Food Policy 75 (2018) 109–123

Contents lists available at ScienceDirect

Food Policy

journal homepage: www.elsevier.com/locate/foodpol

Viewpoint

Food waste in the sharing economy

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A B S T R A C T

Wasting food is one of the rare problems that affects our ability to achieve economic goals in terms of food security, environmental sustainability, and farm-financial security. Most of the ideas proposed to this point involve either behavioral nudges or administrative regulations that are either too paternalistic or piecemeal to represent viable solutions. In this study, we investigate the potential for commercial peer-to-peer mutualization systems (CPMSs), or sharing-economy firms, to emerge as market platforms for the exchange of surplus food. If a system of CPMSs is able to develop in a self-sustaining way, then the market prices they create will generate sufficient incentives for all actors to manage surplus food more efficiently. We develop an empirical model of a CPMS operating as a platform in a two-sided market, and examine its viability using data from one of the first CPMS firms in the surplus-harvest industry, Imperfect Produce, Inc. Empirical estimates of a two-sided network-demand model show that user-demand rises in the number of growers shipping to the platform, and grower demand for distribution rises in the number of users. Our findings indicate that secondary markets have the key elements needed for CPMS success, and that policy tools designed to facilitate transactions in secondary markets can be highly effective in reducing food waste.

1. Introduction

Food waste is one of the rare problems that cuts across multiple social issues, from food security (Coleman-Jensen et al., 2014) and environmental degradation to economic efficiency (Parfitt et al., 2010; Gustavsson et al. 2011; Buzby et al., 2011; Buzby and Hyman, 2012). Wasted food not only impairs society's ability to feed an estimated 9.7 billion people globally by 2050 (UN, 2015), but it also accounts for roughly 25% of US freshwater supplies each year and consumes nearly 300 million barrels of oil (Hall et al., 2009). Food production generates substantial environmental externalities associated with greenhouse gas emissions and phosphate run-off (Buzby and Hyman, 2012), the unconsumed portion of which is unnecessary, and food waste at the terminal point of the food system accounts for roughly 18% of total solid waste in municipal landfills (EPA, 2016). In terms of the discarded value of food, alone, USDA estimates that the US loses 31% of total food supply, or $165.5 billion per year in total value (Buzby et al., 2014). Food waste occurs at virtually all stages of the supply chain from farmer to retailer to consumer, resulting in the disposal of potentially usable food in nearly every sector of the food system in the distribution channel between farmers and consumers.

An important strand of economic research examines consumer food waste as a behavioral problem, seeking to address the problem by regulating waste disposal by educating consumers about expiration dates and changing consumers' incentives to generate waste (Tsiros and Heilman, 2005; Theotokis et al., 2012; Buzby and Hyman, 2012; Halloran et al., 2014).[1] These are important priorities that confront a growing population. However, policies designed to reduce food waste in the consumer market only control incentives at the end of the distribution channel and fail to encompass all stages of the food system where food waste occurs. In the upstream stages of the food economy, commercial peer-to-peer mutualization systems (CPMSs), that seek to match farmers and distributors to consumers for fresh produce items, represent a potentially important market-based solution to more

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[1] Emerging research has identified a range of causes specific to different levels of the food-supply chain. While losses at the farm level due to weather damage and natural variation in quality are substantial (Gustavsson et al., 2011; Kummu et al., 2012), most of the waste in developed economies comes from households (Griffin et al., 2009; Buzby et al., 2011; Cicatiello et al., 2016). Food waste at the household level is primarily due to a lack of understanding of "best-before" or "use-by" dates, inaccurate meal planning, imperfect home-storage systems, and discounts on large packages that encourage over-buying (Gustavsson et al., 2011; Halloran et al., 2014). Demand uncertainty, and the inability to accurately forecast demand, are also key to food waste among foodservice operators and food manufacturers (Mena et al., 2011), resulting in the so-called bullwhip effect that magnifies food waste through the supply chain.

https://doi.org/10.1016/j.foodpol.2018.01.008
Received 18 September 2017; Received in revised form 19 December 2017; Accepted 21 January 2018

efficiently allocate food at higher levels of the food system by stimulating price realization for products that are edible, but contain defects in size, color, shape and size; the so-called market for "ugly food" (Garfield, 2016).[2] In this paper, we examine the efficiency of food exchange in upstream markets of the food system by examining the performance of CPMS systems in facilitating the exchange of harvested produce that is too small, large, misshapen, discolored, or otherwise deemed in excess of need through traditional marketing channels.

It has long been understood in the management of negative environmental externalities that attaching a price to an activity is more likely to lead to its efficient control, including waste (Dinan, 1993; Fullerton and Kinnamanm, 1995; Fullerton and Wu, 1998; Buzby and Hyman, 2012; Acuff and Kaffine, 2013). By creating a market for imperfect, or surplus, food, suppliers will be better able to match the distribution of quality produced by the natural variability of biological production, with the willingness-to-pay for quality in the consumer market.[3] This is a classic price discrimination result – whereas supermarket grading standards (which are generally higher than USDA grades for fresh produce) serve as an effective minimum-quality standard, selling imperfect produce that is inarguably below-grade allows suppliers to segment consumers according to their willingness to pay for quality (Mussa and Rosen, 1978; Caswell, 1998), sell a greater quantity, and reduce the amount of surplus-harvest. In this paper, we investigate the potential for CPMS markets to emerge for such ugly food products.

