

Internet Economics and Financial Technology - Notes

Dom Hutchinson

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1 The Big Picture

Remark 1.1 - *History of Commercial Computing*

1950-60 Mainframes - slow; size of rooms.

1960-70 Minicomputers - slow; couple per rooms.

1970-80 PCs - faster; one per desk.

1980-90 LANs - distributed networks.

1990-10 Internet - world wide distributed network.

2010-20 Cloud Computing

Where does IT go next? Has it peaked as IT is almost fully diffused?

2 Economic Principles

Definition 2.1 - *Externality*

The production or consumption of a good has an *externality* if it affects a third party who was not involved in the transaction. e.g. Pollution from production is a negative externality; education is a positive externality.

2.1 Micro-Economics

Definition 2.2 - *Microeconomics*

The study of the behaviour of individual economic actors (individuals & business) and how decisions are made based on the allocation of limited resources.

Definition 2.3 - *Production-Consumption Cycle*

Producers produce goods & services which consumers wish to buy. Consumers have a limited amount of money so have to choose what to & to-not buy at given prices. Similarly, producers have a limited number of resources (raw, labour & capital) so need to decide what goods & services, at what price, to produce. These lead to the idea of supply & demand curves.

Definition 2.4 - *Supply and Demand Equilibrium*

The *Equilibrium* of a supply-and-demand curve is a *price* where the quantity demanded by all consumers is equal to the quantity supplied by all producers.

When there is *excess demand* prices will rise due to scarcity of supply. The increase in supply will reduce demand as some consumers will not be happy to pay the higher price, meaning a new (higher) *equilibrium price* will be reached.

If there is *excess supply* prices will decrease as producers try to encourage customers to buy their product over others, this will in turn attract new customers and cause some producers out of business. A new lower *equilibrium price* will be reached.

Definition 2.5 - *Consumer Demand Curve*

A consumer's *Demand Curve* plots the quantity of a product a consumer is willing to buy for a given price-per-unit. These are typically downwards sloping as consumers prefer to pay lower prices. It is assumed a consumer will buy the quantity of units equal to the point where the *Demand Curve* intersects the market price.

The area under the curve, but above the *Market Price* is known as *Consumer Surplus*. This quantifies how much more a given consumer was willing to pay than the market price. The number of items a consumer is willing to buy at the *Market Price* multiplied by the *Market Price* gives the *Expenditure* for that consumer. Consumers want to maximise *Consumer Surplus*. See Figure 2

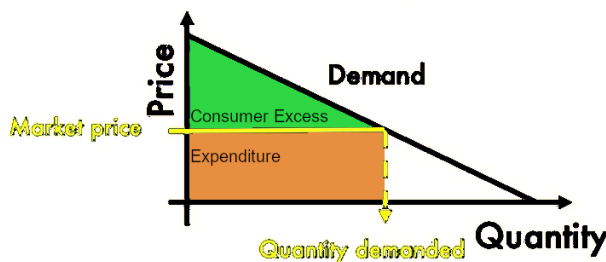


Figure 1: Consumer Surplus & Expenditure

Definition 2.6 - Production Costs

A producer will have costs they need to pay in order to stay in business. These costs can be categorised as

Fixed Costs A company must incur in order to operate, even before they start producing. (e.g. rent)

Variable Costs are costs which depend on the number of units produced. (e.g. equipment, raw materials)

Semi-Variable Costs Labour can be considered a variable cost as you can choose to pay overtime or to hire someone new in order to increase production.

The sum of these values will give you the *Total Cost* of production.

Definition 2.7 - Marginal Cost Curve

Marginal Cost is the cost of producing the last unit. It is equal to

$$\frac{\text{Change in Cost}}{\text{Change in Quantity Produced}}$$

We can plot a *Marginal Cost Curve* of marginal cost against quantity. Typically these are initially downwards sloping, then upwards sloping.

Definition 2.8 - Economies of Scale

When the *Marginal Cost Curve* is downwards sloping *Economies of Scale* are being experienced. *Economies of Scale* are the cost advantages a producer obtains by scaling their business. e.g. By hiring a new staff member existing staff are able to specialise better on their task and thus production per staff member increases.

