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***On Poverty and the International
Allocation of Development Aid***

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Keywords: Poverty; Development; Aid; Resource Allocation; Claims

JEL Classification: D63; F35; I30; O10



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On Poverty and the International Allocation of Development Aid¹

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Abstract

We analyze the role of poverty levels on the allocation of international development aid. We estimate “claims” for each recipient, based on the incidence and depth of poverty in its territory, and explore possible reallocations of the current (overall) official development assistance (ODA) based on those claims. We consider four allocation rules rooted in ancient sources: the Aristotelian *proportional* rule, two *constrained egalitarian* rules, inspired by Maimonides, and the *Talmud* rule. Each of them is grounded on different normative principles, which allows assessing claims in different ways. Our results indicate that the current allocation of international development aid cannot be supported by any of those rules, which leads us to conclude that the allocation of ODA is not driven by eradicating world’s poverty as a goal.

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“The greatest escape in human history is the escape from poverty and death.” (Angus Deaton, 2013)

“Pauperism should be stopped every evening at 10 pm.”
(Ferdinand Llop, French Journalist, 1891-1974.)

1 Introduction

Although there exists a large consensus that living standards have increased considerably in the last two centuries, and fewer people than ever live in dire poverty nowadays, it can safely be argued that poverty is pervasive in many countries: Almost a billion people still live in material destitution and this is mostly a consequence of their birthplace.

After World War II, rich countries (donors) tried to help poor countries (recipients) in their attempts to reduce poverty using foreign aid.² In this paper, we concentrate on the largest component of foreign aid, the so-called official development assistance (ODA), which refers to funds transferred by donors to support the welfare and development of recipients.³

The United Nations have repeatedly urged developed countries to give 0.7 percent of their income as foreign aid. Nevertheless, and though the United States is the largest provider of ODA, it falls well behind that threshold, whereas Scandinavian countries are well above. We are not concerned with the appropriate amount of foreign aid each donor should meet. Instead, we take as given the overall amount of ODA and explore four “ancient” allocation rules based on the needs of recipients: the Aristotelian *proportional* rule, two *constrained egalitarian* rules inspired by Maimonides’ writings and the *Talmud* rule. Beyond the overall amount of ODA and the set of recipients, each rule requires to know how much each recipient demands or needs. We follow the theoretical literature and call these needs “claims.” There exist many possibilities to compute claims. One could, for instance, use some measure based on the Human Development Index, which is obtained by a weighted average of four other measures (life expectancy at birth, expected years of schooling, mean years of schooling and gross national product per capita in

²This is somewhat reversing the flow from the times in which colonial exploitation or military conquests were pumping resources from poor countries to rich countries.

³The cumulative amount of ODA since 1960 is approximately \$5 trillion. ODA rose rapidly in the 1960s and 1970s. It drastically decreased between 1980 and 2000, as a consequence of the end of the Cold War, but increased by more than 50 percent later on (Deaton, 2013, p.275).

PPP dollars).⁴ But here, we are essentially interested in a direct measure of poverty, and consider the number of poor individuals within each recipient (region or country), weighted by the poverty gap. In other words, each recipient's claim will be the amount it would need to push all its poorest citizens to defined poverty line.

Our main message is that the current ODA allocation is supported by none of these rules. This is of course not fully surprising for several reasons among which we single out the following ones: (a) Excessive dispersion of development assistance (Flogstad and Hagen, 2017); (b) though the distribution of aid is decided by committees of experts, for unknown reasons, some poor countries are suddenly under the spotlights of groups of donors and are evaluated for other reasons than their poverty. This creates a *bandwagon effect* (Dudley and Montmarquette, 1976) and every donor presses to donate to these countries. Then, all of a sudden the pressure goes to others; (c) ODA's aid includes the salaries of agents from the developed world who have to carry out the projects, so that the numbers get blurred; (d) geopolitics play a crucial role (e.g., Harrigan and Wang, 2011); (e) substantial and entrenched donor heterogeneity, which cause donor fragmentation (Clist, 2011); and, finally (f) the poorest countries do not always have the absorptive capacity to spend all the money that is made available, or, even worse, cannot use the funds because they are unable to contribute by counterpart funds.

