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Resource scarcity and prioritization decisions in medical care: A lab experiment with heterogeneous patient types

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[Correction added on 30 November 2020, after first online publication: The university name in the second affiliation and the footnote citations in Table 2 have been updated in this version.]

Abstract

During the COVID-19 pandemic, health care systems around the world have received additional funding, while at other times, financial support has been lowered to consolidate public spending. Such budget changes likely affect provision behavior in health care. We study how different degrees of resource scarcity affect medical service provision and, in consequence, patients' health. In a controlled lab environment, physicians are paid by capitation and allocate limited resources to several patients. This implies a trade-off between physicians' profits and patients' health benefits. We vary levels of resource scarcity and patient characteristics systematically and observe that most subjects in the role of physician devote a relatively stable share of budget to patient treatment, implying that they provide fewer services when they face more severe budget constraints. Average patient benefits decrease in proportion to physician budgets. The majority of subjects chooses an allocation that leads to equal patient benefits as opposed to allocating resources efficiently.

KEYWORDS

laboratory experiment, physician behavior, prioritization, resource scarcity, social preferences

JEL CLASSIFICATIONS

C91, D64, I11

1 | INTRODUCTION

Although cutbacks in social welfare spending can affect public health outcomes negatively (e.g., Kmietowicz, 2016; Stuckler, Basu, & McKee, 2010a, 2010b), some countries reduce public spending by lowering financial support for health care providers. Some European countries reduced health care providers' pay after the financial crisis, for example (Mladovsky et al., 2012; Quaglio, Karapiperis, van Woensel, Arnold, & McDaid, 2013). On the other hand, many European countries are now planning to increase health care spending including payments to providers in response to the COVID-19 pandemic (Thomson, Habicht, & Evetovits, 2020). Either way, a change in payments is likely to alter physicians' provision behavior and, thus, affect patients' health outcomes.

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In a stylized lab experiment, we explore the causal link between both, degrees of resource scarcity and patient characteristics, and medical service provision under capitation payment. In the field, it would be difficult to isolate effects of physician budgets and patient characteristics from other potential influences.¹ Therefore, we use a controlled lab environment that allows *ceteris paribus* variations of the levels of physician budget and patient characteristics (for a general discussion of the experimental method see, e.g., Fréchette & Schotter, 2015, and for a discussion of health economics experiments see Galizzi & Wiesen, 2018). Overall, our study contributes to previous literature in three aspects as follows: (1) We systematically vary the degree of resource scarcity in order to investigate its influence on the provision and allocation of medical care, (2) Our setting involves resource rivalry among heterogeneous patients. This allows studying how patient characteristics influence the allocation of resources, and (3) Using a within-subject design, we are able to account for variations in physicians' decision-making.

So far, only few studies investigate how different levels of payment affect physicians' decisions. Clemens and Gottlieb (2014), for example, analyze US data and find that a 2% increase in payment rates for medical services translates into a 3% increase in care provision on average. In controlled lab experiments, Brosig-Koch, Hennig-Schmidt, Kairies-Schwarz, and Wiesen (2013) and Brosig-Koch, Hennig-Schmidt, Kairies-Schwarz, Kokot, and Wiesen (2019) observe no significant differences in provision behavior between two different capitation payments. In contrast to our experiment, physicians allocate services to only one patient at a time in their experiments, though. As physicians frequently allocate resources to several patients, it is important to investigate effects of resource scarcity in settings that can lead to a trade-off between several — possibly heterogeneous — patients.² Similar to our study, Ahlert, Felder, and Vogt (2012) and Di Guida, Gyrd-Hansen, and Oxholm (2019) experimentally study allocation decisions in settings with multiple patients. Ahlert et al. (2012) observe that physicians treat fewer patients and give a lower share of their budget to patients as it decreases. Their payment scheme does not involve a trade-off between physician profit and patient benefit, though. Di Guida et al. (2019) implement a fee-for-service payment with varying fee levels and ask their participants to assign a limited number of services to one or two patients. They find that a lower fee reduces overprovision when physicians face patients with relatively low optimal service quantities. In contrast to Ahlert et al. (2012) and Di Guida et al. (2019), we implement a capitation payment while systematically analyzing the effects of different budget levels and patient characteristics on medical service provision. The experimental setting is presented in Section 2. Section 3 summarizes our main findings and Section 4 concludes.

