the "excess rent" model as a refinement to Walras' model of equilibrium price adjustments. Smith accepted Walras' claim that the magnitude of excess supply would influence the rate at which traders would adjust prices as they seek to realize trades. He reasonably argued, however, that the vigor of traders' efforts would also respond to the opportunity cost of foregone profits, or the level of rents that they perceived available at the prevailing price. In a situation where excess supply equals exactly one, Smith reasoned, a seller rationed out when they stand to make $10,000 by lowering prices a little will surely act more swiftly and decisively than one who stands to make only $10—yet, according to the Walrasian model, both will act identically.

More formally, Smith defined excess rent as the difference between the total rent (consumer plus producer surplus) realized at the equilibrium price, and the rent that would be realized at a disequilibrium price were the rationed side of the market able to have its excess demand or supply met. We depict the concept of excess rent in Figure 1.1.

[2] Scores of experimental studies have reported support Walras' model (see Cason and Friedman, 1993) and equilibrium price predictions (Smith, 1962; Smith, 1965; Hong and Plott, 1982; Joyce, 1983; Joyce, 1984; List, 2004; List and Price, 2005).

Figure 1.1: Excess Rent



Smith argued that the absolute size of excess rent, rather than the absolute size of excess supply, drives the rate of change of prices when markets are in disequilibrium. Excess rent, he argued, more accurately measures the trader's foregone opportunities when markets fail to clear; and, consequently, better measures the traders' propensity to adjust prices to pursue those foregone opportunities.

As part of his pioneering work on markets and competitive equilibrium, Smith tested and found support for the excess rent model over its Walrasian counterpart. Despite his model's success, and the widespread recognition of the papers wherein it was presented (they are cited by the Nobel committee), the excess rent model has remained understudied.[3]

This paper seeks to advance our understanding of price dynamics by reviving interest in and awareness of the excess rent model. We begin by taking a retrospective look at the experimental and econometric methods deployed by Smith (1962, 1965) to differentiate amongst the models. In

[3] Inoua and Smith (2020) provides a discussion of the predictions for a variety of classical and neoclassical models of price adjustments and the empirical tests of these models; including an in-depth theoretical discussion of Smith (1962, 1965) and the excess supply model.

doing so, we identify and discuss a number of potential confounds inherent to his analysis. We then design a new series of experiments to address these issues and provide a more definitive test of the excess rent model vis-à-vis its Walrasian antecedent. The ultimate goal of our study is to provide a foundation that inspires fruitful theoretical and empirical advances to the basic Walrasian model and enhances our understanding of price dynamics. We report several insights. First, a retrospective exploration of Smith's (1965) data and experimental design shows that his reliance on naturally-occurring variation and many of his empirical modeling choices erroneously drove his rejection of the Walrasian model. Second, we show that the bijective relationship between excess supply and excess rent inherent in previous experimental designs necessitates that we reconsider the evidence and insights from much of the extant literature; studies that report to have found support for the Walrasian model have also implicitly found support for the excess rent model as the two models are indistinguishable in such settings. Third, using randomization of the treatment variable within an appropriate supply and demand system, we find strong support for the excess rent model versus the Walrasian model. Importantly, this result holds across two distinct trading institutions, Chamberlin markets and double oral auctions, suggesting that it is a general property of price dynamics in markets as opposed to an artifact of behavior in a particular institution.

2. OTHER MODELS OF PRICE DYNAMICS

The aim of our paper is to explore price dynamics through the lens of Smith's excess rent model and its Walrasian antecedent. To date, the Walrasian model remains the workhouse model of price adjustments in the economic sciences and forms the foundation for Smith's extension which considers not just the absolute level of excess in a market but the foregone value of such excess.

We should note, however, that there are several other models of price dynamics that have been explored in the literature and shown to have relevance in specific settings.