Our procedure implies that each donor chooses how much it donates, but not the recipient(s) of this donation. This is computed using a specific sharing rule, decided by a qualified majority of all donors, and does not need committees of experts. An organization (say, the World Bank, or the OECD) would collect the donations and redistribute them using a specific rule. We acknowledge that this may, of course, be criticized by donors, who usually choose their recipients according to some idiosyncratic or *ad hoc* criteria and old or more recent links with recipients: France would preferably give to its former colonies, and so would Belgium; the US would probably not like giving to Cuba, especially in the present context. But the distribution would probably be more efficient, since today some countries collect too much, and some too little. The chosen rule may also have its drawbacks, but at least, the choice would be based on the "objective" axioms that support it.

We consider four rules which treat claims in different ways. The Aristotelian *proportional* rule awards each recipient an amount proportional to its claim. It imposes that the ratio

⁴See the latest Human Development Index Ranking at <http://hdr.undp.org/en/2018-update>.

between the amount obtained and the amount claimed is the same across recipients. The *constrained equal awards* rule, which can be traced back to Maimonides, imposes instead equal awards (rather than ratios), provided no recipient obtains an amount larger than its claim. The *constrained equal losses* rule is dual to the previous rule, and imposes equal losses (to be understood as the difference between claim and awarded amount) for recipients, provided no recipient obtains a negative amount. Finally, the *Talmud* rule is a hybrid between the *constrained equal awards* and *constrained equal losses* rules. The first or the second is used depending on whether the amount to divide falls below or above one half of the aggregate claim recipients make.

Rules are grounded on normative principles. Therefore, the choice of the rule is ultimately driven by its normative foundations, and endorsing a specific rule is equivalent to endorsing the distinctive principles on which it relies.

The paper is organized as follows. In Section 2, we discuss the data, and show that ODA's distribution is not in line with the needs of the poorest people. Section 3 formally introduces our model and the rules that can be used to "share the pie." Section 4 is devoted to the results, which look very different from the current distribution of ODA. We conclude in Section 5.

2 Data: What the rich give, and what the poor receive

Most data come from the World Development Indicators that the World Bank (WB) provides.⁵ We use data for the net official development assistance received (in constant 2015 US\$) that are available from 1960 to 2016.⁶ For reasons briefly developed above (such as bandwagon effects), we use the average ODA aid between 2012 and 2016, which amounts to \$107.5 million. Though disaggregation by country is of course feasible, here we aggregate countries into six regions defined by the WB: East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and the Caribbean (LAC), Middle East and North Africa (MNA), South Asia (SAS) and Sub-Saharan Africa (SSA).

⁵<https://datacatalog.worldbank.org/dataset/world-development-indicators>

⁶According to them, the source is the Development Assistance Committee of the Organization for Economic Co-operation and Development, Geographical Distribution of Financial Flows to Developing Countries, Development Co-operation Report, and International Development Statistics database. Data are available online at: www.oecd.org/dac/stats/idsonline.

Table 1 collects the recipients, their populations and the amounts they obtained from the average 2012-2016 ODA allocation. Observe that the per capita amounts that inhabitants of these regions receive from ODA range from \$4.26 in East Asia and The Pacific to \$64.11 in The Middle East and North Africa. This is somewhat intriguing, as the Middle East and North Africa receive almost 40 percent per head more than Sub-Saharan Africa, and Europe and Central Asia receive more than twice as much as South Asia.

[Insert Table 1 about here]

Data on global poverty from 1981 to 2013 used to determine the recipients' claims, are also computed by the WB.⁷ We rely on the 2013 estimate based on over two million randomly sampled households which were interviewed in countries that represent 85 percent of the world population. *Headcount ratios* represent the share of the population in each region (or country) which is below a given poverty line. These exist for three possible levels: \$1.90, \$3.20 and \$5.50 per day. In Sub-Saharan Africa (SSA), for example, 42.2% of the population is below the \$1.90 per day poverty line. *Poverty gaps* measure by how much the average "under the poverty line" citizen is located. Again, for SSA and the \$1.90 per day poverty line, the percentage is 16%, which means that the average citizen below that poverty line is 16% away from this line.

The annual claim of each region is obtained by the number of poor agents in the region (headcount ratio times population) multiplied by the average distance to the poverty line (poverty gap) multiplied by 365 (the number of days in a year). We thus assume that each poor agent in the region falls below the poverty line by as much as the average poverty gap indicates. Table 2 displays poverty numbers (headcount and gap) and their corresponding claims for all three poverty levels.