When the *Marginal Cost Curve* is upwards sloping *Diminishing Marginal Returns* are being experienced. This is common as it is unlikely that hiring 10 new staff will increase marginal production by 10 times that of a single new staff member.

Economies of scale & diminishing marginal returns affect the *Cost Curve* for a producer.

Remark 2.1 - Minimum Sale Price

The *Marginal Cost* of a product is the minimum price a product must be sold at in order to make a profit.

A producer will go out of business if it cannot sell above its *Average Variable Cost* (per unit produced) in the short run; and if cannot cover its *Average Total Cost* (per unit produced) in the long run.

The point where these *AVC* & *ATC* curves intersect the *Marginal Cost Curve* define the minimum amount of units a business needs to sell to stay in business in the short and long term, respectively.

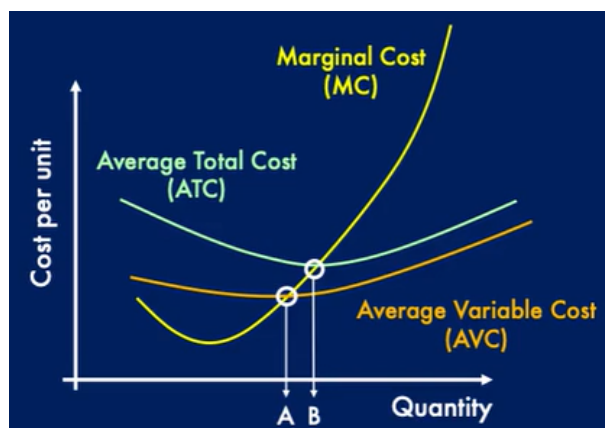


Figure 2: Cost Curve for a Product of a Physical Retailer

Definition 2.9 - Business Supply Curve

A business's *Supply Curve* is the minimum price-per-unit it is willing to sell each quantity of product at. It tends to be upwards sloping as marginal cost increases with quantity. The *Supply Curve* will be truncated and not have a value for small quantities (in practice) as the business would fail if it sold too few products.

Definition 2.10 - Market Supply Curve

The *Market Supply Curve* is the total number of units available, for a given price, across all producers in a market.

The area above the *Market Supply Curve* and below the *Market Price* is the *Producer Surplus*. This is the total additional income a producer receives after costs (i.e. total profit). Producers want to maximise *Producer Surplus*.

Definition 2.11 - Competitive Equilibrium

In a *Competitive Market* the *Market Equilibrium Price* will be that where the *Consumer Demand Curve* and *Market Supply Curve* intersect, as this is the price where quantity demanded and supplied are equal. The *Market Equilibrium Price* maximises total surplus for both consumers and producers.

Definition 2.12 - Shifts

Shifts can occur which move the whole of a supply or demand curve. These occur from non-price factors. e.g. a pandemic will cause a shift in the demand curve for face masks. These will cause a shift in *equilibrium price*.

Definition 2.13 - Monopoly Market

A market is considered a *Monopoly* if its structure is characterised by a single seller (The *Monopolist*). The *Monopolist* faces no competition and thus can be a price setter, rather than price taker. In the real world a firm with over 40% market share is considered to have a monopoly. Monopoly markets are not competitive.

2.2 Elasticity

Definition 2.14 - Price Elasticity of Demand

Price Elasticity is a measure of the how much the price of a product affects the quantity demanded. The more horizontal the demand curve, the greater the quantity demanded increases for a given decrease in price, (i.e. the more elastic the price is).

- A *Horizontal* demand curve has *Perfect Price Elasticity* as a change in quantity has no affect on price.
- A *Vertical* demand curve has *Perfect Price Inelasticity* as a fix quantity is demanded, at any price.
- A *45 degree* demand curve has *Unit Price Elasticity* as an $\Delta\%$ change in supply will produce an $\Delta\%$ change in demand.

Definition 2.15 - Price Elasticity of Supply

Supply Elasticity is a measure of how much a change in quantity supplied will affect the cost of production. The more horizontal the *Supply Curve* is the less the price of production increases for a given quantity.

- A *Horizontal* demand curve has *Perfect Price Elasticity* as a change in quantity has no affect on price.
- A *Vertical* demand curve has *Perfect Price Inelasticity* as a fix quantity is demanded, at any price.
- A *45 degree* demand curve has *Unit Price Elasticity* as an $\Delta\%$ change in supply will produce an $\Delta\%$ change in demand.

