

# **Integrated Framework for the Design of Technology-Based Marketplaces for Development**

Research Program

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# 1 Problems and Possibilities.

Information and communications technologies (ICTs) have been hailed as the engine for future economic growth throughout the world. Unfortunately, the adoption and proliferation of network industries in developing countries has remained scarce, creating what has become known as “the digital divide” (Sciadis, 2003). There are many immediate explanations for the observed differences in ICT penetration and uptake rates between the advanced industrial economies of the North and the less developed economies of the South. The reasons include but are not limited to the high fixed cost of fiber optical networks and the low skills and literacy rates in the developing world. One less discussed factor for the existence of the “digital divide” is the relationship between ICTs and the productive stock of economies at different stages of development. In advanced industrial countries, information technology has been used for the creation of fast moving “knowledge” economies. These are economies where the shortening lifespan of new products mandates the reduction of costs for research, development, and organization of production. The extensive use of information technology has managed to deliver cost savings precisely in these areas. The economies of less developed countries are not faced with the same pre-production cost-cutting predicament. There, the “digital divide” presents itself hand in hand with a substantial “knowledge gap”. Due to weak institutions, dependence on commodity exports and the unequal playing field of international trade, the equitization of innovation has not worked in favor of developing countries (Persaud, 2001). Much-hoped for leapfrogging opportunities have remained scarce and awkward (Davison et al. 2000). In the immediate term “new” industries are unlikely to match traditional ones as a source of income for developing economies. In fact, the agricultural sector offers some of the few efficient and pro-poor development options (Hazell, 2004). As it happens, this is precisely the sector where trade (local or international) is most problematic and remains an undeniable sticking point. We see ICTs as a potential infrastructure for markets of agricultural produce – be it staple or high value. The creation of (dynamic) electronic and/or mobile marketplaces could contribute significantly to increases in rural incomes and to broad-based poverty and inequality reduction.

Semantically, we side with Fink and Kenny (2003) who propose the paradigm of “digital opportunity” as an alternative to the currently pervasive notion of the “digital divide”. The shift in language indicates a move away from presenting the growing gap in access to

ICTs as a development challenge in and of itself. We believe that the challenge lies in the creation of functional income-generating ICT uses for the developing country context. The specific focus of this research program is on the construction of an integrated framework for the design of technology-based dynamic marketplaces. This is an interdisciplinary effort concerned with the design of market institutions, market mechanisms and market technology.

## **2 Motivating Cases.**

Dynamic technology-based marketplaces such as *eBay* have become widely used in advanced industrial economies, and they are quickly expanding in countries with high rates of industrialization such as China and India (Martinsons, 2002). Still, their applicability to agriculture and development has been held in doubt. In order to demonstrate the viability of technology-based marketplaces and the revenue and coordination gains they create, we briefly describe two cases from the Philippines and Ethiopia. We use these cases in order to illustrate our design agenda.

### **2.1 Electronic Marketplace for Farmers: B2Bpricenow, the Philippines.**

*B2Bpricenow* is an electronic marketplace catering to farmers in the Philippines. Its mission is to connect farmers and to provide them with a venue for trading their goods. The founder, Edgardo Herbosa observed the considerable information asymmetries in the agricultural market: “farmers produce crops that they soon realize have no potential buyers” (Rimando, 2002). Herbosa decided to put together a Web site which would address this problem by providing farmers with immediate information about the demand for their produce.

*B2Bpricenow* collects offers to sell and requests to buy, and posts the information in specified product categories. The contact information of the buyers and sellers is easily available and in case they are interested in the possibility of trade both parties are able to pursue it. *B2Bpricenow* has to offer more than a listing service. Its features include: price change alerts, SMS and WAP phone accessibility, setting virtual meetings, negotiating online, closing legally binding contracts and processing transaction documents, paying online via affiliated banks, and others.