An immediate aspect to be raised for the \$1.9 level is that the incidence of extreme poverty varies considerably among regions. Two regions (ECA and MNA) have small claims (the incidence of extreme poverty is small), two regions (EAP and LAC) have reasonable claims, whereas one (SAS) has a large claim and the last (SSA) an extremely large claim (2,000 times larger than the smallest), which reflects its extreme poverty. While the overall ODA amount is two times larger than the total claim, it is far from taking into account this variation: the amount claimed by the highest claimant (SSA) is not fully covered by ODA, while all other

⁷<http://iresearch.worldbank.org/PovcalNet/home.aspx>

regions obtain more than what they claim, and in two cases (ECA, and MNA), almost 400 and 650 times more than their claim. It is striking, for instance, that the Middle East and North Africa region is awarded the second largest ODA amount, while it has the second lowest claim.

[Insert Table 2 about here]

Another important aspect is that the aggregate claim falls below the overall ODA amount. This implies that if the goal of ODA were to eradicate completely extreme poverty, this is potentially doable over time: A similar point has been made by many others recently. Deaton (2013) underscores that it would only take each American adult to donate \$0.30 per day to lift the whole world's citizens above the \$1 poverty threshold.⁸ If the adults of Britain, France, Germany and Japan joined the coalition the per-head donation would just need to be \$0.15 per day. Similarly, Collier and Dollar (2002) argue that, with the 1996 actual allocation, aid lifted around 10 million people annually out of poverty in their sample of countries. With a poverty-efficient allocation, the productivity of aid would nearly double.

Related to the last issue raised above, note that all regions, with the exception of SSA, obtain larger amounts than their claims. As we shall see later, the literature on adjudicating conflicting claims assumes that, if the endowment is below the aggregate claim, no recipient should get an amount above its claim. In the opposite case, that is when the endowment is above the aggregate claim, it seems natural to require the counterpart: All recipients should get amounts above their individual claims. Consequently, the ODA obviously discriminates against Sub-Saharan Africa which needs help very badly.

The two lower parts of Table 2 display the same results for the \$3.2 and the \$5.5 per day poverty levels. The aggregate claims are now much larger than the observed ODA amount, which implies that current ODA amounts cannot eradicate completely moderate poverty (\$3.2 per day), but still give too much to ECA and MNA, and fail to help the two largest claimants (SAS and SSA). This gets of course much worse if the objective is to reach the \$5.5 per-day poverty line.

⁸Admittedly, some Americans might be unable to afford this.

3 Using rules to distribute ODA

We now introduce the four rules that should lead to more justice and efficiency. Appendix 1 justifies these rules through axioms.

Let N denote the set of recipients of official development assistance (ODA) and E be the exogenously given budget (*endowment*) to be allocated among recipients as *development aid*.⁹ Each recipient holds a claim against the budget, according to its needs. We formalize needs by considering poverty numbers, that is, we take the number of poor individuals in each recipient region, weighted by the mean (poverty) gap. Let c_i be recipient i 's claim and $C = \sum_{i=1}^n c_i$ be the aggregate claim. It is natural to assume that $E < C$, for otherwise each recipient could receive its claim.

Formally, the problem is defined by a 3-tuple (N, c, E) where N is the set of recipients, c is the vector of claims containing elements c_i , $i \in N$, and E is the endowment to be allocated among recipients. The family of all the problems so described is denoted by \mathcal{P} . A rule is a mapping that associates with each problem the allocation each recipient receives. We impose the *efficiency* condition that the whole endowment E is allocated, and a *boundedness* requirement that no recipient receives a negative amount or an amount larger than its claim. Formally, for each $(N, c, E) \in \mathcal{P}$, $\sum_{i=1}^n R_i(N, c, E) = E$, and for each $i \in N$, $0 \leq R_i(N, c, E) \leq c_i$. This problem is mathematically equivalent to the so-called *problem of adjudicating conflicting claims* formalized by O'Neill (1982).¹⁰ We now consider the focal rules mentioned in Section 1:

(a) The **proportional rule** awards agents in proportion of their claims. Formally, for each $(N, c, E) \in \mathcal{P}$, and each $i \in N$,

$$P_i(N, c, E) = \frac{E}{C} \cdot c_i.$$

(b) The **constrained equal awards** rule distributes the endowment equally among all recipients, subject to no recipient receiving more than its claim. Formally, for each $(N, c, E) \in \mathcal{P}$, and each $i \in N$, $A_i(N, c, E) = (\min\{c_i, \lambda\})_{i \in N}$, where $\lambda > 0$ is chosen so that $\sum_{i \in N} \min\{c_i, \lambda\} = E$.