2 | EXPERIMENT

2.1 | Experimental design

Our within-subject design extends the design of earlier health economics experiments (e.g., Brosig-Koch et al., 2019; Brosig-Koch, Hennig-Schmidt, Kairies-Schwarz, & Wiesen, 2016; 2017; Martinsson & Persson, 2019; Wang, Iversen, Hennig-Schmidt, & Godager, 2020) by (1) including a second patient in the physician's allocation decision³ and by (2) systematically varying the physician's budget. In our medically framed experiment, subjects take the role of physicians and patients and keep their assigned role throughout the entire experiment.⁴ One subject in the role of physician faces the same two subjects in the role of patients over the course of 27 periods.⁵ In each period, the physician receives a budget and determines the quantity of medical services q_j allocated to each of the two patients $j \in \{1, 2\}$. While physicians face convex costs for treatment in most health economics experiments (e.g., Brosig-Koch et al., 2016; 2017; Brosig-Koch et al., 2019; Hennig-Schmidt, Selten, & Wiesen, 2011; Martinsson & Persson, 2019; Wang et al., 2020), some experimental studies assume linear costs (e.g., Kesternich, Schumacher, & Winter, 2015; Reif, Hafner, & Seebauer, 2020). We follow the latter approach and implement linear costs $c = 1$ per medical service in order to keep the decision situation as simple as possible. Physician profit is specified as

$$\pi(q_1, q_2) = \text{budget} - (q_1 + q_2).$$

Patient health benefit $b_j(q_j)$ increases with the quantity of medical services q_j , depending on the marginal health benefit $\theta_j \in \{0.5, 1, 2\}$. For medical service quantities exceeding the optimal quantity $q_j^* \in \{10, 15, 20\}$, patients neither experience a decrease in benefit nor gain further benefits:

$$b_j(q_j) \begin{cases} \theta_j q_j & \text{if } q_j < q_j^* \\ \theta_j q_j^* & \text{if } q_j \geq q_j^* \end{cases}.$$

TABLE 1 Patient characteristics in the nine combinations of patient types

Combination of patient types	Patient 1	Patient 2	$q_1^* + q_2^*$
1	Ay: $\theta_1 = 0.5, q_1^* = 15$	Ay: $\theta_2 = 0.5, q_2^* = 15$	30
2	By: $\theta_1 = 1, q_1^* = 15$	By: $\theta_2 = 1, q_2^* = 15$	30
3	Cy: $\theta_1 = 2, q_1^* = 15$	Cy: $\theta_2 = 2, q_2^* = 15$	30
4	Ay: $\theta_1 = 0.5, q_1^* = 15$	By: $\theta_2 = 1, q_2^* = 15$	30
5	By: $\theta_1 = 1, q_1^* = 15$	Cy: $\theta_2 = 2, q_2^* = 15$	30
6	Ay: $\theta_1 = 0.5, q_1^* = 15$	Cy: $\theta_2 = 2, q_2^* = 15$	30
7	Ax: $\theta_1 = 0.5, q_1^* = 10$	Bz: $\theta_2 = 1, q_2^* = 20$	30
8	Bx: $\theta_1 = 1, q_1^* = 10$	Cz: $\theta_2 = 2, q_2^* = 20$	30
9	Ax: $\theta_1 = 0.5, q_1^* = 10$	Cz: $\theta_2 = 2, q_2^* = 20$	30

We define nine combinations of patient types with varying combinations of patient characteristics (see Table 1). In combinations one to three, both patients have the same marginal benefits and optimal quantities. In combinations four to nine, we mix different patient types: patient 2 has a higher marginal benefit than patient 1. The experiment is conducted once with each combination of patient types and each of the three budgets $\epsilon \in \{20, 30, 45\}$. We use these three levels of budget because first, these values are considerably different from each other and second, they imply a significant variation in the constraints for optimal treatment since the sum of optimal service quantities is constant at $q_1^* + q_2^* = 30$ throughout all decision scenarios.

