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ADDRESSING MARKET INEFFICIENCIES THROUGH AGRICULTURAL MARKET INFORMATION SYSTEMS AND DIGITAL TECHNOLOGIES IN PUNJAB

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Abstract: The paper intends to analyze the market inefficiencies in agriculture and how these inefficiencies can be overcome by Agricultural Market Information Systems (AMIS) and Digital Technologies in the context of an agrarian economy of Punjab. Market inefficiencies lower the profits that the farmer receives from agricultural operations. Numerous market inefficiencies limits agricultural operations, which includes technological inefficiencies, input and output market inefficiencies, land market inefficiencies, labour market inefficiencies, credit market inefficiencies, risk market inefficiencies, and informational inefficiencies. Therefore, in order to address market failures in agriculture, there is need to evolve the potential strategies for making markets more efficient to overcome existing inefficiencies through robust Agricultural Market Information Systems (AMIS) and Digital Technologies in the context of Punjab. AMIS can play a vital role in agricultural development by enhancing transparency, competitiveness and equity in benefit sharing. Robust AMIS can be useful for enhancing the capacity of the government to take appropriate programmes for agricultural growth. AMIS can strengthen the bargaining power of small farmers and improve their awareness on market opportunities and options. However, understanding market information often requires external assistance and in this context, the digital technologies can help the small farmers to identify and address market inefficiencies by tapping the opportunities of Information and Communication Technologies (ICTs). AMIS along with the digital technologies help the small farmers overcome the market inefficiencies and increase their knowledge by new ways of providing extension services for improving agricultural supply chain management. The "digital dividends" of ICTs in the form of improved rural livelihoods are evident, but have not scaled up to the extent expected, as the technology can only address some, but not all, of the market inefficiencies faced by farmers.

Keywords: Market inefficiencies, Agricultural market information systems, digital technologies, Punjab

JEL Codes: Q02, Q13, Q16, Q19

I. INTRODUCTION

Globally, it is estimated that the majority of the poor will live in rural areas until 2040 (Ravallion *et al.*, 2007) with agriculture as a major source of income and employment. Therefore, reduction of poverty is directly linked to agricultural outcomes by switching to new crops, improved breeds of animal, or changes in agricultural practices and crop diversification. In recent past, the new agricultural technologies have benefited many farmers in Punjab, but have increased both intra-and inter-regional inequalities (Freebairn, 1995). However, rural market inefficiencies have lowered the agricultural outcomes from adoption of new technologies. Agricultural market imperfections are mainly due to missing markets for risk, credit, or land. Absence of market inefficiencies will have resulted in better agricultural outcomes from adoption of new technologies in Punjab.

Therefore, successful strategies for addressing the market inefficiencies will remove technological constraints on their adoption and improve farmer's welfare. For instance, agricultural technologies might result in higher adoption rates if credit markets offered low-interest loans or if property rights were secure. It is likely that improving market efficiency by providing the farmers with strategies to overcome existing inefficiencies will increase technology adoption. In this context, agricultural market information system (AMIS) and digital technologies have huge potential to address the constraints on adoption of beneficial technologies. With above backdrop, the present paper is an attempt to identify the market inefficiencies that constrain agricultural technology adoption and how these inefficiencies can be overcome through agricultural market information system (AMIS) and digital technologies. It will provide strategies to overcome adoption constraints to the promoters of agricultural technologies.

II. BENEFICIAL TECHNOLOGY ADOPTION AND MARKET INEFFICIENCIES

An agricultural technology may dramatically increase agricultural production, but it does not necessarily mean that it should be adopted. For instance, some crops may have higher yields but also may be more sensitive to drought and making these technologies profitable requires large investments in irrigation infrastructure, which may be very costly for some farmers. In this case, the labour and capital costs of infrastructure development are real costs and if the real costs are less than the total value created by higher adoption rates, then the investment in irrigation are worthwhile. However, market inefficiencies may add additional costs, thereby making irrigation investment unprofitable due to difficulties in securing a loan if credit markets are weak. The farmer may not be able to recover these fixed costs from future users if contracting is difficult.

Farmers may not adopt the agricultural technology if market inefficiencies lower the profits.