One such alternative is the Marshallian theory of market equilibrium which posits that contract formation and, hence, price development adjusts proportionally to the difference between demand price and supply price at any given market quantity (Marshall, 1890). The Marshallian theory has provided an influential competing model that has been widely studied in the experimental literature. For example, Plott and George (1992) find support for Marshallian stability over the Walraisan counterpart. However, to generate discriminating variation, they explore behavior in market systems where at least one out of supply or demand has a perverse slope. Plott, Roy and Tong (2013) extend exploration of the Marshallian model but focus on its complementarities with the Walrasian model in equilibration dynamics. While important, the analysis and comparison of Marshall's theory of equilibrium vis-à-vis the excess supply and/or excess rent models is outside of the scope of this paper.[4]

A related strand of the experimental literature has set forth to model and test price adjustments within the context of a specific trading institution or economy. For example, Cason and Friedman (1996) develop a series of testable predictions for price dynamics in double oral auctions. However, to generate testable predictions, they must rely upon stylized forms of bounded rationality – an assumption that could limit the application of their approach to a broader class of markets and traders. Kimbrough and Smyth (2018) test whether complete information about traders' values and costs and/or market power impedes the ability of double auction markets to

[4] We would refer the interested reader to Colander (1995) for a more detailed description of the Marshallian model, particularly as it pertains to the analysis of general equilibrium.

reach an equilibrium – particularly in situations where the competitive equilibrium generates extreme inequality in earnings. Cason, Friedman, and Hopkins (2021) utilize a continuous-time experiment to study price dynamics and stability in the context of the Burdett and Judd (1983) model whose Nash equilibrium predictions features price dispersion and price cycles. Gjerstad (2013) investigates price adjustments – both within and across trading periods – using continuous double auction trading in a pure exchange economy with strong income effects. Finally, Anderson et al. (2004) and Goeree and Lindsay (2016) utilize double auctions to explore the stability of competitive equilibrium in a three commodity Scarf economy (Scarf, 1960). Our paper differs from this literature in that we use randomization across two distinct market institutions to explore the pricing dynamics of each, effectively setting up a fair horse race between the two major price adjustment models in the literature.[5]

An alternate body of work builds upon the theoretical bargaining literature of the 1980s as a means to investigate the micro foundations of competitive equilibria in markets with bilateral negotiations. For example, there is a large literature exploring whether price-taking competitive equilibria could emerge as the outcomes of such markets as frictions –e.g., the discount rate or explicit bargaining costs – tended to zero (see, e.g., Rubinstein and Wolinsky 1985, Wolinsky 1988, 1990, Gale 1987, and Moreno and Wooders, 2002). A related body of work examines the properties of bilateral bargaining but without taking the limit as frictions go to zero (see, e.g.,

[5] In this regard, our paper is closest in spirit to Easley and Ledyard (1993) who develop a theory of convergence in double auctions experiments and test the performance of this model vis-à-vis predictions from alternatives such as the Walrasian, Marshallian, or game-theoretic.

Cramton 1984; Perry 1986; Chatterjee and Samuelson 1987; Samuelson 1992; Taylor 1995).[6] Yet, such modes focus largely on the existence and properties of equilibria in markets with bilateral bargaining rather than developing explicit predictions about or explanations of price movements en route to equilibrium.

3. RESEARCH QUESTIONS AND APPROACH

The aim of our empirical analysis is to explore which model – excess supply or excess rent – better explains price dynamics. Our identification strategy relies upon differences in the causal effect of the prevailing price on the rate of change in price across the two models. Further, our experiment allows us to explore whether such impacts differ across trading institutions or source of identifying variation – exogenously induced or naturally occurring prices.

In the market for a commodity, let p_t denote the prevailing price at discrete time t, let $\Delta p_t = p_t - p_{t-1}$, and let p^* denote the equilibrium price level. We are seeking to answer the following questions.

1. What is the causal effect of $(p_{t-1} - p^*)$ on Δp_t?
2. If the causal effect of $(p_{t-1} - p^*)$ on Δp_t is non-zero, does the excess supply (Walrasian) model or excess rent (Smithian) model better explain the mechanics?