2.3 Price Discrimination

Definition 2.16 - Price Discrimination

Price Discrimination is the practice of charging different prices to different customers for the same product. There are three levels of price discrimination

- 1st Degree *Personalised* pricing. The business charges the maximum possible price for each unit sold (perfect price discrimination).
- 2nd Degree Product *versioning* or *menu pricing*. A company charges a different price for different quantities/qualities (ie bulk discount). Consumers have a choice over which version they buy, and thus the price.
- 3rd Degree *Group* pricing. The business charges a different price to different customer groups (e.g. age, location). The consumer does not get to choose their group. The groupings try to separate customers by their *price elasticity* (The more price elastic charged less).

See Figure 3

Proposition 2.1 - Requirements for Price Discrimination

For a seller to be able to effectively price discriminate they must fulfil the following

- i). Be able to *distinguish between customers* so as to know what price to charge them.
- ii). Have enough *market power* to be able to set prices above marginal costs.
- iii). *Resale* must be impractical to prevent arbitrage.

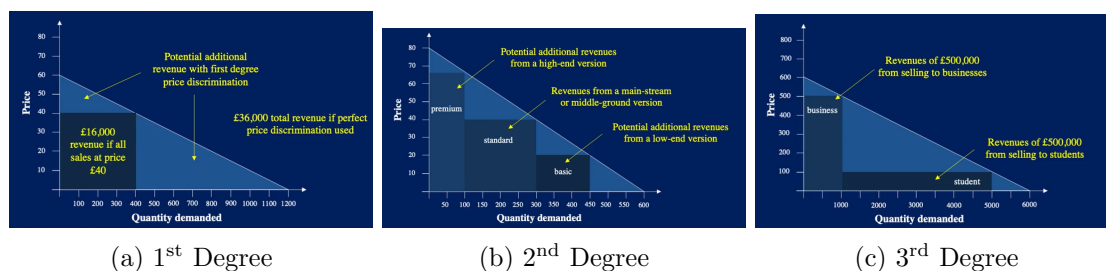


Figure 3: Potential revenue increases for different pricing strategies

It is generally easier for online business to meet these criteria.

Definition 2.17 - Net Utility

The *Net Utility* of a product to a consumer is the difference between the price of the product and the consumer's perceived value of the product. (e.g. If a product is sold at £5 but a consumer values it at £7, the net utility is $£7 - £5 = £2$). It is assumed a customer will never buy a product that has a *negative net utility* to them.

Example 2.1 - Economics of Versioning

Suppose we have a product priced at £10. Consider two customers: *addict* who values it at £20; and *casual* who values it at £8. The company will sell a single unit (to *addict*) at £10.

Now, suppose the company brought in a *cut-down* version at £5 which *addict* values at £8; and the casual user at £7. The company will now sell one full product (to *addict*) and one *cut-down* product (to *casual*) for a total of £15.

In fact, pricing the *cut-down* version at £7 and the *full* version at £19 would maximise profit (assuming customers go for the superior product when they have the same net utility for both) as this would be a perfect price for *casual* and the net utility is the same (£1) for *addict* for both products.

Proposition 2.2 - Competing against Yourself

A risk of versioning is that consumers who are willing to pay for the higher price, will choose to pay for the lower price one (due to greater net-utility). Thus choosing pricing points & functionalities is therefore critical to business success.

Proposition 2.3 - Bundling

Bundling is a form of *versioning* where several goods are sold together for a single price. (e.g. microsoft office). Bundling is used to sell customers products they would not otherwise buy. Bundling can create barriers to entry for competitor producers as it requires competitors to produce a wider variety of product (e.g. a spreadsheet software & word processor rather than just one).

3 The Economics of The Internet

Definition 3.1 - Network Externalities

A *Network externality* is an *Externality* that occurs when the act of buying a product/service has an indirect cost or benefit to those who already own the same product/service. Products with positive network externalities are often known as *Network Goods*.

Owning a mobile phone has a positive network externality as you are increasing the number of contactable people. Owning a car has a negative network externality as you increase road

traffic.

Positive network externalities can produce a *Positive Feedback Loop* where people buy products which are compatible with their friends, rather than necessarily the best product. This is part of *Brand Value*.