Ideally speaking, a beneficial technology creates benefits greater than its costs and is profitable without market inefficiencies and market failures. An agricultural technology which is profitable to one farmer may not be profitable to other because of differences in credit access or household-specific labour constraints. The profitability of existing agricultural technologies may not include all inputs such as household labour (Foster and Rosenzweig, 2010). Even the information needed to determine agricultural investment to improve farmer's welfare through technology adoption is lacking. Uncertainties such as weather, price, and other shocks also determine the expected profitability of a technology. Expected profitability from agricultural investment also varies spatially, with micro-climates or distance from urban markets. Individual farmer or household preferences will also affect the perceived benefits from technology adoption, which may vary within the household. For instance, productivity increases due to the high-yield varieties is more in ecologically favourable areas but have often bypassed small farmers on marginal land (Almekinders and Hardon, 2006). Rich farmers are able to correct unfavorable micro-environments through inputs such as irrigation and fertilizer, but poorer farmers are not. The profitability of highly sensitive technologies will be affected by the micro-climate and other variable factors (Evenson and Westphal, 1995). Therefore, an agricultural technology, which is profitable in specific circumstances, should not be adopted by all farmers. Rates of return to high-yield varieties are often more on demonstration plots but may not be uniformly positive across farmers (Suri, 2009).

Besides micro-environment, the macro-economic environment also directly and indirectly affects agricultural prices and the profitability of new technologies for potential adopters. Government policies that directly distort prices include tariffs, input and credit subsidies, price controls and public investment. Likewise, industrial protection, exchange rates and interest rates, and other fiscal and monetary policies indirect affect agricultural prices and profitability (Schiff and Valdés, 2002). Therefore, it is necessary to address market barriers to agricultural technology adoption through robust market information system and digital technologies.

III. MARKET INEFFICIENCIES AND TECHNOLOGY ADOPTION

There are numerous market inefficiencies that constrain the adoption of beneficial agricultural technologies, which includes externalities, input and output market inefficiencies, land market inefficiencies, labour market inefficiencies, credit market inefficiencies, risk market inefficiencies, and informational inefficiencies.

(i) Externality related inefficiencies

Externality related inefficiencies arise when adoption of agricultural technologies may not exclusively benefit the individual farmer who adopts them. For instance, practices which reduce soil erosion, conserve water, or control pests may not benefit the practicing individual farmer only but the wider farming community. Likewise, the first farmers to adopt a new technology in an area may generate positive externalities for other farmers in the form of information about how to use the technology (Besley and Case, 1993; Conley and Udry, 2001). In these situations, investment in a new technology will be less than optimal, as long as individual farmers are not rewarded for the benefits which they generate for others (Foster and Rozensweig, 1995). Early adopters of a technology provide information for others about the benefits and correct use of a technology, and disproportionately bear costs of the learning process. There are associated informational externalities, which result in delayed adoption of technologies. Besides, farmers strategically postpone adoption and free ride on the benefits provided by others. Technology subsidies also contribute to resource-depleting activities, such as electricity subsidies that lead to over-extraction of groundwater, or chemical fertilizer subsidies that generate downstream pollution (World Bank, 2008).

Natural resource externalities need collective action to overcome over-extraction such as groundwater decline, which is a common property wherein each individual's extraction is linked with the extraction of neighbour's resource too. Thus, private benefits associated with groundwater extraction are more than the social costs. The likelihood of collective action to resolve natural resource-related externalities tends to depend on the costs of cooperation specifically the transactions costs (Pender and Scherr, 2002; Godquin and Quisumbing, 2008). New institutional arrangements are needed to penalize those who generate negative externalities and reward those who generate positive externalities. Incentives such as financial subsidies for early technology adopters may also be provided through informal mechanisms at the community level to eliminate the incentive to free ride. Lowering monitoring costs may also help reduce environmental externalities and improve natural resource management through collective action and address market inefficiencies (Ostrom 2005).