(c) The **constrained equal losses** rule imposes that losses are as equal as possible subject to

⁹In the calculations provided in Section 4, E is the average of the overall ODA amount allocated during the last 5 years. To make the analysis less tedious, we consider the six large regions of developing countries provided by the World Development Indicators. We could extend the analysis disaggregating it to the level of countries, although poverty data are missing for some of them.

¹⁰See Thomson (2003, 2015, 2018) for excellent surveys on the sizable related literature.

no recipient receiving a negative amount. Formally, for each $(N, c, E) \in \mathcal{P}$, and each $i \in N$, $L(N, c, E) = (\max\{0, c_i - \lambda\})_{i \in N}$, where $\lambda > 0$ is chosen so that $\sum_{i \in N} \max\{0, c_i - \lambda\} = E$.

(d) The **Talmud rule** behaves like one of the previous two rules, depending on whether the endowment falls short or exceeds one half of the aggregate claim, while using half-claims (instead of claims) as individual bounds. Formally, for each $(N, c, E) \in \mathcal{P}$, and each $i \in N$,

$$T_i(N, c, E) = \begin{cases} \min\{\frac{c_i}{2}, \lambda\} & \text{if } E \leq \frac{1}{2}C \\ \max\{\frac{c_i}{2}, c_i - \mu\} & \text{if } E \geq \frac{1}{2}C \end{cases}$$

where λ and μ are chosen so that $\sum_{i \in N} T_i(N, c, E) = E$.¹¹

The *Talmud* rule applies equal division until the claimant with the smallest claim has obtained one half of its claim. Then, that agent stops receiving additional units and the remaining amount is divided equally among the other agents until the claimant with the second smallest claim gets one half of its claim. The process continues until every agent has received one half of its claim, or the available amount is distributed. If there is still something left after this process, agents are invited back to receive additional shares. Now agents receive additional amounts sequentially starting with those with larger claims and applying equal division of their losses.

The normative foundations for the four rules provided in Appendix 1 should guide those who would have to choose the rule. We highlight, for instance, that the *proportional* rule prevents coalitional manipulations among recipients, whereas the *Talmud* rule guarantees meaningful lower bounds for awards and losses for all recipients. These are probably their most distinguishing features. As for the *constrained equal awards* and *constrained equal losses* rules they guarantee, respectively, meaningful lower bounds for awards or losses for all recipients, as well as an appropriate reaction to tentative allocations of a wrong estimation of the endowment.

4 Rules: What the poor ought to receive

Table 3 collects the results for two poverty lines only (\$3.2 and \$5.5), as the computed claims at poverty line \$1.9 add up to an amount that is smaller than ODA's average \$107.5 billion per

¹¹This formula was proposed by Aumann and Maschler (1985), as a convincing way to formalize the apparently unrelated suggestions made in the *Talmud*.

year to be shared. In this case, each region should receive its claim.

The observed ODA allocation is compared to the ones obtained using each of the four rules discussed in Section 3: constrained equal awards (CEA), proportional (PROP), Talmud (TAL) and constrained equal losses (CEL).¹² A common feature of the four rules is that they all preserve the ranking provided by claims: Regions with larger (or equal) claims receive higher (or equal) amounts. All four rules thus satisfy the axiom of *Order preservation* (see Thomson, 2018).

The rankings derived from the rules differ from the ODA ranking though ECA always appears at the bottom, which seems reasonable, and SSA or SAS are at the top. As mentioned earlier, MNA gets the second largest ODA amount, which is no longer so if rules are used.

[Insert Table 3 about here]

The CEA rule would lead to an allocation favoring regions with smaller claims: it would give their full claims to EAP, ECA, LAC and MNA, whereas it would give the same amount (lower than their claims, but higher than the amounts obtained by the previous four regions) to the other two regions. This distribution is very different from the actual ODA allocation, except perhaps for SSA.

The CEL rule would, as expected, lead to an allocation favoring regions with higher claims. It grants zero to EAP, ECA, LAC and MNA, whereas the two other regions receive amounts guaranteeing that they lose the same with respect to their respective claims. Again, CEL's distribution differs from that of ODA.