Among these services the significance of the feature offering mobile access to price quotes has been recognized by the World Bank as one of the 30 winners in the Development Marketplace Competition held in January 2002. As mobile phone use in the

Philippines continues to increase<sup>1</sup> the significance of the service cannot be overstated.

Its success does not make *B2Bpricenow* the perfect marketplace. Problems related to on-line payments and credibility risk are as significant as in other online marketplaces. More than anything else, the popularity of *B2Bpricenow* underscores the need for up-to-date market information in the agricultural sector in the Philippines. It also demonstrates the viability of electronic/mobile technology-based marketplaces as modes for delivering such information.<sup>2</sup>

## 2.2 Internet Auctions for “Fair Trade” Coffee: ECAFE, Ethiopia.<sup>3</sup>

In July, 2005, was held the first *Q-Auction* – an Internet auction for Ethiopian coffee. The auction was realized by the ECAFE foundation with the support of ACDI/VOCA<sup>4</sup>, the Coffee Quality Institute (CQI), Coffee Corps, the Specialty Coffee Association of America, the Ethiopian Coffee & Tea Authorities and the Ethiopian Coffee Unions. CQI who have the responsibility of organizing the *Q-Auction* proceedings describe it as an “alternative that guarantees quality through industry-accepted cupping procedures, verified by Q-Graders.” The auction offers full-container loads of mainstream specialty coffee and as such is targeted at the primary coffee buyers, as opposed to buyers of boutique and rare coffees. The *Q-Auction* also boasts a dependable and transparent ascending auction mechanism, consistent with current business practice.

The prices achieved in the first auction for Ethiopian coffees averaged US\$ 3.22 per pound i.e. more than double the world market price of US\$ 1.30 per pound. The income generated for Ethiopian cooperative farmers was more than US\$ 187,800. Two percent of these revenues are earmarked for community development projects by the organizers of the *Q-Auction* whose aim is not only to increase the cash receipts of the growers, but also to ensure the sustainable supply of quality coffee for the benefit of the entire specialty coffee industry.

The highest bid at the Ethiopian coffee auction (US\$ 6.50) was placed by the US company Green Mountain Coffee Roasters. The second highest bid (US\$ 5.50) came from a US cooperative bidding group. As a consequence of the fragmentation of the buyers’ side of

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<sup>1</sup> Manila is currently known as “the sms capital of the world”. See Estopace (2005).

<sup>2</sup> Ross (2004) presents another initiatives aiming at providing local agricultural market information to producers within developing countries. He describes the collaboration between the FOODNET program and MTN, Uganda, which delivers market price information to mobile users via SMS.

<sup>3</sup> Facts and figures used in this section were reported by Afrol (2005).

<sup>4</sup> Agricultural Cooperative Development International (ACDI) and Volunteers in Overseas Cooperative Assistance (VOCA). Both are U.S. nonprofit economic development organizations working largely in agriculture.

the market, small roasters have not been able to participate in the market for full-size coffee lots. Coalition bidding in the *Q-Auction* allows small roasters to aggregate their demands in order to bid on full-size lots and to compete against companies with greater market share, thereby increasing revenues for the producers.

### 2.3 Illustrating the Design Agenda.

The cases described above present two very different modes of exchange in terms of organization, standardization of transactions, and technology use. Even though it provides additional services, the main function of *B2BPricenow* is as a venue for an otherwise decentralized market. Buyers and sellers find each other's contact information at the Web site but the product quality is verified, the terms of the deal are negotiated and the trades are carried out elsewhere – in person, on the phone, or by other means. The technological and skills barrier to entrance in the marketplace is minimal. The single requirement is an Internet connection or a mobile phone. Due to the symbolic nature of mobile communication even basic literacy is not a necessary requirement. The *Q-Auction* presents an entirely different scenario. It is heavily institutionalized by the intermediation services of CQI. The institute actively organizes not only both sides of the market by ensuring the quality of the coffee and the credibility of the buyers, but it also designs and sets the auction mechanism. The technology presents essential infrastructure for the strategic interaction during the auction and its use requires a degree of competence, as does the bidding decision itself.