(ii) Input and output market inefficiencies

Input and output market inefficiencies reduce the profitability of a technology to the farmer. Lack of infrastructure drives a wedge between the prices that farmers receive for their output and the market price, thereby lower the benefits from technology adoption (Jimenez, 1995). Poor infrastructure increases the market power of intermediaries. Farmers associations and agricultural cooperatives may offer solutions to lowering the transaction costs associated with smallholder inclusion in markets (Reardon and Timmer, 2007). The private sector may be promoted as a reliable source of inputs and a provider of output markets to overcome adoption constraints associated with input and output market inefficiencies. Unreliable supply, high prices of fertilizer, and other inputs are primary barriers to technology adoption due to inadequate infrastructure, missing supply chains, and unprofitably high prices. Therefore, public infrastructure plays a key role in facilitating technology adoption and investment. Technologies that increase production may not translate into higher profits if higher supply lowers prices. To the extent that farmers (or groups of farmers) anticipate these price responses, they have less incentive to increase outputs. Information asymmetries also increase the gap between farm-gate and market prices. If middlemen have better information about market prices, then they can extract information rents from the farmers.

Farmer organizations and agricultural cooperatives have the potential to address many of the adoption constraints associated with input and output market inefficiencies by improving farmer bargaining power, reducing individual risk, decreasing transaction costs, and improving credit. Crops that rely on more complex marketing chains are affected more by input and output market inefficiencies (Ashraf *et al.*, 2009). Similarly, crops that are extremely timing-sensitive in distribution are least likely to be taken up if markets, intermediaries, and storage facilities are unreliable. Without intermediaries that foster trust and build reliable supply relationships, smallholders may be unable compete in supermarket and export markets. Therefore, better off farmers are better able to participate in modern supply chains (World Bank, 2008). Private sector supply chains and improving public sector distribution may offer more sustainable solutions. Leveraging information technology to reduce transaction costs may help farmers overcome existing inefficiencies. Approaches to improve input and output market efficiency involve stimulating and stabilizing demand for inputs through input supply chains. Subsidies can be helpful in stimulating the demand side of agricultural value chains, but are often distortionary or politically motivated and may deliver the benefits to those who are least in need. Therefore, there is need for better targeting of subsidies to ensure that the subsidies go to those who would not have otherwise taken up the product.

(iii) Land market inefficiencies

Land market inefficiencies have significant implications for agricultural technology adoption. Lack of tenure security undermines incentives for long-term investment in irrigation and planting tree crops (Ali *et al.*, 2011). A lack of formal title often means farmers cannot use land as collateral to borrow, and cannot sell land to raise financing for investment in technologies. Rural poor have more of their wealth in land, and land markets inefficiencies affect them disproportionately. Other than land sales, share tenancy and rental markets are most common institutional arrangements (Otsuka, 2007). Therefore, approaches to reduce the surplus extracted by landlords and to increase landholder investment incentives may help to overcome the barrier to technology adoption created by weak land tenure arrangements.

Compared to output sharing, land rental markets should create strong investment incentives by making the renter the full beneficiary of increases in productivity. Rental contracts generate the greatest incentive to invest. Insecure property rights are commonly associated with lower investment in agricultural productivity. In particular, investments with long payback periods, such as tree crops, are least likely to be adopted because by the time that benefits are generated, land may have changed hands and expanding formal property rights is associated with increased investment (Do and Iyer, 2003). Therefore, interventions that improve trade in land rights are likely to improve adoption incentives, since those best able to make productivity investments will value the land most. Improved trade can also ease inefficiencies associated with externalities. Improvements in rental markets have also been shown to increase investment and generate productivity gains.

(iv) Labour market inefficiencies

Human capital plays a very vital role in agricultural technology adoption. Labour market inefficiencies may mean farmers do not gain all the benefit of their improved productivity, which can undermine the incentive to invest in human capital accumulation. Labour market inefficiencies directly affect incentives to adopt new technologies. Profitable technologies can increase the productivity of labour and allow for more off-farm labour income (Huffman and Orazem, 2007). However, where local labour markets are seasonal and characterized by involuntary unemployment, the incentive to adopt labour-saving technologies is diminished. Agricultural technologies require additional labour may not be adopted if hired labour is more expensive than household labour. This is because the household bears the transaction costs of labour market participation (Roumasset and Lee, 2007). Labour market inefficiencies are likely to be exacerbated by poor transportation infrastructure and information flows. Out-migration is typically associated with labour-saving technology (Foster and Rosenzweig, 2008). Accumulation of human capital can affect technology adoption rates. More educated farmers are better able to process more general forms of information to innovate with respect to available technology, and to copy early adopters (Wozniak, 1993). Institutions that support better labour market outcomes have tended to produce economic growth (Acemoglu *et al.*, 2001). Investment in human capital, including general education and specific training associated with new technologies is thought to speed the technology adoption process. Improved access to transportation infrastructure and information can assist with mobility and the geographic allocation of labour.