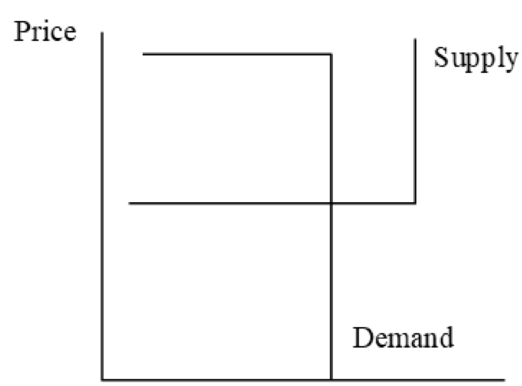
One approach to answering these questions is to create an environment where the explanatory variable of interest, $(p_{t-1} - p^*)$, is exogenously varied using randomized control within a market

[6] Rustichini et al. (1994) and Cason and Friedman (1997) examine similar issues in single call markets rather than those arranged through bilateral negotiation.

system where the predictions of the excess supply and excess rent model differ. To the best of our knowledge, we are the first to implement such an experiment.

In a typical market system, at least one of (if not both) demand and supply are strictly monotonic. In such markets, the relationship between excess supply and excess rent is bijective: the two variables are not variation free, in the language of Heckman (2000). Since both models lack micro-foundations, the only way to empirically distinguish the two models is to rely upon arbitrary functional form assumptions (Alton and Plott, 2008). Smith (1962, 1965) developed an alternate solution to this problem; he introduced the constant excess supply market, shown in Figure 2.1, to eliminate the bijective relationship between excess supply and excess rent.

Figure 2.1: Constant Excess Supply System



In this market, the causal effect of changes in the prevailing price on the rate of change of prices under the excess supply model is zero, whereas the causal effect is positive under the excess rent model.

While Smith successfully tackled the problem of bijectivity, other features of his experiments were problematic and could confound the validity and/or interpretation of his findings. First, Smith did not randomize the prevailing price p_{t-1}; he relied upon naturally occurring variation in trade prices. Hence, it is not clear whether his results should be interpreted as causal due to concerns with the endogeneity of the key treatment variable.[7]

Second, Smith pooled data across market systems with three different levels of excess supply and the various subsystems that arise within a market as trade occurs.[8] The validity of such an approach requires strong assumptions regarding homogeneity of treatment effects across these different systems and subsystems.[9] Neither form of pooling, however, has a theoretical motivation beyond a desire to increase statistical power and could introduce specification errors that bias the estimated treatment effects of interest.

Third, Smith used a linear econometric model despite noting that such a model is potentially a poor approximation of what happens when the prevailing price is close to the equilibrium price. To account for such possibility, he arbitrarily assumed that floor and ceiling effects would affect trades falling within 4.5% of the equilibrium price and examined his results' robustness to dropping trades whose prices fell within this range. However, Smith did not present any robustness checks on the choice of the threshold.

We take a multifaceted approach to explore the robustness of Smith's findings and evidence in support of the excess rent models; we provide a retrospective analysis of Smith's data and

[7] To the best of our knowledge, no paper except Crockett et al., (2011) has deployed randomized control when seeking to estimate the causal effect of the prevailing price on future prices.

[8] In almost any experimental market, the removal of traders following every transaction leads to substantial changes in the remaining demand and supply system – a concern that is enhanced when the number of traders in the market is small.

[9] See Donier and Bouchard (2016) for an exploration of the Walrasian mechanism after trades occur with a dynamic analysis of supply and demand in a continuous time double auction.

complement this with new data from a series of experiments that address the potential confounds embedded in Smith's original design. Results from our retrospective analysis are presented in Tables A1 – A3 of the appendix. Importantly, as shown in Table A3, Smith's findings in support of the excess rent model are not robust and driven by the arbitrary assumptions employed in his original analysis; when we increase the price floor and/or condition the analysis on the underlying level of excess supply, the effect of prevailing price on the subsequent change in prices loses significance.[10] Below we describe data from a new series of experiments that address these concerns and allow us to investigate the causal effect of prevailing prices on observed price adjustments – the key outcome differentiating Smith's model from its Walrasian antecedent.