Definition 3.2 - Network Effect Demand Curve

We can plot a *Network Effect Demand Curve* (Figure 3) of the price customers are willing to pay against network size. This is slope upwards initially as the marginal value of each extra user is higher; eventually it will slope downwards as these marginal gains diminish.

For any given price there are three equilibrium points q_0, q_1, q_2 for network size. q_1 is deemed unstable, the 'tipping point', as once the network is larger than q_1 it will naturally grow to q_2 (as there is a consumer excess) but whilst it is smaller it will shrink to q_0 (as there is a consumer deficit). This means q_1 is the *Critical Mass* for the network to be sustainable.

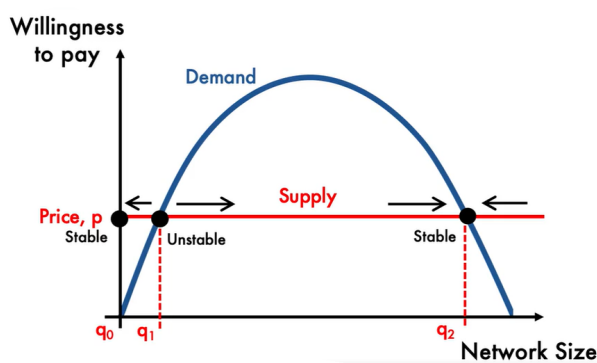


Figure 4: Network Effect Demand Curve

Proposition 3.1 - The Long Tail

Sales business typically sell either: high volume, low margin goods (e.g. burgers); Or, low volume, high margin goods (e.g. cars). Physical sales businesses are constrained by the physical shelf space they have and thus avoid low volume, low margin goods. This means that the sales distribution for products in a physical store will be a truncated *Pareto Distribution*.

Internet businesses have unlimited shelf space to advertise products, and since warehouse space is much cheaper (per sq ft) they can store a lot more products for the same cost, effectively increasing the margin of each product. Meaning there are more products which are profitable to stock and the sales distribution for products of an internet business will have a much longer tail. (See Figure 1).

Remark 3.1 - How to take advantage of 'The Long Tail'

- i). Make everything available.
- ii). Reduce prices (due to economies of scale & reduced costs).
- iii). Help customers find new products.

Remark 3.2 - Sustaining v. Disruptive Innovations

Sustaining Innovations are those that incrementally improve existing products on traditional performance metrics. Eventually these will supersede customer requirements.

Disruptive Innovations perform less well on traditional performance metrics but sufficiently better along other metrics in order to generate new markets.

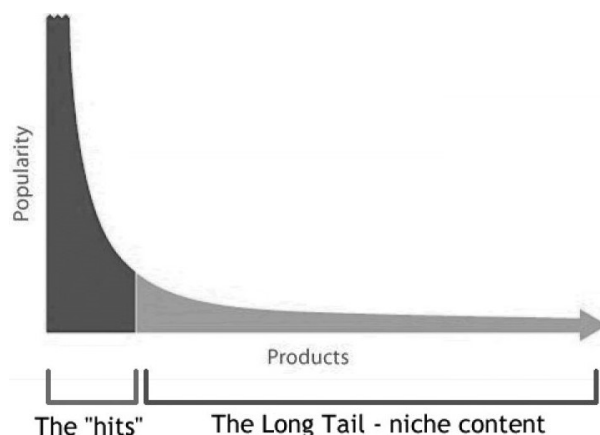


Figure 5: The Long Tail

Proposition 3.2 - Disruptive Technology

Established companies are often late to invest in new *disruptive* technologies. Typically this is due to the *disruptive* tech not reaching the requirements of their customers. However, the *disruptive* tech maybe better in other ways (lighter, more durable etc.) and so can establish a sufficient market for startups to invest in it. Once the *disruptive* tech does reach the requirements of mainstream customers, they are likely to jump to the new tech for these bonus features (lighter, more durable etc.) and the established company may fail.

The new tech may still be less powerful than the established tech, but it is sufficient for customers so it doesn't matter. The traditional performance metric for performance will vary by industry (e.g. mb/£ for hard drives).