(v) Credit market inefficiencies

Lack of capital is a major reason for not adopting an agricultural technology to improve productivity (Croppenstedt *et al.*, 2003). Imperfect rural financial markets can prevent farmers from borrowing to invest in a new technology. Collateral is often used to improve access to financial products because it helps offset asymmetric information and moral hazard risks to lenders. But the rural poor require collateral substitutes such as supply contracts for farm output (Dries *et al.*, 2004), standing crops, and reputation (de Janvry *et al.*, 2010). Therefore, overcoming financial market inefficiencies has positive implications for agricultural technology adoption. Credit market inefficiencies constrained farmers to use significantly less high-yielding inputs, which acts as a major barrier to technology adoption. Financial market imperfections make borrowing difficult for the poor and allow lenders and other financial intermediaries to extract many of the financial gains from technology adoption. Rural financial markets are also often highly fragmented and different rates are charged within a single market (Conning and Udry, 2007).

Lowering the costs of providing credit to the poor is almost certainly desirable, however, subsidizing credit is not efficient. Lenders are often less willing to finance investments that are more susceptible to information asymmetries. Poor farmers who lack assets such as secure land tenure may be unable to offer the collateral necessary to access credit. If farmers lack access to insurance markets, credit may be sufficiently risky and poor farmers would prefer not to borrow at all. Collateral is a straightforward way to address financial barriers, but for the poor there is a need to find collateral substitutes. A more common collateral substitute is group liability, which uses social capital for collateral and is typically viewed as a useful innovation that reduces monitoring costs and lowers default rates. Additional adaptation of collateral substitutes to agricultural settings may help lower financial barriers to technology adoption. Lowering the transaction costs in verifying collateral has potential to improve credit access. Improvements in information technology can help reduce the transaction costs that make financial transactions costly.

(vi) Risk market inefficiencies

Risk market inefficiencies constrain adoption of new technologies, especially early in the adoption process when proper use and average yields are not well understood and risk-coping mechanisms are not available (Duflo and Udry, 2004). Insurance, safety nets, and other risk coping strategies are potential approaches to offset risk market inefficiencies. The technology adoption decision may be a discrete problem (whether to adopt at all) or a continuous problem (how much to adopt). Divisible technologies that allow for adoption of small amounts at a time may be less hindered by risk barriers than are technologies that take on an all-or-nothing character. The degree, to which a potential adopter can try something out on a small scale first before adopting it completely, is a major determinant of adoption. Thus, agricultural technologies that require large upfront investments, such as machinery or irrigation systems, may be deterred by both imperfect credit markets and by risk and uncertainty. Risk and uncertainty may affect decision making at any stage of the production process, from inputs to storage, processing and marketing.

Households may also buy and sell assets to smooth income (Rosenzweig and Wolpin, 1993). Households also mitigate risks by adopting crops or practices with lower yield variance. New technologies that increase yield variance are unlikely to be adopted by a household concerned with risk management. At the same time, households often pursue multiple sources of income to diversify risk, resulting in lower average income than would result from a strategy that focuses on more lucrative income streams (Banerjee and Duflo, 2007). Farmers are most likely to take on a new crop variety if they have other sources of stable income to offset the risk of experimentation (Minten and Barrett, 2008). Short-term shocks, such as those created by most adverse weather events, will have long-term effects if formal and informal coping mechanisms are inadequate (De Janvry *et al.*, 2006). Weather insurance is an option available to farmers in an effort to offset risk and uncertainty barriers to technology adoption.

