Abstract:

Presently, markets in agricultural products are regulated under the Agricultural Produce Market Committee (APMC) Act enacted by State Governments. The APMC system is riddled with problems. Rigged by middlemen and local politicians, small and marginal farmers often get unfair deals. APMCs levy multiple fees of significant magnitude that are hefty and non-transparent and resulting in a source of political power skewness.

Recent advancements in decentralized finance (DeFi) have resulted in a rapid increase in the use of Automated Market Makers (AMMs) for creating decentralized exchanges (DEXs). In this paper, we organize these developments by treating an AMM as a neoclassical black box characterized by converting input (the price of agricultural products) to outputs (prices). An AMM is independent of a middleman, and price discovery happens through efficient market hypothesis and free market demand-supply dynamics. The conversion is governed by the technology of the AMM summarized by an 'exchange function'. In the following study AMMs are examined, including Constant Product Market Makers; Constant Mean Market Makers; Constant Sum Market Makers; Hybrid Function Market Makers; and, Dynamic Automated Market Makers.

Introduction:

Agriculture, with its allied sectors, is the largest source of livelihood in India, and it has a dire need for robust, trustless, and transparent agricultural infrastructure. India is the largest producer of milk (165 MT), jute, and pulses (14% global share), the second-largest producer of rice, wheat, sugarcane, cotton and groundnuts, and fruit and vegetable producer, accounting for 10.9% and 8.6% of the global share, respectively.

Presently, markets in agricultural products are regulated under the Agricultural Produce Market Committee (APMC) Act enacted by State Governments. The rates of commodities started varying in every region all across India, leading prices to be highly fragmented. Moreover, there are a limited number of APMC mandis which leads to insufficient market options for farmers to sell their produce. Analysis of estimated coefficients shows that the domestic prices of the 15 commodities over the 10–years (2004–05 to 2013–14) were on average 72 percent of the time below the export parity prices

Automated Market Makers: Alternative ways of creating a national market for agricultural commodities

Blockchain technology, consisting of a distributed ledger shared among the stakeholders in a supply chain, provides immutability, transparency, traceability, and fosters trust, which will help address many of the current problems of Indian agriculture, such as the absence of systematic quality assessment, high-quality uncertainty, many intermediaries, questionable market and financial integrity, weak enforcement of rules, poor information flow, high cost, and wastage. Blockchain also helps to keep tabs on abundant commodities and reduce cases of illegal harvesting and shipping fraud. The United Nations reveals that food fraud costs the global economy around $40 billion per year because of illicit trades.

DEXs, and AMMs:

A DEX provides agents with the opportunity to exchange one asset for another without a centralized third-party responsible for overseeing the trading activity. DEXs do not rely on trust in, or security of, a single centralized party as traders retain custody of assets and smart contracts execute trades.

In general, a market maker is an institution that stands ready to buy or sell an asset, generating a profit from the bid-ask spread: the difference between the ask or offer rate (the rate at which the market maker sells an asset) and the bid rate (the rate at which the market maker buys an asset). AMM automates this by allowing traders to place orders with the AMM, which then algorithmically provides a price.

Owners (In this case Farmers) of various assets/commodities place their tokens (tokenized assets on Blockchain) within a liquidity pool in the AMM; the quantities of tokens in a liquidity pool are its reserves. In return, liquidity providers are typically entitled to a share of the fees paid by traders for exchanging tokens. Returns in the form of trading fees provide incentives for agents to act as liquidity providers.

Smart contracts:

A liquidity pool in an AMM is a smart contract with a certain set of tokens that the smart contract can maintain balances of, as specified by its code. The balances of tokens are the quantities that serve as reserves, which change as traders swap tokens in the liquidity pool. The code specifies, among other things, the rules for trading, how prices are determined based on reserves, the rules for liquidity provision, and the trading fees that traders pay to utilize the liquidity pool. An AMM itself, then, is simply a set of liquidity pools.

The workings of a Constant Product Market Maker (CPMM):

In a CPMM, the product of the quantity of two tokens in a liquidity pool is constant. Many AMMs utilize the Constant Product Market Maker model $xy = k$. This design requires that the total amount of liquidity (k) within the pool remains constant. Prices in the pool are determined by this function (shown by the curve below). The cost of each trade is based on how much it shifts the curve. Each additional unit of Asset B that the trader purchases shifts the curve even further right, meaning each unit of Asset B is more expensive than the previous one.

