Appendix

Definition 1 (Buyers/Sellers)**.** *Each buyer, B_i, has a true cost for the item they are buying, c_i, and a bid b_i such that $b_i \geq c_i$. Each seller, S_j, has a true price for the item they are selling, p_j, and an ask a_j such that $a_j \leq p_j$. Buyers and sellers also have a UUID unique with respect to their type. For example, if there are 5 buyers and 5 sellers, the buyers will have UUIDs $0, 1, 2, 3, 4$ and the sellers will have UUIDs $0, 1, 2, 3, 4$. In the program we represent the buyer B_i as a list $[u_i, c_i, b_i]$ such that $B_i[0] = u_i$ is the UUID of the buyer, $B_i[1] = c_i$ is the true cost of the buyer, and $B_i[2] = b_i$ is the bid of the buyer. We represent the seller S_j as a list $[v_j, p_j, a_j]$ such that $S_j[0] = v_j$ is the UUID of the seller, $S_j[1] = p_j$ is the true price of the seller, and $S_j[2] = a_j$ is the ask of the seller.*

Definition 2 (Clearing Price)**.** *Consider some bid b and ask a. The clearing price, $cp(b, a)$, a function of the bid and ask that maps to the price at which the transaction clears. We require that $cp(b, a) \in [a, b]$.*

Definition 3 (Surplus)**.** *Let B_i denote a buyer with cost c_i and bid b_i. Let S_j denote a seller with price p_j and ask a_j. Consider some clearing price $cp(b_i, a_j)$. The surplus for the buyer is defined as $s_{B_i} = c_i - cp(b_i, a_j)$ and the surplus for the seller is defined as $s_{S_j} = p_j - cp(b_i, a_j)$. The total surplus of the transaction, defined $s_{B_i,S_j} = s_{B_i} + s_{S_j}$, is the sum of the surplus for the buyer and the seller. The surplus of any buyer or seller not involved in a transaction is 0.*

Theorem 1 (Surplus Calculation)**.** *The calculation of surplus in the market does not depend on the clearing price.*

Proof. We define the surplus of the market as the summation of the surplus for each transaction. Note that for each transaction with buyer and seller B_i, S_j, the surplus is defined as $s_{B_i,S_j} = c_i - p_j$ and thus does not depend on the clearing price. □