4. EXPERIMENTAL DESIGN

4.1. MARKET STRUCTURE

We designed a market with constant excess supply over a range of prices, but which modified extraneous elements of the system from round to round. This allows us to discriminate between the excess supply and excess rent models while ensuring that subjects accumulated experience with our protocol but not the underlying features of any given system. The market's properties are as follows.

[10] Nelson (1980) also conducts a retrospective analysis of Smith's experimental design and addresses some of its shortcomings.

- Six "active" traders – two buyers with value v and four sellers with value c, implying a constant excess supply of two units; according to competitive equilibrium theory, there should be exactly two trades per round.
- Values and costs are displaced by an additive constant to ensure that the bargaining tunnels do not overlap in any two rounds.
- Two levels of surplus that alternate between rounds: in half of the rounds (high), $v - c =$ \$16, in the other half (low), $v - c =$ \$8.
- Four "inactive" traders: two buyers with a value below c, and two sellers with a cost above v, who can never trade as we do not allow negative earnings.
- Four real rounds during which traders play either as buyers or sellers exclusively; the four real rounds are preceded by two practice rounds where each trader plays as a buyer once, and as a seller once.
- Every round, traders are randomly assigned active or inactive status; buyers are active exactly twice, and sellers are active at least two times.

Figure 4.1.1: Demand and Supply System Used in Experiments

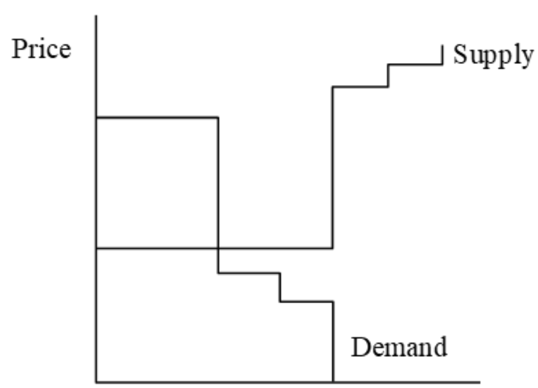


Figure 4.1.1 shows the form of the demand and supply system employed in our experiment. Beyond the generic trading rules below, the only market properties declared to the subjects are the

number of rounds – both practice and real – and that they will be assigned as a buyer or seller in all real rounds.

4.2. Trading Rules

When a transaction occurs at price p, the buyer earns $v - p$, and the seller earns $p - c$; both traders also earn a commission of \$0.25 per transaction. To facilitate comparability with Smith (1965), we run double oral auctions (DOAs) with the usual rules. We also run a series of Chamberlin markets similar to those in List (2004). These markets have the following rules:

- The 10 subjects sit facing the monitor in close physical proximity.
- Each round lasts three minutes.
- Negotiations can take any form, but we ban threats, inappropriate language, side payments, or discussions that reveal a trader's private information.
- Upon agreeing a contract, subjects approach the monitor, who ensures that the trade is legitimate and publicly declares the trade price.

The only substantive difference in the DOA is that the only communication permitted is the announcement of bids and offers when called upon by a monitor. Detailed experimental instructions can be found in the appendix.

4.3. Randomized Price Inducement Technique

A key innovation of this paper is exogenous variation in the prevailing market price to address concerns with past work that relied upon naturally occurring variation.[11] To achieve this goal, the monitor makes the following statement prior to the start of each round:

"In a similar market to the one you are about to participate in, a trade occurred at price $X. You may now begin trading."

The prevailing price *X* is randomized across sessions and rounds, to generate exogenous variation to facilitate identification of a causal effect rather than to push traders into certain equilibria in markets with multiple equilibria as in Plott and George (1992).[12] We provide more detail on our protocol and discuss alternate techniques to induce prices in the appendix.

4.4. Experimental Treatments

Under the assumption that shifting the values/costs by a common additive constant does not affect market dynamics (an assumption that we test and fail to reject), our sessions examine two markets only: $8-per-trade surplus and $16-per-trade surplus. Inference is thus based upon variation in the prevailing price (p_{t-1}) within a given supply and demand (surplus) system. To maximize power, we would ideally induce the highest and lowest possible trade prices in any given market.