With reference to these two cases the integrated agenda for the design of technology-based marketplaces focuses on the following research questions:

- ❖ Is the level of organization provided by the intermediary optimal? Would the customers at *B2BPricenow* be better served by the provision of more extensive intermediation services (e.g. delivery infrastructure, warranties, security)? Would the participants at the *Q-Auction* benefit from reduced intermediation resulting in broader access to the marketplace?
- ❖ Is the market mechanism optimal? Could the one-to-one take-it-or-leave-it bargaining which dominates *B2BPricenow* be improved on by the introduction of competition between buyers/ sellers in the form of online auctions? Does the *Q-Auction* format provide an efficient allocation? Does it maximize revenues? What are the benefits and dangers of coalition bidding? How should it be facilitated?
- ❖ Is the choice of information technology optimal? Can a technology imposing smaller skills requirements on the

*B2BPricenow* user be designed? Would an extensive migration of the services from the Internet to mobile be preferable to the *status quo*? Does the technology implementing the *Q-Auction* influence the realized allocation and payment outcomes? How can this technology be improved so that the market performs at its best?

### 3 Market Institutions Design.

Intermediated markets compete with decentralized direct exchanges for buyers and sellers. If the performance of a decentralized market can be improved by the services of an intermediary, we are going to witness the evolutionary emergence of such an intermediary. If the presence of an intermediary comes as a cost, rather than a benefit to the transaction, we are likely to witness the sidestepping of the intermediary and its eventual disappearance. Technology-based marketplaces for agricultural products are open to both scenarios. They could give rise to substantial intermediation, as in the case of the *Q-Auction*, or they could be used as tools for eliminating profiteering by traditional intermediaries as in the case of *B2BPricenow*.<sup>5</sup>

The design of market institutions is concerned with the mapping from the set of possible market microstructures to the performance set of the market. In the presence of economies of scale, information asymmetries, or costs to operating or using the market mechanism, the performance of the market can be improved as a result of the introduction of an intermediary. In these cases Bailey and Bakos (1997) summarize the performance-enhancing functions of the intermediary as follows:

- ❖ *Aggregate* supply and/or demand in order to achieve economies of scale. The aggregation of information about demand ensures an efficient level of production. Intermediaries reduce the asymmetries in bargaining power between atomic agents on one side of the market and big players on the other side.
- ❖ *Reduce risk* and exposure to opportunistic behavior. The transfer of information from both sides of the market to the intermediary alleviates the information asymmetries between them. Intermediaries create trust in the marketplace.

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<sup>5</sup> The role of traditional intermediaries in agricultural markets has ensued from the costly access to markets. Producers who cannot afford transporting their goods to markets sell to intermediaries at the point of production. Perception of such intermediaries is rarely favorable. The essence of the information problem is summarized in the words of a small farmer from Uganda, reported by Ross (2004): "I don't know the real market price but they come and buy my coffee at a low price."

- ❖ *Facilitate* the market by reducing operating costs. Reduce processing and coordination costs. Provide associated payment and delivery services.
- ❖ *Match* buyers and sellers. In situations with searching or matching costs, intermediaries can increase the likelihood of trade or improve the terms of trade relative to direct exchange. Ensure efficient level of trading in the market.

The design of institutions for technology-based markets is concerned with the establishment of the optimal boundaries for the market-maker. These boundaries are determined by the characteristics of the technology-based marketplace. If the market is free from the problems listed above, then the role of the intermediary would be exhausted by the provision of the technological infrastructure for the operation of the market. Otherwise, the technology provider would have to assume more of the functions of traditional market intermediaries in order to ensure the functioning of the marketplace.