Both the proportional and Talmud rules offer, as expected, more balanced allocations. Under the proportional rule, each region obtains roughly one fourth of its claim (the proportion between the overall ODA amount and the overall claim). This contrasts seriously with what we observed in Table 2, where half of the regions obtain ODA amounts exceeding their claims. The comparison between the proportional and the ODA allocation shows that the treatment of regions varies: SAS gets one third, while ECA gets 64 times what the proportional allocation suggests.¹³

¹²This order of rules is more intuitive and easier to discuss. In Section 3, we needed to present CEL and CEA before TAL, since TAL is a combination of the two first rules.

¹³The remaining ratios are 1.8 (EAP), 11.4 (LAC), 43.7 (MNA) and 0.72 (SSA).

Finally, under the Talmud rule, the four regions with lowest claims (EAP, ECA, LAC and MNA) get exactly one half of their claims, while the other two regions share equally the remaining budget. Again, this can be contrasted with what we pointed out in Table 2, since half of the regions obtain ODA amounts that are above their claims. Comparing directly the Talmud and the ODA allocations shows that the treatment of regions varies: SAS gets an ODA allocation that is about four times smaller than what the Talmud rule recommends; ECA, receives 32 times less under the Talmud rule.¹⁴

Though ODA and the Talmud rule differ, they are somewhat closer than the allotments under the three other rules. Nevertheless, it can safely be argued that the current ODA distribution is unrelated to any of our allocation schemes. This leads us to conclude that the observed ODA allocation is not meant to eradicate poverty.

Under the highest poverty line (\$5.5 per day), some new features arise, as is shown in the second part of Table 3. To begin with, SAS is the new highest claimant, and is now the only recipient under CEL. Although extreme poverty is more prevalent in Sub-Saharan Africa, South Asia (which has a much larger population) overcomes the former as the number of poor individuals increases dramatically if the poverty line goes from \$3.2 to \$5.5 per day. Under the Talmud rule, only the two regions with smallest claims get half of their claim, while the other four share equally the remainder. Similarly, under CEA, only the region with the smallest claim (ECA) is fully honored, while the other five regions share equally the remainder.

5 Conclusions

We revisited the allocation of international development aid from the viewpoint that eradicating poverty should be one of its fundamental goals, if not the only one. To show this, we estimate claims based on the incidence and depth of poverty in six regions, and explore possible reallocations of ODA based on these claims. We consider four allocation rules rooted in ancient sources and grounded on different normative principles, which makes it possible to assess the claims in different ways. Our results indicate that none of the rules leads to an allocation that is close to the one we observe, and conclude that aid is not driven by the idea of eradicating poverty. This is not surprising since aid is also, and unfortunately so, given for political reasons,

¹⁴The remaining ratios are 0.91 (EAP), 5.68 (LAC), 21.72 (MNA) and 0.92 (SSA).

even if the distribution is controlled by experts.

Our analysis considers six developing regions in the world. We tried to extend it to individual countries, but this is difficult as data for poverty levels are not available for all countries. Based on our exploratory analysis, we believe that the disaggregated analysis would only reinforce our main message.

It is frequently argued that donors seem to give aid to *countries* rather than to *people* and would prefer to give to as many countries as possible, paying little attention to where poor people live. As a result, small countries receive more than large countries (Deaton, 2013; pp. 277-278). This is positively reflected in our data, where we observe that, for instance, MNA is awarded the second largest ODA amount, though it has the second lowest claim.

As mentioned in the introduction, we are fully aware that the ODA allocation is not centralized. In fact, about 80 percent of ODA is bilateral (Deaton, 2013, pp. 276-277). Here we consider instead that there is a hypothetical big pool in which all national donations should be aggregated and redistributed. This is probably not politically feasible, but our work might be considered as advocating for a change in that direction. This is, for instance, in line with Bigsten and Tengstam (2015), who argue that much could be gained in terms of aid effectiveness from improved donor coordination. A centralized distribution process would be much more efficient (and fair). Similar proposals have been made, among others, by Burnside and Dollar, 2000; Llavador and Roemer, 2001; Easterly, 2003; Banerjee, 2007, and McGillivray and Clarke, 2018.

6 Appendix

We consider now several axioms for the allocation of aid on the basis of recipients' claims.