Proposition 3.3 - Timeline of Disruptive Technology

- i). *Disruptive Technology* is invent. Often by an established company.
- ii). The *disruptive technology* does not meet established the established company's requirements and so not focused on.
- iii). New companies form to pursue the *disruptive technology*. Often by ex employees of the established company.
- iv). *Disruptive Technology* improves & meets traditional performance metric requirements. The established company will likely try to enter the new market at this point but will be too late.
- v). *Disruptive Technology* becomes the main stream.

Proposition 3.4 - How to spot Disruptive Technology

- i). Determine whether the technology is disruptive or sustaining

3.1 Properties of Online Businesses**Remark 3.3 - Economic Laws**

The *Economic Laws* are not fundamentally different between online & irl businesses, but the characteristics of online business activities can result in different markets.

Definition 3.3 - Combinatorial Innovation

Combinatorial Innovation describes a technology whose components can be combined & recombined to create new products and services. The Internet is a *Combinatorial Innovation* due to its standardised and open-source nature.

Proposition 3.5 - Economic Differences between Digital & Physical Goods

- Digital goods tend to be costly to produce; but *cheap to reproduce*. (i.e. Fixed costs are high but variable costs are low).
- Production costs for digital goods are sunk costs. (e.g. You can sell a building you don't need, but cannot get money back from a software developer).
- There are *no capacity constraints* limiting the number of times something can be reproduced.
- Digital goods are often *Experience Goods*. (i.e. a customer will not know whether they will like it before they try it, and thus cannot assign a value to it).
- *Search Costs* for a consumer are very low. It is easy for consumer to compare products and go with the best. IRL this is harder as it requires going to different stores.
- Digital goods have *strong positive network externalities*

Remark 3.4 - Switching Costs

A customer may incur a cost (inc. non-monetary) to switch services. This is more common (and costly) in the digital space than the physical. When switching costs are too high, consumers are *locked in*. Possible switching costs include:

- Training cost.
- Network effects.
- Setup costs.
- Reduced service quality due to new provider not having all your information (consider switching from Netflix).

Proposition 3.6 - Cost Curve for Digital Goods

Since digital goods have high fixed cost but low variable costs their *cost curves* are very different. The *Marginal Cost Curve* is effectively zero for all quantities; Average Variable Costs are effectively zero for all quantities; and, average total costs tend asymptotically towards zero. This means it is easy for an online business to survive in the short term and the minimum price they are willing to sell a product at is zero (due to v. low variable costs). Eventually the company will need to pay off its fixed costs.

Remark 3.5 - Competition between Digital Companies

- Due to low variable costs, companies with identical digital products will very quickly move prices to near-zero.
- New companies will struggle as fixed costs are high.
- Network effects & switching costs make it hard for new companies.

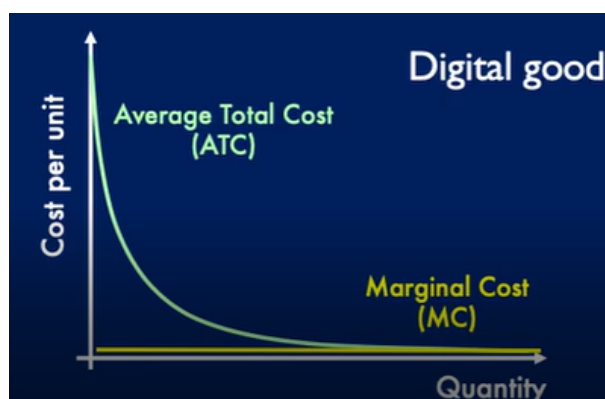


Figure 6: Consumer Surplus & Expenditure

Due to these *barriers to entry* monopolies are common among digital companies. To succeed, a company needs to focus on product differentiation (i.e. innovation).

Remark 3.6 - Formats

Companies can make their software use *Proprietary Formats*, meaning the files cannot be used by other software. This increases switching costs for customers.

Using *Industry-Wide Standards* allow a user's files to be shared between providers. This can increase the network effect, potentially attracting new customers. Here companies have a trade-off between having a large part of a small pie, or a small part of a large pie.

Remark 3.7 - How Standards Develop

Industry-Wide Standards general develop in one of two ways

- i). A *single (major) player* sets a standard by opening up their proprietary format (e.g. PDF).
- ii). A *war* occurs between multiple standard setters. Generally detrimental to everyone involved.
- iii). A *negotiation* occurs between multiple standard setters. There is a risk that one party may pull out of the deal and use their own proprietary format.