Under the assumption of rationality and selfishness, physicians should keep the whole budget to maximize their own profit. However, previous experimental studies provide evidence that subjects systematically deviate from selfish behavior (e.g., Brosig-Koch et al., 2016; Di Guida et al., 2019; Hennig-Schmidt et al., 2011). Our experiment is designed such that it furthermore allows to distinguish between the three main allocation principles based on medical need (e.g., Culyer & Wagstaff, 1993; Williams & Cookson, 2000; see also Martinsson & Persson, 2019):

1. **Equal health outcomes:** This principle is based on everyone's right to a normal life span with a good quality of life (Williams, 1997). It implies providing the same health outcomes ($b_1 = b_2$) for both patients.
2. **Severity of illness:** According to this principle, patients should be prioritized based on their initial level of illness. Since both patients share the same severity (0) in all combinations of patient types, this implies allocating the same service quantities ($q_1 = q_2$) to both patients.
3. **Capacity to benefit:** This principle entails that priority should be given to patients who benefit the most from treatment. It translates into giving a higher quantity to the patient with the higher marginal benefit, that is, patient 2 ($q_1 < q_2$).

2.2 | Experimental procedures

The computerized experiment was programmed with z-Tree (Fischbacher, 2007) and conducted at the Essen Laboratory for Experimental Economics (*elfe*). We used ORSEE (Greiner, 2015) to recruit 174 participants.⁶ Several experimental studies investigate if medical or non-medical students and physicians differ in their behavioral reactions to changes in decision settings (e.g., Brosig-Koch et al., 2016; Brosig-Koch et al., 2017; Hennig-Schmidt & Wiesen, 2014; see Galizzi & Wiesen, 2018 for a short discussion). Even though the intensity of behavioral changes might vary between participant groups, they show qualitatively similar responses to changes. We chose a conventional subject pool for our study which allowed us to identify behavioral responses to different levels of resource scarcity but not to estimate effect sizes. Nevertheless, we had 13 medical students in the role of physicians. Since we found no qualitative differences in behavior between the 13 medical and the 45 non-medical students in the role of physicians, we pooled the observations from both groups for the results reported in the next section.

The order of the 27 decision scenarios was randomly selected and kept constant for all sessions. Note that using the same order for all subjects may lead to an order effect. However, based on findings in health economics experiments, we

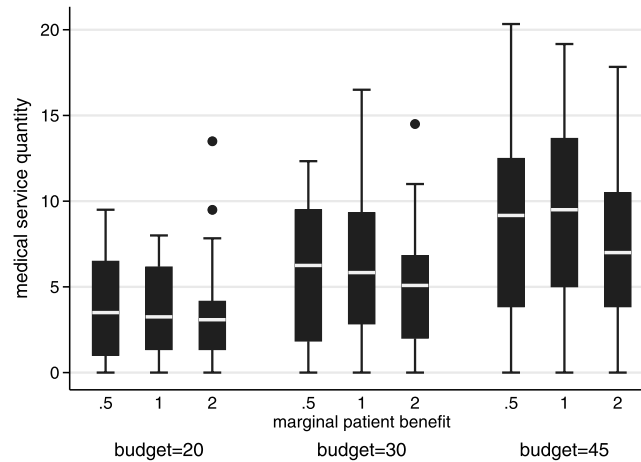


FIGURE 1 Boxplots for provided medical service quantities by budget and marginal patient benefit; This figure shows boxplots for the provided medical service quantities separately for the three marginal patient benefits within the three levels of budget. The gray boxes mark the interval from the 25th to the 75th percentile with the bright line indicating the median. The whiskers give the range of adjacent values while the dots represent outliers

expected to observe variation in physicians' allocation behavior (Brosig-Koch et al., 2017; Godager & Wiesen, 2013; Li, Dow, & Kariv, 2017) and wanted to avoid additional differences through heterogeneous order effects. Moreover, experimental studies report mixed evidence with a tendency toward the absence of order effects in health contexts (see Brosig-Koch et al., 2019; Buckley et al., 2015, 2016; but Wang, Iversen, Hennig-Schmidt, & Godager, 2017). Subjects were informed in the instructions that one period would be randomly chosen for payment (see Appendix B for the instructions). All amounts were given in tokens which were converted to Euro at an exchange rate of 1 token = 1.00 Euro at the end of the experiment. As second part of the experiment, we implemented the Social Value Orientation slider (Murphy, Ackermann, & Handgraaf, 2011). After the second part of the experiment, we asked subjects to complete a short questionnaire which contained questions on trust and inequality (based on the European Values Study, 2020) and questions on demographics (age, gender, nationality, and field of study). The ten experimental sessions were conducted between November and December 2016 as well as in December 2017. Each of the sessions lasted 1.5 h at most and subjects earned 19.50 Euro on average.