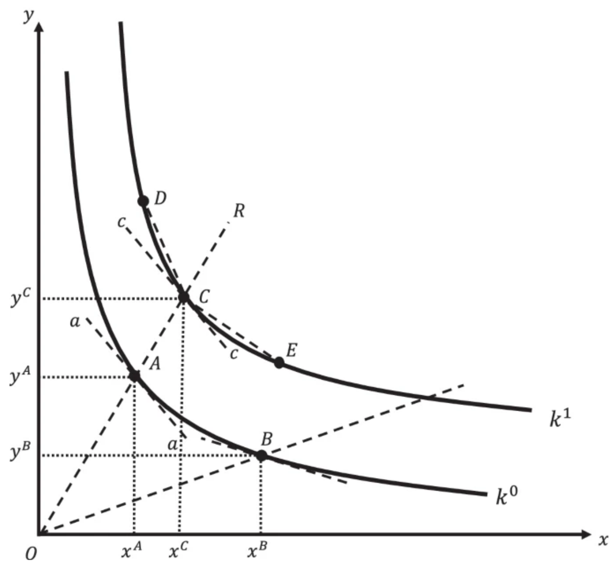
The geometry of a CPMM:

The function used in a CPMM is an example of a class of functions referred to as homogenous functions, which we define formally below.

Homogenous functions A function $f(x1, x2, \ldots, xn)$ is defined to be homogenous of degree r when the following condition is satisfied:

$$f(\lambda x1, \lambda x2, \ldots, \lambda xn) = \lambda r f(x1, x2, \ldots, xn)$$

Geometrically, the exchange function $xy = k$ generates level or contour curves that are rectangular hyperbolas in a two-dimensional graph, as shown in Fig. 1. A level curve shows, in the x−y plane, various combinations of x and y that yield a specific value of k



To see how this works, let the initial amount of Rice supplied by liquidity providers be $x0$=10, and the amount of Wheat provided be $y0$=500; these are the initial reserves of the two commodities in the AMM liquidity pool. In a CPMM, the product of the two is a constant or invariant, k, which takes an initial value $k0$ = $x0y0$ = 5000.

Suppose the trader wishes to sell 1 metric unit of Rice in exchange for Wheat. In the absence of a trading fee, this entire amount is added to the liquidity pool, resulting in a pool balance of $x1$=11 RICE. Given $k0$, the amount of WHEAT in the pool is

$$y^1 = \frac{k^0}{x^1} = 454.5454$$.

The change in the pool reserves of WHEAT is $y1-y0$=−45.4546, which is negative because the reserves of WHEAT in the AMM have fallen; this quantity of 45.4546 WHEAT is sent to the trader's account. The trader has effectively sold 1 RICE in order to buy 45.4546 WHEAT with the AMM, which is the counterparty to the trade; consequently, the liquidity providers for the AMM now, in the aggregate, hold 1 RICE more and 45.4546 WHEAT less. While the AMM has an altered reserve profile ($x1$,$y1$), it is evident that $x1y1$=$k0$, and the product of the new reserve quantities equals the constant $k0$. The price of 1 RICE in terms of WHEAT in this example is $P^b_{Y/X} = 45.4546$ WHEAT/RICE.

In terms of the notation, the subscript Y/X indicates that the price is for one unit of token X (RICE) in terms of token Y (WHEAT), while the superscript b indicates that this is the bid price: the price at which the AMM buys RICE.

It is straightforward to work the example in reverse, where the trader buys 1 RICE from the AMM. Proceeding as before: $x1$=9, $y^1 = \frac{k^0}{x^1} = 555.5556$ and $y1-y0$=55.5556. The price in this instance is $P^a_{Y/X} = 55.5566$ WHEAT/RICE, where the superscript a indicates that this is the ask (or offer) price of RICE: the price at which the AMM sells 1 unit of RICE to the trader

Other types of AMMs for decentralized exchanges:

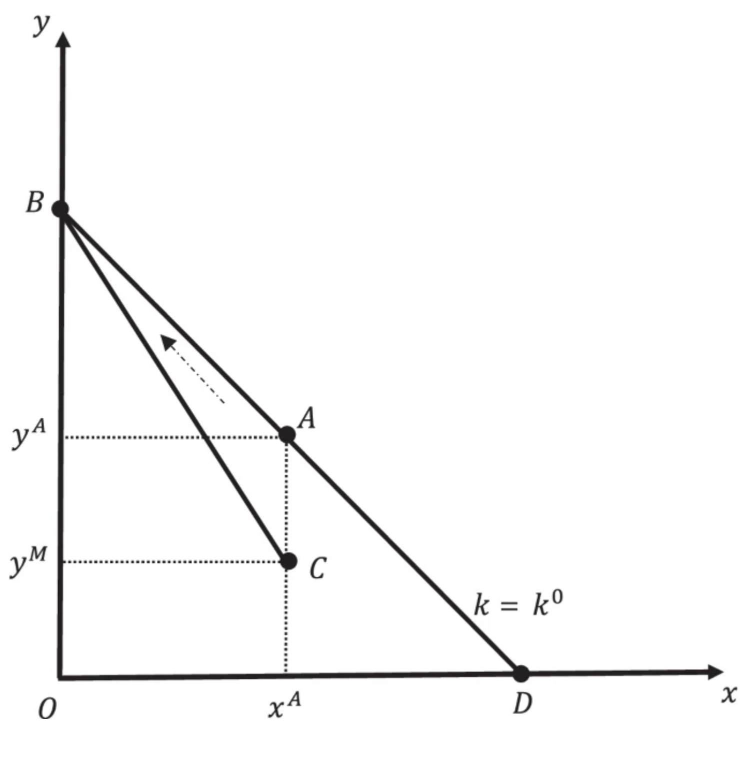
Constant Mean Market Makers (CMMM)

