Market Failure in Kidney Exchange

Kidney exchange markets enable approximately 800 transplants per year. Patients in this market need a kidney transplant, and most come with a living, but incompatible, donor. Transplants are organized using patient-donor swaps and chains initiated by altruistic donors. The importance of this market has grown because of a shortage of organs from deceased donors, and because current law prohibits using monetary compensation to acquire organs.

This paper evaluates the kidney exchange market in the US (after more than a decade long) and shows that, despite significant success in organizing transplants, the market suffer from two serious and fixable market failures that together result in hundreds of lost transplants per year. Indeed, our descriptive evidence suggests that the market is fragmented and operates inefficiently. We use price-theoretic arguments to explain that this inefficiency arises from two standard market failures. Each failure corresponds to a specific problem with current institutions. Both problems yield suboptimal incentives for hospitals, the key decision makers. First, large national kidney exchange platforms use inefficient mechanisms to match patients. Due to biological compatibility, there is substantial variation in the additional transplants that result from different patient and donor types being submitted to the national platform. But current mechanisms ignore these differences in social value. This limitation in the design pushes hospitals to match patients with high social value outside the platform, even when it is inefficient. Second, there is scope for agency problems: hospitals face most of the costs of participating in the national platforms but receive only a fraction of the benefits. We show that fixing these two problems can result in hundreds more transplants per year.

This argument has three parts. First, we use administrative datasets and institutional detail to diagnose and document the causes and consequences of these market failures. Second, we argue that, although kidney exchange markets look different from other markets, their inefficiency is caused by standard market failures. To analyze the market, it is useful to think about the role of a kidney exchange platform as a producer of transplants that takes patients and donors supplied by hospitals as inputs. This re-framing allows us to use classic price theory arguments that have clear policy implications. Third, we estimate the key primitive of the model, a transplant production function, using data from the largest kidney exchange platform. The primitive allows us to estimate the magnitude of the inefficiencies, design practical alternative mechanisms, and suggest appropriate policy responses.

In the first part, we document key facts about the market to motivate our model. We merge administrative data on the universe of transplants in the United States and proprietary data from the largest kidney exchange platform. The data reveal several signs of inefficiency. Rather than most transactions taking place at a few large platforms, the market is highly fragmented. Approximately 63% of kidney exchange transplants involve patients and donors that belong to the same hospital. Crucially, we find direct evidence that many within-hospital exchanges are inefficient from a social perspective. An efficient market would use easy-to-match donors only for hard-to-match patients. We show that small
within-hospital exchanges often violate this simple rule, but large national platforms do not.

These facts motivate our model in the second part. The key insight underlying our approach is that although kidney exchange markets do not directly use monetary incentives to acquire organs, it is useful to analyze them similar to a platform that produces a final good (transplants) from intermediate goods (submissions of patients and donors) supplied by a competitive fringe (hospitals), according to a production function. This re-framing is based on three key institutional features. First, hospitals supply patients and donors to a platform voluntarily and are not forced to participate. Instead of submitting a patient-donor pair to a large platform, a hospital can perform a transplant with other pairs that it is treating. Thus, kidney exchange platforms must reward hospitals with transplants to procure necessary inputs (patients and donors). Second, due to biological compatibility constraints, some types of patients and donors enable more transplants than others, i.e. some inputs are more productive than others. For example, blood type O donors can donate to patients of any blood type. This fact makes them both scarce and valuable when organizing kidney exchanges. Because hospitals can perform exchanges within their set of patients and donors, a platform may have to increase the rewards for submitting valuable types in order to procure them. Third, due to biological compatibility constraints, some types of patients and donors are in abundance, and the platform must ration transplants within this set. A transplant can therefore be transferred to a hospital by selecting its patient instead of another hospital’s. This fact makes transplants a natural numeraire good, even though direct monetary transfers for acquiring organs are illegal.

Our main theoretical result, formally shows that market failure can result from two sources of inefficiency. The first source is based on an inefficient mechanism. Most kidney exchange platforms run optimization algorithms that select which patients are matched. When a hospital submits a patient to the exchange, the hospital is rewarded according to the probability with which the patient is matched. In contrast, the result shows that, to maximize hospital welfare, hospitals should be rewarded based on the marginal product of their submissions. Because existing platforms do not reward hospitals for the social value of their submissions, even a hospital that maximizes the number of its own patients that are transplanted has to perform socially inefficient matches. Hospitals must therefore decide between helping their patients or performing socially efficient matches. This problem can be ameliorated using point mechanisms that reward hospitals according to marginal products.

The second source of inefficiency are due to externalities if hospital welfare differs from social welfare. These externalities arise if hospitals do not maximize the number of their own patients that are transplanted. It creates inefficiency, for example, if a hospital performs too many internal matches to avoid the administrative costs of kidney exchange, even though these matches happen at an inefficiently small scale. We argue that these administrative costs are small relative to the value of a transplant to patient and his or her health insurer. But, they are a significant fraction of hospital revenue from kidney exchange. Therefore, these externalities are likely due to agency problems created by the reimbursement system for hospitals.
Our main theoretical result shows that there is no inefficiency if neither of these two sources are present. This decomposition of market failure sources is consistent with long-standing concerns of surgeons, insurers, platforms, and researchers, and even with recent policy changes. Our analysis pinpoints the sources of market failure to specific wedges, a result that points to practical policy implications. The third part of our argument uses the data to quantify these issues’ importance and to design responses. We estimate the platform’s transplant production function using administrative data from the largest kidney exchange platform, the National Kidney Registry (NKR), and detailed information about the matching algorithms and operational procedures used in the platform. This information allows us to build an empirical model of a kidney exchange platform. The model fits the data well and allows us to estimate the flow of transplants that would be produced given a flow of submissions.

The estimated production function yields the following results. First, we measure the returns to scale of the production function and estimate the inefficiency from market fragmentation. We find that the largest kidney exchange platform is well above the minimum efficient scale. At the same time, almost all single-hospital hospital platforms are far below the efficient scale. This difference in productivity suggests considerable inefficiency due to fragmentation. We estimate that the gains from moving all the production to the efficient scale is at least 200, and likely closer to 400 transplants. Thus, consistent with the descriptive evidence and the shape of the production function, fragmentation has a large efficiency cost. Second, we assess the current mechanism and characterize rewards in an optimal mechanisms. Motivated by our main result result, we calculate the marginal products and probabilities of matching for each type of submission using the estimated production function. We find that marginal products are considerably different from the probabilities of matching, which implies that existing mechanisms are far from optimal. We then develop point mechanisms that give approximately optimal incentives to hospitals.

Finally, we study the importance of the two sources of market failure. In our price-theoretic approach, the loss in hospital welfare due to the inefficient mechanism depends on the wedge between current and optimal rewards, and on the elasticity of supply from hospitals. We have estimated the wedges and the marginal products, but our data do not have enough information to credibly estimate supply elasticities. Therefore, we calculate this deadweight loss under a broad range of assumptions on elasticities. Except under extreme assumptions, the deadweight loss is significant but considerably lower than the inefficiency due to market fragmentation. Therefore, except in extreme cases, both the current mechanism and agency problems cause significant inefficiency in the market. Taken together, these results motivate a combined approach that improves the mechanism design and implements policies that encourage hospital participation in the national platforms.