3 | RESULTS

In this section, we analyze how the 58 subjects in the role of physicians allocate the budget between themselves and the two passive patients.⁷ First, we look at the number of selfish decisions ($q_1 = q_2 = 0$) and optimally treated patients ($q_j = q_j^*$) for each level of budget. We observe that physicians more often allocate resources selfishly with an increasing degree of resource scarcity (*budget* = 20: 18.6%, *budget* = 30: 13.4%, *budget* = 45: 10.0%, $p \leq 0.082$, pairwise Wilcoxon matched-pairs signed rank tests). Concurrently, the number of optimally treated patients decreases with resource scarcity (*budget* = 20: 1.1%, *budget* = 30: 7.5%, *budget* = 45: 24.1%, $p < 0.001$; see also Table A3 in Appendix A). Boxplots for the quantity of provided medical services by physician budget and marginal patient benefit are shown in Figure 1 (average values are in Table A4 in Appendix A).

The number of services provided increases with physicians' budget. This is confirmed by ordinary least-squares regressions in which we control for physicians' personal characteristics and other influences.⁸ The share of budget that physicians devote to patient treatment, the *services-budget-ratio* ($\gamma = (q_1 + q_2)/\text{budget}$), remains remarkably stable across the three budget levels on average (*budget* = 20: 35.4%, *budget* = 30: 37.2%, *budget* = 45: 36.3%; $p \geq 0.338$, pairwise Wilcoxon matched-pairs signed rank tests; see also Figure A1 and Table A6 in Appendix A). As depicted in Figure A2 in Appendix A, the individual services-budget-ratios vary widely between physicians, though. To examine physicians' different reactions to budget variations in more detail, we compare the average services-budget-ratio by budget for each subject. We observe that 35 physicians change their (positive) services-budget-ratio by less than 10 percentage points between the different levels of budget.⁹ For the remaining physicians, we find no clear direction of the effect. Six physicians decrease their services-budget-ratio by more than 10 percentage points when the budget is

TABLE 2 Classification of decisions and subjects

		<i>N</i>	Selfishness $q_1 = q_2 = 0$	Equal benefits $b_1 = b_2$	Equal quantities $q_1 = q_2$	Efficiency $q_1 < q_2$
All	# of decisions	1044	135 (12.9%)	473 (45.3%)	406 (38.9%)	255 (24.4%)
	# of subjects with >50% decisions	58	6 (10.3%)	26 (44.8%)	16 ^a (27.6%)	10 (17.2%)
	<i>subject id</i>		2, 7, 16, 36, 45, 58	4, 9, 14, 17, 18, 19, 23, 24, 27, 28, 30, 31, 33, 34, 37, 39, 40, 41, 44, 47, 48, 50, 52, 53, 56, 57	1, 3, 6, 20, 21, 22, 24, 27, 29, 30, 32, 42, 49, 51, 55, 56	1, 6, 8, 11, 12, 13, 35, 43, 54, 55
<i>budget</i> = 20	# of decisions	348	59 (17.0%)	130 (37.4%)	128 (36.8%)	65 (18.7%)
	# of subjects with >50% decisions	58	9 (15.5%)	19 (32.8%)	18 ^b (31.03%)	8 (13.8%)
	<i>subject id</i>		2, 7, 16, 25, 26, 36, 45, 46, 53	9, 18, 22, 23, 27, 30, 31, 32, 33, 34, 39, 40, 41, 44, 48, 50, 52, 57, 58	1, 3, 5, 6, 10, 12, 20, 21, 22, 24, 27, 29, 30, 32, 43, 49, 51, 55	8, 11, 12, 13, 35, 43, 49, 54
<i>budget</i> = 30	# of decisions	348	45 (12.9%)	161 (46.3%)	113 (32.5%)	69 (19.8%)
	# of subjects with >50% decisions	58	6 (10.3%)	26 (44.8%)	10 ^c (17.2%)	9 (15.5%)
	<i>subject id</i>		2, 7, 16, 36, 45, 58	9, 14, 17, 18, 19, 22, 23, 24, 27, 28, 30, 31, 32, 33, 34, 37, 39, 40, 41, 44, 46, 48, 49, 50, 52, 53	20, 21, 22, 24, 25, 27, 30, 32, 42, 51	1, 8, 11, 12, 13, 15, 35, 54, 55
<i>budget</i> = 45	# of decisions	348	31 (8.9%)	182 (52.3%)	165 (47.4%)	121 (34.8%)
	# of subjects with >50% decisions	58	5 (8.6%)	29 (50.0%)	24 ^d (41.4%)	13 (22.4%)
	<i>subject id</i>		2, 7, 16, 36, 58	4, 6, 8, 11, 14, 17, 18, 19, 23, 24, 28, 29, 31, 33, 34, 37, 38, 39, 40, 41, 42, 44, 47, 48, 50, 52, 53, 56, 57	4, 6, 8, 9, 11, 15, 20, 22, 23, 24, 25, 28, 29, 30, 31, 32, 38, 42, 47, 50, 51, 52, 56, 57	6, 8, 11, 13, 23, 29, 31, 38, 42, 43, 55, 56, 57