[11] Crocket et al. (2011) independently and simultaneously detected this same problem but followed a different approach to address it.

[12] To avoid deception, the announced price was an actual price observed in previous pilot that utilized the same market structure.

However, we chose interior prices for two reasons. First, one cannot get too close to the equilibrium price to avoid a floor effect. Smith (1962, 1965) assumed that this occurred within 4.5% of the constant per-trade surplus equilibrium price[13]. We provide extra clearance by inducing a prevailing price that is 25% above the equilibrium price as the low inducement. Second, on the high side, we induced a prevailing price that is 75% above the equilibrium price to avoid a priming effect (Bargh and Chartrand 2000). Testing for a priming effect requires trade prices to be both above and below the induced price and necessitated we use an induced price that is lower than the highest induced value in any period.

We chose two sequences of price inducement for the four rounds. In session type 1, we chose low-low-high-high. In session type 2, we chose high-high-low-low.

5. RESULTS

5.1. OVERVIEW

We conducted 20 Chamberlin market sessions and 14 DOA sessions across two locations (George Mason University and University of Tennessee at Knoxville). Subjects were recruited using campus specific databases of subjects who had declared an interest in economics experiments. Sessions lasted approximately 45 minutes and subjects earned an average of $20.

Each session contains four real markets with a possibility of two trades per market. For the low surplus markets, there are two versions, both of which are additive displacements of $c = \$0, v =$

[13] See online appendix for an explanation of the floor effect as in Smith (1962, 1965).

$8; similarly, there are two versions of the high surplus markets that are additive displacements of $c = \$0, v = \$16$. For the basic exposition, we pool each pair but later check and confirm that this is statistically valid. Consequently, each market observation i yields the following data:

- The trading rules: Chamberlin market or DOA.
- The surplus $v_i - c_i$, which is either high ($16) or low ($8).
- The induced price $p_{0,i}$, which is either high $p_{0,i}^H = c_i + 0.75(v_i - c_i)$ or low $p_{0,i}^L = c_i + 0.25(v_i - c_i)$.
- The price of the first trade (p_1) and the second trade (p_2).

Table 5.1.1 provides the sample means and standard deviations for the prices of both the first and second trades for each trading institution and surplus level. Based on the two price observations, we calculate the rate of change of prices at the first and second trades, $\Delta p_1 = p_1 - p_0$, $\Delta p_2 = p_2 - p_1$. To avoid assumptions regarding homogeneity in treatment effects across systems, all inference will be conditional on the underlying market system.

Table 5.1.1: Sample Means and Standard Deviations (in Parentheses) of Key Variables

Institution	Surplus	# Obs	Induced price	Trade price 1	Trade price 2
Chamberlin market	Low ($8): c = $0, v = $8	20	Low: $2	$2.4 ($1.7)	$1.6 ($1.3)
		20	High: $6	$2.9 ($1.9)	$2.6 ($1.8)
Chamberlin market	High ($16): c = $0, v = $16	19	Low: $4	$3.6 ($1.9)	$3.5 ($1.4)
		20	High: $12	$6.5 ($3.1)	$5.6 ($3.3)
Double oral auction	Low ($8): c = $0, v = $8	14	Low: $2	$1.7 ($1.2)	$1.9 ($0.9)
		14	High: $6	$3.1 ($2.0)	$2.6 ($2.4)
Double oral auction	High ($16): c = $0, v = $16	14	Low: $4	$3.7 ($2.4)	$2.0 ($1.8)
		14	High: $12	$5.6 ($3.1)	$5.0 ($2.7)

All markets have been transformed by an additive constant such that the common seller cost is $0. One observation was lost from the high surplus, low induced price Chamberlin market.

5.2. PRELIMINARY RESULTS

We begin by examining the homogeneity of various components of our data. The full set of statistical tests underlying each result is presented in Tables A4 – A6 of the appendix.

Preliminary Result 1a: Data from the two experimental locations (GMU, UTK) can be pooled.

We conducted eight Kolmogorov-Smirnov tests for the equality of the distribution functions across locations, covering the two surplus levels, the two induced prices, and the two trading institutions. All fail to reject the null of equality – see Table A4 in the appendix.