Fresh foods that are harvested below marketable quality and left unsold contribute to the food waste problem. Indeed, Gustavsson et al. (2011) and Kummu et al. (2012) have found weather damage and natural variation in quality to lead to substantial quantities of unsalable farm products. Because farmers face uncertain demand and supply conditions, and forecasting is imperfect, over-production of farm products occasionally occurs, leading to low price realizations that leave perfectly edible food unharvested in the field. In the absence of a market for surplus, or leftover food, excessive amounts of usable food are discarded either by being "plowed under" at the farm level or by being harvested and sent to downstream markets that may ultimately process these products as waste (Garrone et al., 2014). CPMS services that help match these products with buyers can offer an important market for reducing food waste.[4]

We base our observations on the performance of CPMS systems for surplus food on data from Imperfect Produce, Inc. Imperfect Produce, Inc. is a startup company based in California that aims to reduce food waste in the surplus-harvest market by matching producers at the farm level with consumers at the retail and foodservice levels of the food system for the exchange of food products that are not graded through conventional channels of the food system. Our data consists of four years of peer-to-peer transactions, including the amounts ordered, prices paid, and attributes of consumers and the sharing firms. These data are sufficiently rich to allow us to test an empirical model of activity on the sharing platform in which the breadth of sales transactions matches with the range of consumer preferences for product attributes that drive value in final goods markets for food products. These data are sufficiently rich to allow us to investigate whether the fundamental conditions are present for a CPMS to succeed in matching buyers and sellers in food market, and if so, whether farm-to-consumer platforms in the "food sharing" economy present a viable opportunity for a upstream food markets to help alleviate the problem of unwanted food.[5]

CPMS firms such as Uber, AirBnB, FarmLink, TaskRabbit, and Liquid have increased consumer's willingness to transact goods in the "sharing economy" (Bardhi and Eckhardt, 2012; Lamberton and Rose, 2012; Sundararajan, 2013, 2014; Belk, 2014; Fraiberger and Sundararajan, 2015; Möhlmann, 2015). As Botsman and Rogers (2010) argue, CPMS markets emerge when advances in sharing technology – e.g., cell phone applications – facilitate markets for durable assets with excess capacity. In the case of food, a farmer's field is the durable asset, and excess capacity is manifest in surplus harvest. A novel feature of CPMS markets for surplus food is that excess capacity in food markets results in a perishable stock. For this reason, policies that facilitate food transactions in a CPMS market, and thereby generate sales that would otherwise not transpire, serve to reduce surplus output that would otherwise be discarded, plowed under, or end up in lower-valued uses than intended.[6]

Our empirical approach is framed around recent estimation techniques employed in two-sided markets (Armstrong, 2006; Kaiser and Wright, 2006; Steiner et al., 2016). In a two-sided market, demand for a "platform", for instance a menu of food items coordinated for sale by a CPMS provider like Imperfect Produce, is comprised by demand for distribution from potential suppliers of surplus food on one side, and by demand for procurement from potential consumers of food waste on the other side. The nature of demand on the platform is two-sided due to indirect network economies (Rochet and Tirole, 2003, 2006) created by the breadth of the items available on the platform. Specifically, the benefit to consumers from interacting on the platform rises with the number of suppliers providing surplus food on the platform, while the benefit to suppliers from interacting on the platform rises with the number of consumers purchasing surplus food on the platform. Network economies on a two-sided platform thereby create a "virtuous cycle" in which supply facilitates its own demand, causing emerging platforms either to succeed or fail in spectacular fashion.

We estimate the strength of demand on each side of the market in our empirical model, allowing us to determine: (i) whether demand conditions exist for CPMS markets to emerge as a viable business model for surplus food; and (ii) whether policy tools such as subsidies on "ugly food" are effective in reducing the amount of surplus food. Our findings indicate that consumers' preferences for the breadth of food items available on the site is particularly important in driving indirect network effects in the CPMS market. This result suggests that the profitability of a CPMS in this setting is directly related to the number of suppliers the platform sources from in procuring surplus food, and that the value of transacting surplus food on the platform rises significantly for producers with the size of the network. This feature of the market makes food policies that subsidize purchases on CPMS platforms for surplus food particularly effective in reducing excess produce. To

[2] We view CPMS systems broadly as any technology that matches buyers and sellers on a platform derived from peer-to-peer transactions. Botsman (2013) provides a general characterization of CPMS firms as any entity that facilitates the decentralized trade of products or services that are underutilized in the economy.

[3] A reviewer suggests that creating markets for surplus harvest will increase supply, reduce the price, and encourage more waste. While this effect is plausible, we believe it represents a second-order effect relative to the direct incentive embedded in a price for waste.

[4] In this study, we do not attempt to measure the amount of food loss, or waste, so we use the terms interchangeably throughout. We do appreciate, however, that the concepts are not identical (Bellemare et al., 2017).

[5] While food waste occurs at all points of the food supply chain, CPMSs to date have emerged largely between farmers and consumers, providing rich transactional data on which to base our empirical investigation. However, Food Cowboy represents one example of a "B2B" firm that transacts surplus food that has been purchased by restaurants, or even households. In this regard, Food Cowboy represents an example of how the CPMS concept may be extended to downstream food markets and encompass consumer-level food waste.

[6] An interesting possibility suggested by a reviewer is that creating new, upstream markets for surplus harvest will reduce food prices, potentially resulting in greater post-consumer food waste. While our model is silent on general equilibrium effects, the total amount of food transacted on CPMS platforms is currently small and likely to have negligible effects on overall food prices. Moreover, we believe enhancing the efficiency of food utilization at upstream levels of the food system leads to better matching in downstream consumer markets that will tend to dominate second-order effects relative to changes in consumer food prices. Comprehensive modeling of general equilibrium effects of CPMS innovations in upstream food markets, which includes changes in land use, changes in animal feed prices, as well as consumer price changes in fresh produce markets relative to processed, shelf-stable foods (and the attendant consumer health implications), are beyond the scope of the present study.