Note: The first row in each cell gives the number of decisions which are consistent with an allocation principle. The second row gives the number of subjects who decide in line with an allocation type in more than 50% of decisions. Due to the capped patient benefit function and tolerance, decisions may be consistent with more than one principle and subjects may fall into more than one category or none at all. Therefore, percentages might not horizontally sum up to 100%. Italic numbers give the id of subjects who fall into a category.

^aFour subjects fall into the categories *equal quantities* and *equal benefits*, three subjects fall into the categories *equal quantities* and *efficiency*.

^bFour subjects fall into the categories *equal quantities* and *equal benefits*, three subjects fall into the categories *equal quantities* and *efficiency*.

^cFive subjects fall into the categories *equal quantities* and *equal benefits*.

^dSixteen subjects fall into the categories *equal quantities* and *equal benefits*, ten of these subjects also fall into the category *efficiency*.

lowered. This might be interpreted as a strategy of target income. In contrast, 11 physicians increase the services-budget-ratio when resources are more constrained. These subjects seem to give up some of their own profit to compensate for the lower budget level.

Next, we analyze how physicians allocate resources between heterogeneous patient types. Following the prioritization principles based on medical need (see Section 2.1), we consider *equal benefits*, *equal quantities*, and *efficiency* besides selfish decision-making (see Table A1 in Appendix A for predictions). For the analysis, we restrict the

data to patient combinations four to nine since predictions for *equal benefits* and *equal quantities* are exactly the same and there are no predictions for *efficiency* in combinations one to three. We allow a tolerance of one unit of medical services for *equal benefits* and *equal quantities*.¹⁰ Table 2 summarizes the classification results.

Overall, 32 physicians decide in line with one of the two *equality* principles in at least two budget conditions. The majority of these subjects decides in line with *equal benefits*. The trend that *equal benefits* is most often applied persists in all three budget conditions. Considering only decision-making in the high budget condition, 121 observations (34.8%) with heterogeneous patient types fall into more than one category. This problem arises because predictions for several principles coincide for a provided sum of 20 or more services. Therefore, we only compare the low and intermediate budget levels. We observe that, as physician budget decreases, fewer physicians choose *equal benefits* ($p = 0.022$, exact McNemar's test) and more decide in line with *equal quantities* ($p = 0.039$).¹¹ On an aggregate level, the average health benefit generated per unit of available budget differs between the low and intermediate budget conditions for patients with $\theta_j = 1$ (*budget* = 20: 0.182, *budget* = 30: 0.198, $p = 0.056$, Wilcoxon matched-pairs signed rank test) but not for the other patient types ($\theta_j = 0.5$: $p = 0.966$, $\theta_j = 2$: $p = 0.151$; all values are in Table A7 in Appendix A). Consequently, the increase in resource scarcity leads to a proportional decrease of average patient benefits.