3.2 Price Discrimination Online

Remark 3.8 - Personalised Pricing Online

- Consumers tend to perceive personalised pricing as *unfair*.
- Consumers like *transparency* (i.e. how a price is decided).
- European data protection laws *require* companies inform people about the specific purpose of processing their personal data.

Proposition 3.7 - Digital Product Versioning

- Digital versions are used extensively and creatively as they are easy to prepare and near-zero cost to duplicate.
- Buyers have a choice over which version to buy, so do not find the practice controversial.
- *Personalisation of Product* is an extreme type of product versioning (becoming closer to 1st degree price discrimination) as it allows user to specify many properties (e.g. screen quality, amount of ram & storage for a pc).

- People tend to *upsell* towards an “almost top option” when given a choice (the 2nd most expensive bottle of wine is often the most popular).
- Product versioning can cause you to *compete with yourself* as some people who would have paid the higher price, will go for the lower price.

Remark 3.9 - Unbundling

Bundling is common with physical software but there is also a practice of *unbundling*. Since there is no physical substrate online there is less commercial pressure to bundle. (e.g. publishers can sell individual articles rather than a full magazine).

Remark 3.10 - 'Free' Digital Versions

As the duplication cost of digital goods is almost zero, many are given away for free. In these cases there are still several ways for producers to make money: cut-down versions encourage you to buy a full version; Artificial delay (e.g. stock feeds); Ads (or pay for no ads).

'Free' versions allow a customer to build a truer valuation of a product, particularly useful for *experience goods*.

Even if a user is on the free model they are building the *network effect* of the product and likely increasing the *swapping costs* they will experience if they want to change product.

Proposition 3.8 - Freemium Model

The '*Freemium*' business model is to offer different versions at different prices, *including a free one*. The hope is a consumer will *upgrade* to a paid version because they like the service.

4 Auction Theory

Remark 4.1 - Why Use Auctions?

Auctions allow an item to be sold for a price which is wholly decided by a consumer's willingness to spend. *Auctions* are a mechanism for first-degree *price discrimination*, this makes them particularly popular online.

Auctions are used when sellers are *uncertain* about the value consumers place on an object (common with one off items). In this case auctions are good as they allow for *price discovery*.

Auctions are easy to automate and a form of differential pricing.

Definition 4.1 - Private Value

An object's *Private Value* is the value each consumer places on the object. Each bidder knows their private value for an object, but do not know the private value of others nor does knowledge of other bidders' private values affect your private value. This situation is common for consumable goods, less so with investments.

Definition 4.2 - Interdependence

Interdependence occurs when a bidder does not have a fixed value for an object and use other bids to improve their estimate of an object's value. This is common when other bidders may have more information.

Definition 4.3 - Open Auction

In an *Open Auction* all bids are known to all participants.

Remark 4.2 - Assumptions in Auction Theory

In Auction theory several assumptions are made:

- All auctions are equally attractive (ie there are no auctions where no one turns up);
- There is no collusion between bidders;

These assumptions means auction theory often does not work well in practice.

Remark 4.3 - Attendance at Auctions

Entering an auction can be quite involved, so often bidders will skip auctions they don't think they can win.

Definition 4.4 - Signalling

During an auction a bidder may place a 'weird' bid which signals their intent for the rest of the auction to other bidders. This is a form of collusion without any prior agreement necessary. (Consider the T-Mobile - Mannesbanc auction for parts of the german telephone network).

4.1 Open Auctions

Definition 4.5 - English Auction

AKA *Open Ascending-Price Auction*. Used in *Homes under the Hammer*.

- The auctioneer announces a (low) price to everyone.
- If a bidder is happy to pay that price they raise their hand. (Price is reduced if no one bids).
- Auctioneer will announce that that bidder is currently winning and will announce a new, higher price.
- ii)-iii) repeat until no-one accepts the new higher price (ie no hands are raised)
- The item is sold to the person who bid last, at the price of that last bid.

Bidders can infer information from when others drop out of an auction. However, with *Private Values* this will not change their strategy (it would for *Interdependence*).