A constant mean market maker (CMMM) has reserves $(x1,x2,\ldots xn)$ of n tokens $X1,X2,\ldots Xn$ that satisfy the exchange function:

$$\prod_{i=1}^{n} x_i^{w_i} = k, \text{ where } \sum_{i=1}^{n} w_i = 1$$

Constant Sum Market Makers (CSMM):

There has been some discussion in the DeFi space about the usefulness and limitations of a constant sum market maker (CSMM). For reserves (x,y), a CSMM holds the sum of reserves constant, that is, the exchange function satisfies $x + y = k$. Of course, one could generalize this to $ax + by = k$, or to $a1x1 + a2x2 + \cdots + anxn = k$. In a decentralized exchange, however, the constant price in a CSMM is problematic if the external market price is variable.



Hybrid Function Market Makers (HFMM)

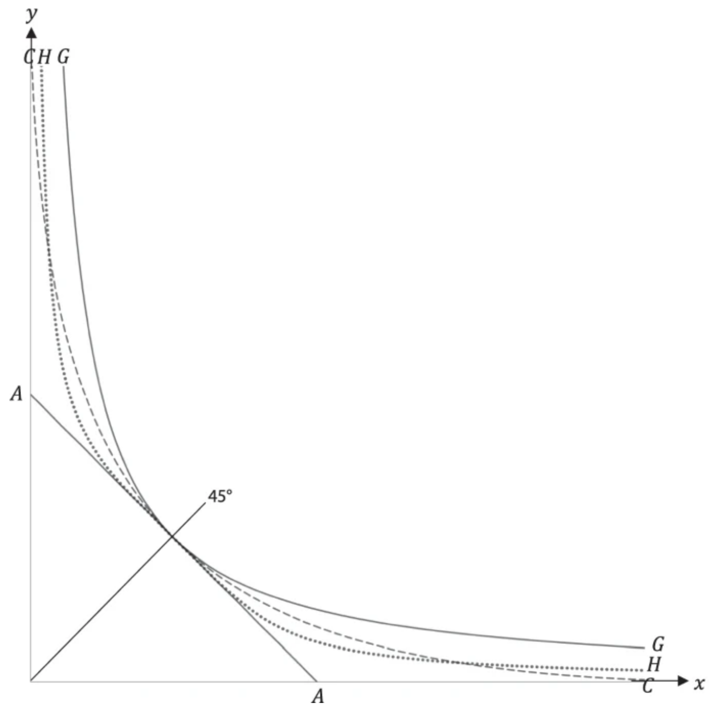
One of the advantages of a CSMM is that there is no price slippage, which is a problem with a CPMM/CMMM. However, the disadvantage of a CSMM is the possibility of a corner equilibrium when token prices are volatile, which cannot happen in a CPMM/CMMM. A mix of a CPMM/CMMM and a

CSMM that emphasizes both their advantages, while minimizing their problems, would be a desirable middle-ground in many situations, such as the exchange of stablecoins. A Hybrid Function Market Maker (HFMM) attempts to achieve this by integrating the exchange functions of a CSMM and a CPMM/CMMM.

We can derive the bilateral price using the same AM-GM inequality as:

$$P_{X_j/X_i} = -\frac{dx_j}{dx_i} = \frac{2\left(1-\frac{G}{A}\right)\frac{\partial G}{\partial x_i} + \frac{G^2}{A^2}\frac{\partial A}{\partial x_i}}{2\left(1-\frac{G}{A}\right)\frac{\partial G}{\partial x_j} + \frac{G^2}{A^2}\frac{\partial A}{\partial x_j}}$$

The outcome of this discussion is shown geometrically in Fig. 3 for the two commodities:



Conclusions:

This paper presented a unified framework based on the neoclassical black-box to characterize different types of AMMs that are currently popular as DEXs. One of the main advantages of such a framework is that it provides a set of simple tools that can be used to visualize the geometry of a given AMM. AMM models provide a different class of solutions that
are decentralized, fast, and attract fair pricing on the fair interplay of market dynamics. Although the AMM model overcomes the problem of the centralized counterparty, the institutions are sensitive to the size of the pool and the trades.

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Understanding Automated Market-Makers, Part 1: Price Impact
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