Preliminary Result 1b: Data from the two additive displacements within a surplus level can be pooled.

We conducted eight Kolmogorov-Smirnov tests for the equality of the distribution functions across each pair of markets within a surplus level, covering the two surplus levels, the two induced prices, and the two trading institutions. All fail to reject the null of equality – see Table A5 in the appendix.

Preliminary Result 1c: Data from the two trading institutions (Chamberlin market, DOA) cannot be pooled.

We conducted eight Kolmogorov-Smirnov tests for the equality of the distribution functions across trading institution, covering the two surplus levels, the two induced prices, and the two trading prices. One fails to reject the null of equality – see Table A6 in the appendix.

This result is unsurprising since the diffusion of information and the form of negotiations both differ significantly between the two trading institutions. Note that the details of the theoretical and empirical differences between a Chamberlin market and DOA are beyond the scope of this short paper; we merely report their existence and hope that future research can expand upon these differences.

We next investigate whether our interventions had a substantive impact upon the dependent variable.

Preliminary Result 2: The causal effect of induced prices on subsequent trade prices is non-zero.

In each of the four samples (low surplus Chamberlin, high surplus Chamberlin, low surplus DOA, high surplus DOA), we conduct a Mann-Whitney test where the treatment variable is the induced price and the dependent variable is the first trade price. The p-values corresponding to the above four samples are (28%, 0.14%, 3.8%, 9.7%), respectively, meaning that two are significant at conventional levels, one is marginally significant, and one is insignificant. We consider these results as confirmation that our chosen method of inducing prices successfully had an impact on subsequent trade prices.

5.3. Main Results

We next evaluate our primary research questions: when using randomized control, is there support for the excess rent hypothesis over the excess supply (Walrasian) hypothesis?

Result 1: The causal effect of the prevailing price (p_0) on the rate of change of prices (Δp_1) is negative in both our Chamberlin and double oral auction markets.

We first test this using unconditional Mann-Whitney tests on the figures shown in Table 5.1.1. All p-values are less than 1%. To facilitate the interpretation of the estimated treatment effects, we normalize the estimated treatment effects so that they correspond to a $1 increase in the induced price:[14]

- -$0.87/trade in a low surplus Chamberlin market.
- -$0.64/trade in a high surplus Chamberlin market.
- -$0.64/trade in a low surplus DOA.
- -$0.77/trade in a high surplus DOA.

To explore the robustness of these findings and allow for dependence in the data, we estimate the following regression model.

$$\Delta p_1 = \alpha + \beta D_r + \theta p_0 + \varepsilon$$

Where D_r is a round dummy (there are two high surplus and two low surplus rounds in each session) and where the error term ε is clustered at the session level. Models 1 to 4 in Table 5.3.1 show that result 1 holds when including additional controls – a one-dollar increase in the announced price leads to an approximate $0.64 to $0.88 reduction in the rate of change in the first price.

[14] As an aside, preliminary result 2 was equivalent to testing whether each of these four figures is significantly different than -$1.

Table 5.3.1: Regression Models

Model	1	2	3	4	5	6	7	8
Dependent variable	Δp_1	Δp_1	Δp_1	Δp_1	Δp_2	Δp_2	Δp_2	Δp_2
Variation type	Induced/exogenous				Naturally-occurring/endogenous			
Trading institution	Chamberlin market		Double oral auction		Chamberlin market		Double oral auction	
Surplus per trade	Low	High	Low	High	Low	High	Low	High
Prevailing price	-0.88***	-0.64***	-0.64***	-0.77***	-0.82***	-0.93***	-0.30*	-0.23**
Standard error	(0.15)	(0.09)	(0.15)	(0.13)	(0.18)	(0.21)	(0.15)	(0.08)
Observations	40	39	28	28	40	39	28	28
R^2	0.54	0.52	0.50	0.58	0.55	0.51	0.15	0.16

All models include a constant and time effects (both omitted from the table). Standard errors are corrected for clustering at the session level. Asterices denote statistical significance (* = 10%, ** = 5%, *** = 1%).