(vii) Informational inefficiencies

Technologies that are individually profitable will not be taken up without information about their profitability or about how to correctly use them. Information about new technologies comes from a variety of sources: farmers' own experience, neighbours' decisions and experiences, and external sources such as extension workers or the market. Generally, technologies that are technically complicated or require precise implementation will suffer most from information barriers due to low or negative expected profits if used incorrectly. Certain groups, such as women, may face larger information barriers if information is less accessible to them. Lack of information may present a barrier on both the demand and the supply side, and a lack of information about the latent demand for a technology may contribute to input and output market inefficiencies and low levels of adoption. Strategies for overcoming a lack of information often involve making information less costly to acquire or distribute. Like the distribution of other goods and services, information distribution relies on the incentives of the distributor. A monopsonist buyer has an incentive to tell farmers about a new technology since they will be able to capture much of the benefit of increased production. A government agricultural extension worker, on the other hand, may lack both the incentive and accountability needed for reliable information supply to meet the needs of smallholder farmers (Anderson and Feder, 2007).

Simply providing information about the payoffs from a technology has been shown to increase adoption (Jensen, 2010). Peers may be better able to pass on information about how to use a technology (Oster and Thornton, 2012). The decisions of leaders within a community can have a substantial impact on the adoption decisions of others, particularly when a technology is unfamiliar and its benefits are difficult to observe. Trusted individuals or those perceived to be experts may be in a better position to supply information about the benefits or use of new technologies (Cole *et al.*, 2013). Information may also be effective in the form of advertising for adoption of new agricultural technologies. Improving approaches to framing and presentation of information may help overcome information barriers to adoption. A fundamental challenge to overcoming informational barriers to technology adoption is making information supply and acquisition less costly. New approaches to providing information to farmers appear promising. Introduction of free internet kiosks showing daily agricultural information significantly increased farm returns. Use of mobile phones and SMS provides information to farmers about the prices available in the nearest wholesale market, where the middleman sells the farmer's product. Farmers with better access to commodity price information via radio are able to bargain for higher prices. Other types of information may be more valuable to farmers, and phones or other forms of ICT may lower the costs of delivery.

IV. AMIS AND DIGITAL TECHNOLOGIES

AMIS can play an extremely important role in addressing market inefficiencies for small farmers by enhancing transparency, competitiveness and the more equitable sharing of benefits in the marketing system. A good MIS is also useful in enhancing governments' capacity to take appropriate policy and planning decisions in support of agricultural growth. With regard to small farmers, an MIS can contribute towards strengthening their bargaining power and improving their awareness of market opportunities and options. Market information can help small farmers regarding market prices and use of new technologies through recent developments in Information and Communication Technology (ICT).

AMIS was not fully promoted in developing countries until the 1980s. AMIS has primarily been used for improvement of public policies through an increased awareness of market realities and enhancement of market transparency for more efficient allocation of resources. Farmers can use market information to decide to whom to sell and at what price, plan their production and harvest and, in some cases, select the optimal market channel. AMIS also enable issuance of early warnings of impending problems, identify areas of possible shortage and signal whether prices are below or above seasonal trends.

Government bodies would collect information and arrange for this to be disseminated using digital technologies. Earlier the government-run MIS were criticized due to their poor accuracy and lack of timeliness. The major criticism was that the information did not reach farmers on time, if at all (World Bank, 2011). Recently, the diffusion of cell phones and the Internet led to the possibility of a new generation of AMIS. These improvements in the ICT sector made it possible to shorten both the time lag in transmitting price data from collection points to central processing units, and in disseminating information to the intended recipients.

AMIS using digital technologies are known as the "Second Generation" MIS (David-Benz *et al.*, 2011; Galtier *et al.*, 2014). Nowadays, real-time information can be delivered within a few hours. Data is no longer limited to prices, but may also include information relating to all aspect of agricultural markets, technologies, policy measures and complementary services intended to reduce market risks, such as storage facilities and credit lines, warehouse receipt systems (CTA and EAGC, 2013). If MIS are to be relevant, they must disseminate useful information that key market players cannot access through other channels. Therefore, digital technologies enhance their capacities for interactivity.

AMIS is highly useful in addressing the market inefficiencies through digital technologies thereby improve their livelihoods. Farmers considered factors such as convenience, certainty of selling, speed of selling, availability of items to buy, safety and established relationships – all of which reduced the potential market inefficiencies (IFPRI, 2013). AMIS must be certain that the information it supplies is relevant to particular farmers based on a thorough understanding of how local marketing systems function. Besides price information, several other services could be offered to farmers through AMIS which includes: weather, current and forecast including temperature, rainfall, wind strength, humidity, news relating to the commodities, quantities and volumes traded at selected markets, and across borders, warehouses, type and prices of inputs sold, consumption levels and patterns, crop types, area planted, stocks, yield levels, and crop calendars, credit, tariffs, and insurance, and regulations including taxes, standards, and export requirements (CTA, 2015).