The significant phenomenon in the study of the optimal institutional framework of technology-based marketplaces for development is the phenomenon of emergence. We have witnessed that intermediaries such as governments, charities, professional organizations and farmers' unions have played significant roles by collecting and listing information, verifying quality, ensuring payment and drafting legally binding contracts. An analytical understanding of the emergence of these structures is instrumental to the synthetic exercise of designing technology-based marketplaces for the future.

## 4 Market Mechanism Design.

Game theory is probably the most advanced tool for the study of market design. It has focused on finding equilibrium strategies for the revelation of private information in situations involving bargains, auctions and negotiations. The process of model-building "is driven in particular directions by the mathematical tractability of particular types of model, and the relative intractability of others."<sup>6</sup> Even though the tractability and the rationality restrictions of this approach have been criticized, the game theoretic paradigm has not been seriously challenged. To the contrary, its success in understanding the sufficient conditions for market performance and its focus on closed-form solutions, has led to the rise of the related field of

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<sup>6</sup> Quotation from Marks (2005), p. 3. In connection with the described research process Marks (2005) alludes to the anecdote about the economist who prefers looking for his car keys underneath the street lamp, rather than in the surrounding darkness where he actually lost them.

mechanism design. The research in this area produces mappings from the space of performance measures to the space of market mechanisms. Thus, subject to individual rationality and incentive compatibility constraints, a mechanism designer is able to recommend optimal allocation and payment rules with respect to different desirables such as revenue maximization and allocative efficiency.

Mechanism design methodology has been successfully implemented in practice in the creation of markets for pollution emissions, electricity and electro-magnetic spectrum. Therefore, it has a lot to contribute to the design of technology-based marketplaces. Mechanism design is up to the task of providing optimal rules for the dynamic pricing and clearing of well studied markets for perishable agricultural commodities such as fish and flowers. The current theoretical literature is also well poised to address issue of collusion and cooperation such as the formation of bidding rings and bidding coalitions. The practices observed in the *Q-Auction* case clearly point to the relevance of these concerns to development marketplaces where one side of the market is disproportionately fragmented.

Related to the literature on mechanism design is that on two-sided matching (Roth and Sotomayor, 1990). It is applicable to situations when there is considerable degree of competition on both sides of the market and participants' primary concern is finding a trading partner with characteristics meeting a clearly stated preference (e.g. a trading partner removed by the shortest distance). For example, as a static listing site *B2Bpricenow* does not match buyers and sellers but many of the posted offers are advertised on a "first come first serve" basis. This indicates that sellers are concerned with finding a buyer and might benefit from participating in a matching mechanism. If participants are concerned with a non-traded attribute of the transaction such as the distance they have to travel for the exchange the participation in a centralized matching mechanism could address this concern without compromising the price of the transaction.

Despite the appeal of its rigor and the generalizability of its results, the top-down approach of mechanism design runs contrary to our understanding of the emergence of market rules. Rather than being designed by an omniscient engineer, market mechanisms have evolved naturally by responding adaptively to changes in the needs and the behavior of their participants. Thus, the implementation of the top-down approach runs into its main problem: ensuring participation. Notably, top-down design has been successful in government sponsored applications where incumbent

markets did not exist<sup>7</sup> and all the interested participants had to subscribe to the newly engineered market. Due to the natural aversion of existing markets to change, it is often difficult to convince a sufficient number of buyers and sellers to join in and deliver critical mass for incipient alternatives to traditional marketplaces.<sup>8</sup> Thus the challenge to mechanism design lies in developing an understanding of how the derived theoretically optimal designs could be evolved in practice.

Within technology-based markets the engineering approach is feasible to the extent that owners of the technology infrastructure have the authority to set the rules of the market mechanism. Still, in order to ensure the success of a new marketplace it is essential to implement rules conducive to broad-based participation. Thus, our goal is to develop an understanding how mechanism rules could be adapted in response to the internal pressures of the marketplace. The capacity for such adaptation will ensure the evolutionary emergence of an optimal mechanism within a functioning, popular marketplace. This bottom-up approach has significant practical advantages to the top-down approach of mechanism design which provides theoretically optimal but often unpopular or cognitively impenetrable solutions.