4 | CONCLUSION

We investigate how different degrees of resource scarcity and patient characteristics influence medical service provision under capitation payment. In our experiment, most subjects in the role of physicians provide constant shares of their budgets to patient care and, thus, fewer services when they face more severe budget constraints. With respect to the allocation of resources between patients, the largest group of physicians provides equal patient benefits. On an aggregate level, patient benefits decrease in proportion to the increase in resource scarcity. On the individual level, we observe a considerable degree of heterogeneity in decision patterns, though, which is in line with findings from other health economics experiments (Brosig-Koch et al., 2017; Godager & Wiesen, 2013; Li et al., 2017).

Our findings indicate that — despite a considerable degree of non-selfish decisions — a change in the size of a physician's budget may lead to a proportional shift in patients' health outcomes. Of course, one has to be careful when transferring findings from the lab to the field, but our experimental results provide valuable guidance by disclosing possible impacts of budget changes on allocation behavior in medical care.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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ENDNOTE

¹ For example, patient characteristics such as comorbidities may not be objectively observable in a natural setting. Furthermore, physicians could face uncertainties regarding their budget and the effectiveness of treatment.

² Theoretically, numerous principles exist for prioritizing resources among patients (Golan, Hansen, Kaplan, & Tal, 2011; Sabik & Lie, 2008; Shah, 2009). While survey respondents seem to prefer equality over efficiency (e.g., Ahlert & Schwettmann, 2017; Attema, Brouwer, l'Haridon, & Pinto, 2015), participants in health economics experiments do not seem to share a clear preference for equality (e.g., Ahlert et al., 2012; Ahlert, Funke, & Schwettmann, 2013; Di Guida et al., 2019; Martinsson & Persson, 2019).

³ Ahlert et al. (2012) and Di Guida et al. (2019) also study physician provision behavior in settings with multiple patients. In contrast to their experiments, we implement a capitation payment scheme. More generally, one could argue that the treatment of two patients involves two simultaneous decisions. Two simultaneous tasks for physicians are also implemented in other experiments. For example, Reif et al. (2020)

- let physicians (1) request a budget from a health insurance and (2) decide about patient treatment, and Waibel and Wiesen (2019) ask physicians to (1) diagnose the patient and (2) decide about referring him to a specialist.
- ⁴ In health economics experiments, patient benefit is either donated to a charity caring for actual patients (e.g., Hennig-Schmidt et al., 2011; Di Guida et al., 2019) or given to subjects in the role of patients (Ahlert et al., 2012). We follow the latter approach and have subjects in the role of patients in the lab to account for different patients. Kesternich et al. (2015) compare experimental conditions with subjects in the role of patients to conditions in which patient benefit is donated to a charity. They observe that decision makers provide higher patient benefits if the corresponding payoffs are donated to charity.
- ⁵ In order to avoid any income effects, only one period was randomly chosen for payment.
- ⁶ Thus, 58 participants were assigned the role of physicians. Personal characteristics of these 58 subjects are summarized in Table A2 in Appendix A. After the first two sessions, we conducted a power analysis using the means and standard deviations of the low and intermediate budget level with G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). The calculation showed that we needed at least 27 subjects in order to detect a normalized effect of $d_z = 0.585$. The analysis was based on a two-sided Wilcoxon matched-pairs signed-rank test with a significance level of 5% and an assumed power of 80%.
- ⁷ Statistical analysis was conducted with Stata 14 (StataCorp, 2015).
- ⁸ See Table A5 in Appendix A for the regression results. While the effect of budget is robust, the tendency to give fewer services to patients with high marginal benefits depends on the experimental session.
- ⁹ In addition, four of the 58 physicians decide selfishly in at least 90% of their decisions.
- ¹⁰ A tolerance of one unit for *equal quantities* is necessary for an uneven sum of quantities provided. For some combinations of patient characteristics and the sum of quantities provided, a tolerance of one unit is necessary for *equal benefits*. For consistency, we apply the same tolerance to all cases in one category.
- ¹¹ Note that this is not caused by the same subjects changing from *equal benefits* to *equal quantities*.

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