The prime considerations in designing an MIS must be its commercial utility and sustainability (Giovannucci and Shepherd, 2006). Therefore, the MIS should be market-driven, accurate, timely and reactive, and cost-effective. When designing and developing an MIS, ensuring its financial sustainability is therefore one of the biggest challenges. Sustainability of an MIS depends on how it generates funding internally (for instance through user fees); how it mobilizes support from users, especially farmers, traders and policymakers, and thus exerts "political" pressure on governments to provide financial support; and how it controls costs (i.e. managing the organization such that the costs of information collection and diffusion are minimized).

Cost control reduces the funding required by the organization and is also likely to increase the willingness of users, the state or external agencies to provide financial support. However, reducing costs must often be balanced against the level of service it is envisaged to provide. The absence of a sustainable business model on the basis of which governments can obtain and disseminate price information reinforces this dependence on donors and grants (Zoltner and Steffen, 2013). Therefore, public-private partnerships, in which government support the private sector's commercial price data collection efforts, in return for the provision of data required for policymaking and early warning, could result in more stable MIS models.

An MIS is likely to require a wide range of partners including market managers, trade associations, Internet companies, mobile phone operators and radio stations, sources of finance and regulators. However, their willingness to collaborate cannot be assumed and must be ascertained from the outset. Clear written agreements must be made with all partners, as disagreements often arise. In the context of the rapid development of the ICT sector across the world, a growing number of market information systems have started to rely heavily on modern ICTs, for both collecting and disseminating information (APCAS-FAO, 2012).

V. CONCLUSION

In developing countries, agricultural product markets faced numerous inefficiencies. Inefficient allocation of goods across markets and volatile food prices lead to severe negative consequences for the welfare of the poor farmers. Agricultural supply chains are often dominated by various intermediaries with substantial market power. Intermediaries' services are often exploitative and there can be large efficiency gains from their removal. Improving the efficiency of agricultural markets is essential. Robust AMIS and digital technologies help improve price transparency, cut out middlemen, and make markets more efficient. Rapid adoption of digital technologies has dramatically reduced the search costs incurred by farmers and traders, and improve welfare of farmers and consumers.

AMIS and digital technologies have had important impacts in linking farmers to markets and key stages of the value chain. The growing knowledge of value chains help farmers to work directly with larger intermediaries and enhance the product's value. Farmers are able to expand their networks and establish contacts directly with other buyers. Reliance on traders or agents creates rent seeking opportunities, adding to the agricultural workers' cost of business. This "information asymmetry" often results in price dispersion, drastically different prices for the same products in markets only short distances apart and thus lost income for some farmers and higher prices for consumers.

Credit constraints, missing insurance markets, and poor infrastructure result in sub-optimal agricultural practices. New production technologies such as improved seed varieties, nutrient management, and pest control methods, are not necessarily reaching farmers. To make those decisions, farmers must have information that the technology exists; they must believe that the technology is beneficial; and they must know how to use it effectively. Information encourages poor farmers to make profitable decisions to invest in new technologies. Agricultural extension has traditionally been the primary means of reducing the information asymmetries related to technology adoption. Public extension agents have tried to overcome some of these information barriers on new agricultural practices and technologies, but such programs have typically been burdened by limited scale, sustainability, and impact.

Digital tools have enabled the revival of agricultural extension and advisory services. Rather than always traveling to visit a farmer, extension agents use a combination of voice, text, videos, and internet to reduce transaction costs and increase the frequency of interaction with farmers. Digital technologies provide real-time and accurate weather monitoring using remote sensing and GIS-enabled technologies for climate-resilient agriculture.

Digital technologies also improve agricultural supply chain management. Smallholder farms turn to cooperatives, which use digital tools to improve collection, transportation, and quality control. By opening up new specialized market opportunities, the internet improved consumer protection and farmers' livelihoods. Effective logistics is critical for producers, retailers, as well as consumers for collection, aggregation, and delivery. Digital technologies are quietly transforming how rural logistics function. Improvement in logistics can be seen through lower transaction costs, improved profits, and less wastage.

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