## 5 Technology Design.

The creation of technology-based marketplaces is essentially the process of migrating existing market activity to the digital environment. Nadin (1999) describes digitalization as: “replacing the underlying structure characteristic of industrial society”, “transition from sequence to configuration, from linearity to non-linearity, from centralism to distributed variable centers, from hierarchy to non-hierarchic methods, from homogeneity to heterogeneity, from permanence to transitoriness”. Nadin (1999) argues that in this new informational context traditional literate forms of communication are challenged by multi-media and the visual. Even though truthful signaling is a concern central to mechanism design, problems of communication have not been considered. When technology provides the infrastructure for the marketplace, its impact on the performance of the market should not be side-stepped by economists. The successful performance of a technology-based marketplace is as much the result of well-designed market institutions and mechanisms, as it is the result of their technological implementation.

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<sup>7</sup> Pollution emissions, electro-magnetic spectrum.

<sup>8</sup> The problem of ensuring participation in the centralized matching mechanisms for medical residents and psychology interns have been well documented, Roth and Sotomayor (1990).

An adaptive market mechanism optimizes market performance by responding to changes in the behaviors of the users. If the human—technology interaction at the input phase is not of sufficient quality, then the signals sent by the users to the market would misrepresent their preferences and intentions even if the users are following strategies of truthful information revelation. Even with an optimal mechanism the market might perform sub-optimally due to its sub-optimal technological infrastructure. Similarly, market institutions evolve in response to problems in the marketplace. If these problems are obscured or aggravated by an unsuccessful technological implementation, then the emerging microstructure would not be optimal for the underlying market. The recognition of the impact of technology on the functioning of the marketplace brings the design of technology which best represents the relevant characteristics of the users to the attention of the market designer.

Naturally, specific technology which best represents the user populations depends on the communication skills and cognitive tendencies of these populations. In this context, Nadin's (1999) proposition that digitalization shifts the method of communication from literate to visual has strong implications. It suggests that communication via ICTs based on symbolic systems could challenge the literacy barrier and deliver interconnections among many more people. The combination of this shift in the language paradigm with developments in the field of technology such as 3G and multi-media mobile services has the potential of moving the world in the direction of higher density and quality of communication in underdeveloped areas. The establishment of an integrated framework for the design of technology-based marketplaces could provide an opportunity for the utilization of the growth in communication to the benefit of the poor and the illiterate.

## **6 Method.**

Optimal design is generally understood as a top-down activity. As such, it runs the risk of producing precisely what the name suggest – a design, rather than a functionally adequate structure for the delivery in practice of optimal performance. Market mechanisms and institutions evolve from the bottom up and respond to the concerns and behaviors of their participants. Therefore, we believe that their design is best addressed via computational methods simulating this evolutionary process. Agent-based computer simulation models are applicable to the study of the phenomena of emergence discussed in the previous sections. The simulated adaptation of institution boundaries, market mechanisms and communication technologies is the approach capable of delivering an integrated framework for the design of technology-based

marketplaces.

Marks (2005) points out that “fully blown [market] design requires a degree of understanding of the mapping from the design space to the performance space which has not yet been developed”. Similarly, the integrated design of technology-based marketplaces requires an understanding of the mapping from the combined design spaces of market institutions, market mechanisms and market technologies to the space of market performance. To say that such mapping has not yet been developed would be an understatement. In fact, as far as we are aware the current program is the first to propose the research of such a mapping. Still, bearing in mind the developments in design and computational economics we believe that the creation of an integrated framework for the computational design of technology-based marketplaces is an achievable medium to long term goal for the engineering-minded social scientist.

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