Market Properties and Policy Implications from a Q-bit Market.

The development and implementation of the quantum internet will give rise to a new commodity, the Q-bit. The pricing mechanisms associated with a market are explained in section <<>>, but the objective of this section is to provide a broader discussion on the economic properties of the market. Two areas are of particular interest ;1) the responsiveness of the market to price fluctuations, measured by elasticity; 2) How the market properties will have implications for broader society in the areas of pricing and taxation.

*The Concept of Elasticity*

Elasticity as a concept is measured through percentage changes. Starting with the demand for Q-bits as an example, the elasticity of demand, Ed, is the percentage change in the quantity demanded of a good, divided through by the percentage change in the price of a good. Mathematically, the elasticity of demand is represented as:

Ed = %ΔQd/%ΔP

From this relationship, inferences about the underlying commodity can be made. If the elasticity has an absolute value greater than 1, this means that the percentage change in quantity is greater than the percentage change in price, and is therefore elastic. This indicates that the quantity demand in the market is responsive to small price changes.

If, however the absolute value is less than 1, then this indicates that there is a proportionally larger change in price, for a smaller shift in the quantity demanded. This indicates that the quantity demanded is less responsive to price changes, and considered inelastic. The point in between, when elasticity is equal to the absolute value of 1, is unit elasticity, where the percentage change in quantity demanded is equal to the percentage change in the price.

Elasticity of demand is just one context where the concept of elasticity can be applied. Other contexts include the elasticity of supply, measuring the supply side responsiveness to changes in price; income elasticity, which captures how the quantity of a goods in the market change relative to changes in the income of consumers; and cross-price elasticity which compares the percentage change in quantity of one good, relative to the percentage change in price of another good. An example that we will come back to is how changes in the price of quantum computing may have an effect on the quantity of High Performance Classical Computing demanded.

*Elasticity of Q-Bit Market and It’s Policy Implications*

A number of factors will affect the elasticity of demand and supply in the Q-bit market. The most significant factor affecting the demand for Q-bits is the availability of substitutes. Given that quantum processing can solve unique problems that classical computing can only approximate, there are no close substitutes for Q-bits. Consequently, elasticity of demand will be relatively inelastic; the quantity of Q-bits demand will be relatively unresponsive to price fluctuations and changes.

The supply side of the equation is also going to be initially highly inelastic. However, as time progresses and technological advancements and enhancements increase the computational power of a quantum internet, the supply of Q-bits will become increasingly responsive to price fluctuations. However, the extent to how elastic the supply becomes over time is also going to be affected by potential for excess capacity given the exponential generation of Q-bits with additional quantum systems becoming available.

Irrespective of the magnitude of change, the elasticities, especially on the demand side, indicates that the Q-bit would be ripe for the application of a consumer driven tax. Graphically the imposition of a tax within a perfectly competitive market would take on the following form:

[INSERT FIGURE SH1 HERE]

The graph indicates a downward sloping demand line, indicating that the lower the price, the more Q-Bits would be demanded. The upward sloping supply curve reflects financial incentive, the higher the price, the greater the incentive there is for firms to increase the quantity of Q-bits available to the market. Correlating this to elasticities, a steeper demand or supply curve indicates a higher degree of inelasticity. As such, in Figure SH1, the slope of both the demand and supply curves are relatively inelastic (compared to a 45o line). From this, the imposition of a consumer-based tax can be shown through the vertical shift of the supply curve, with the magnitude of the shift (Pc - Ps) indicating the per-Q-bit value of the tax. Other important observations from the graph are the tax revenue collected (shaded in light teal), the loss of market efficiency through the imposition of a tax (shaded in dark teal), and a relatively small reduction in the quantity of Q-bits offered on the market from the efficient quantity (Qe) to the quantity with the consumer tax (Qt).

An important implication of the imposition of the tax is the share of the taxation burdon. The change in price from the efficient price (Pe) to the new market price faced by consumers (Pc), is somewhat equivalent to the shift from Pe to the price point that the suppliers of Q-bits will receive (Ps). This means that the tax burdon is likely to be equally shares between producers and consumers, which in the long run could act as a disincentive to increased production in the long run.

Figure SH2 however shows a longer-term view of the Q-bit market, where the supply of Q-bits has become more elastic in nature. That is, the quantity supplied to the market becomes more sensitive to price fluctuations. This change in elasticity results in a shift in the tax burden, with a greater proportion of the tax now being paid by consumers, with only a small shift from the efficient price Pe to the price suppliers will face at Ps.

From a policy implications perspective, this means that governments wanting to cash in on the new technology need to be cautious with the imposition of taxes relative to the market maturity. Imposing a significant tax early on may only act as a disincentive to the development of the industry. However, once the market matures further, the imposition of a Q-bit-tax would make strong economic sense, as there will be minimal loss of market efficiency. Importantly, such a tax on computational power alone could serve to be a relatively stable revenue generation tool for governments.

*Game Theory and the Q-bit*

The previous section discussed the implications of the imposition of a tax on the Q-bit market assuming that it operates in a relatively competitive market. However, given the massive technological and financial investment made to realise just a single quantum-computing system, let alone an entire network, means that the likely market structure that will result will not be a perfectly competitive market. Rather, just a few significant firms will likely dominate the space, creating a global oligopoly where profit extraction in the face of various taxation frameworks is to be the more likely scenario.

This then leads to game-theory, which can make a significant contribution to the understanding of how a potential Q-bit market is not only likely to operate, but more importantly, that the suppliers of Q-bits will be engaging in a cooperative game with each other to maximise their utility (profits), while governments will be engaging in a competitive game with other governments with a clear objective; maximize taxation revenue, while not succeeding ground to competing countries for hosting of Q-bit systems. The following sections will discuss these games and provide an indication of how various strategies in terms of cooperation and competition.

*The Nash Equilibrium and VNM Solution for Maximal Utility*