Proposition 4.1 - English Auction - Optimal Strategy

Let v be the private value a bidder assigns to an object

- It is not optimal for a bidder to bid a price p if $p > v$ as the bidder makes a loss.
- It is not optimal for a bidder to drop out at a price $p < v$ as the bidder still has surplus demand.

Therefore, the optimal strategy is to bid on any price p that does not exceed v .

Remark 4.4 - Weak Bidders

It is harder for a weak bidder to win an English auction as stronger bidders can just accept the next price.

Definition 4.6 - Dutch Auction

AKA *Open Descending-Price Auction*. Used in *Dutch Flower Markets*.

- The auctioneer announces a (high) price to every.
- The auctioneer keep reducing the price until someone bids (raises their hand).

- iii). The item is sold to this (first) bidder, at the price the auction was stopped.

Proposition 4.2 - Dutch Auction - Optimal Strategy

Shade you bid. i.e. bid $p < v$ where v is your private value.

Remark 4.5 - Robustness

Collusion is much easier in an open auction, meaning the auction is less robust.

4.2 Sealed Auctions

Definition 4.7 - Sealed Auction

In a *Sealed Auction* bidding is done in private. Participants do not know what others have bid.

Definition 4.8 - First-Price Sealed Bid Auction

Used to buy *Houses in Scotland*.

- i). Auctioneer announces the auction is open and how long it is open for.
- ii). Each participant makes a single secret bit.
- iii). The highest bid will win, and will pay that price. (ie pay *First-Price*)

Proposition 4.3 - FPSB - Optimal Strategy

Shade you bid. i.e. bid $p < v$ where v is your private value.

Definition 4.9 - Second-Price Sealed Bid

AKA a *Vickery Auction*

- i). Auctioneer announces the auction is open and how long it is open for.
- ii). Each participant makes a single secret bit.
- iii). The highest bid will win, and will pay the price of the second highest bid. (ie pay *Second-Price*)

Proof 4.1 - SPSB Auction - Optimal Strategy

Let v be the private value a bidder assigns to an object, p be the value they bid and c be the greatest value of a competitor bid.

If $p = v$ then

- Bidder wins if $c < p = v$ for a profit of $(v - c)$.
- Does not win if $v = p < c$.

If $p < v$ then

- if $v > p > c$ then the bidder *still* wins with profit $v - c$.
- if $c > v > p$ then the bidder *still* loses.
- if $v > c > p$ then the bidder now loses (making less profit), where they wouldn't have with the previous strategy.

Therefore, bidding $p < v$ never increases a bidders profit. A similar argument can be made for not bidding $p > v$.

The optimal strategy is to bid $p = v$ (same as an *English Auction*)

Remark 4.6 - Auctions for Sellers

If buyers are risk averse (ie don't want to lose the opportunity of buying) then FPSB can increase revenues over SPSB auctions.

Remark 4.7 - Robustness

Sealed auctions are more robust as you cannot observe other bidders actions, and thus cannot punish a colluder who defects.

Remark 4.8 - Weak Bidders

Weak Bidders have a better chance of winning a sealed auction as other bidders may over-shade their bid.

4.3 Equivalent Auctions

Definition 4.10 - Incentive Compatible

Auctions are *Incentive Compatible* if they encourage bidders to bid their true value for an item. Incentive compatible auctions stop game playing between bidders as there is no advantage to second guess other users' values. This makes *Incentive Compatible* auctions more predictable and thus favourable for auctioneers.

English & SPSB auctions are incentive compatible.

Remark 4.9 - Equivalence of English & Second-Price Sealed Bid Auctions

English & SPSB auctions are weakly equivalent as the optimal strategies are only the same if values are *private* (i.e. there is no *interdependence*).

Remark 4.10 - Strategic Equivalence of Dutch & First-Price Sealed Bid Auctions

Bidding a certain amount in a FPSB auction is equivalent to offering to buy at that amount in a Dutch auction. Thus they are *Strategically Equivalent* (for all strategies in one game there is a strategy in the other which will produce the same outcome).

Theorem 4.1 - Revenue Equivalence Theorem

If private values are iid and all bidders are risk neutral, then any standard auction yields the same expected revenue to the seller.

Remark 4.11 - Revenue Equivalence Theorem

In practice the *Revenue Equivalence Theorem* does not hold since bidders are not risk neutral (they do have an emotional attachment to goods) and interdependence exists.