As an even more conservative test, we use between variation and the first observation from each session. As noted in Table A7 of the appendix, our results are unaffected if we restrict the analysis to the first trade within each session.

Neither the excess supply nor excess rent models explicitly designate the absolute rate of change of prices as the dependent variable. Thus, our next robustness check is to repeat the preceding tests using proportionate changes in the price level $(\Delta p_1)/p_1$ as the dependent variable. As noted in Table A8 of the appendix, our basic insights are unaffected if we examine proportional as opposed absolute rate of change in prices.

We induce the prevailing price by making a statement about an actual trade price in a similar market in a previous session. Since this information is delivered by the monitor, there is a risk of an experimenter demand effect. As a final robustness check, we repeat the hypothesis tests omitting either (1) all observations where the first trade price is equal to the induced price or (2) all observations where the first trade price is within $1 of the induced price. As noted in Table A9 of the appendix, our main findings are unaffected if we exclude trades that occur within a given window of the induced price.

We next compare inferences based on exogenous variation in the prevailing price level, to inferences based on endogenous variation. To do so, we estimate the relationship between Δp_2 and p_1.

Result 2: The causal impact of the prevailing price on the rate of change in prices remains present when using naturally occurring data and endogenously determined prices.

Since the explanatory variable p_1 is multi-valued, as opposed to p_0, which takes only two values in each market, we rely on a regression model equivalent to that used above in the exogenous variation case:

$$\Delta p_2 = \alpha + \beta D_r + \theta p_1 + \varepsilon$$

Models 5-8 in Table 5.3.1 show the results. Since the dependent and explanatory variables differ in the two sets of regressions estimated, we cannot perform a formal statistical comparison of the findings. Moreover, the market systems are different as there are two fewer traders (representing 20% of the total number of traders and 50% of the inframarginal traders) in the endogenous case. However, the main qualitative results are unaffected: there is a statistically significant, negative effect of the prevailing price on the rate of change of prices.

6. DISCUSSION

Understanding price dynamics within and across market institutions is central to economics. To date, the Walrasian model remains the cornerstone upon which inquiries of price dynamics are built. Smith (1965) provides strong support refuting the Walrasian excess supply model. Yet, there are fundamental methodological concerns underlying his experimental design and the resulting interpretation of his empirical analysis.

This study attempts to clarify these issues and provide a definitive test of Smith's model vis-à-vis the Walrasian counterpart. We first show that Smith's rejection of the Walrasian model was driven by arbitrary assumptions that fundamentally influenced his inference. We then present results from a new set of experiments that uses randomization of prevailing prices in a constant excess demand and supply system. This approach permits us to discriminate between the two models using experimentally induced variation in the key variable of interest. We find strong support for the excess rent model across two distinct market systems – the absolute rate at which price approaches equilibrium rises not only with the absolute level of excess supply, but also with the absolute level of potential rents foregone.

However, it is important to note that both the excess supply and excess rent models are intuitively derived and lack micro-foundations. As such, the models produce a limited set of predictions and can only be discriminated amongst in a market system with constant excess supply over a significant range of prices. However, results from our experiment suggest that we should be more confident that the mechanism pushing prices toward equilibrium in all markets – regardless of the strict or weak monotonicity of demand and supply – reflects both the volume of rationing under disequilibrium (Walras) *and* the rents foregone by those unable to secure a trade at the prevailing price (Smith).

We hope that our research will spur new explorations into the micro-foundations of price dynamics, leading to deeper insights into predictions across the excess rent and Walrasian models. A next step in this direction is for a team of theorists and experimentalists to flesh out the models to develop a wider range of precise, testable predictions that allow us to better understand how markets equilibrate. Doing so will help us understand many important phenomena, including the rate at which new technologies such as artificial intelligence effect the labor market earnings of human workers, the path that prices take towards the new equilibrium as tariffs or other barriers to trade are adjusted, or how prices and wages adjust as economies recover from shocks induced by a global pandemic. As such, understanding the process by which prices adjust has import beyond an academic exercise, it could also influence the way in which we design and implement a range of public policies.

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