Sometimes, a region within a country may want to secede to join another country or to create another independent nation. A group of countries may decide to be part of another country or create a union. The first axiom says that if a group of recipients $S \subseteq N$ agree to create a union, the share given to the union should be the same as the total share for its members (before the union).

*Union Invariance.*¹⁵ For each $(N, c, E) \in \mathcal{P}$ and each $S \subseteq N$, if $N' = [N \setminus S] \cup \{\nu\}$, $c_\nu = \sum_{i \in S} c_i$,

¹⁵This axiom coincides with “merging-splitting-proofness” in Ju et al., (2007).

and $c' = (c_{N \setminus S}, c_\nu)$

$$\sum_{i \in S} R_i(N, c, E) = R_\nu(N', c', E).$$

As a corollary of a more general result shown in Ju et al., (2007), we obtain that the proportional rule is the only rule satisfying union invariance.

Proposition 1 *A rule satisfies union invariance if and only if it is the proportional rule.*

The next (basic) property says that recipients with equal claims should receive equal amounts. Formally, a rule R satisfies *equal treatment of equals* if for each $(N, c, E) \in \mathcal{P}$, and each pair $i, j \in N$, we have $R_i(N, c, E) = R_j(N, c, E)$, whenever $c_i = c_j$.

Another basic property says that if claims and endowment are multiplied by the same positive number, then so should all awards. Formally, a rule R satisfies *scale invariance* if for each $(N, c, E) \in \mathcal{P}$, and each $\lambda > 0$, we have $R(N, \lambda c, \lambda E) = \lambda R(N, c, E)$.

The next property, which has played a fundamental role in axiomatic work, says that if some claimants leave with their awards and the problem of dividing among the remaining claimants what is left is considered, these claimants should receive the same awards as initially. Formally, a rule R is *consistent* if for each $(N, c, E) \in \mathcal{P}$, each $M \subset N$, and each $i \in M$, we have $R_i(N, c, E) = R_i(M, c_M, E_M)$, where $E_M = \sum_{i \in M} R_i(N, c, E)$.

We now consider two additional properties dealing with the solvability of a problem in stages. To motivate these properties think of the following situation: after having divided the allocation of the endowment, it turns out that the actual value of the endowment is larger than was initially assumed. Then, two options are open: either the tentative division is cancelled altogether and the actual problem is solved, or we add to the initial distribution the result of applying the rule to the remaining endowment. The requirement formulated next is that both ways of proceeding should result in the same awards vectors. Formally, a rule R satisfies *composition up* (Young, 1988) if, for each $(N, c, E) \in \mathcal{P}$, and all $E_1, E_2 \in \mathbb{R}_{++}$ such that $E_1 + E_2 = E$, $R(N, c, E) = R(N, c, E_1) + R[N, c - R(N, c, E_1), E_2]$.

Think now of the dual case. Namely, after having divided the endowment one finds that the actual value of the endowment falls short of what was assumed. Here again we can ignore the initial division and apply the rule to the revised problem, or we can apply the rule to the problem in which the initial claims are substituted by the (unfeasible) allocation initially proposed. The

next requirement is that both ways of proceeding should result in the same awards vectors. Formally, a rule R satisfies *composition down* (Moulin, 1987) if, for each $(N, c, E) \in \mathcal{P}$, and all $E' > E$, we have $R(N, c, E) = R[N, R(N, c, E'), E]$.

As a corollary of a more general result shown by Moulin (2000), we obtain that there are only three rules that satisfy the last five axioms.

Proposition 2 *A rule satisfies equal treatment of equals, scale invariance, consistency, composition up and composition down if and only if it is the proportional rule, the constrained equal awards rule or the constrained equal losses rule.*

The Talmud rule satisfies equal treatment of equals, scale invariance and consistency, but violates composition up and composition down. There are, nevertheless, other appealing properties (such as the following ones) satisfied by the Talmud rule.

We start with two independence properties, known as *Claims Truncation Invariance* and *Minimal Rights First*.¹⁶ The former postulates that the part of a claim that is above the endowment should be ignored. That is,

$$R(N, c, E) = R(N, t(N, c, E), E),$$

where $t_i(N, c, E) = \min\{E, c_i\}$ for each $i \in N$. The latter ensures each recipient the portion of the endowment that is left when the claims of all other agents are fully honored (provided this amount is nonnegative) and divides the remainder according to revised claims. Formally,

$$R(N, c, E) = m(N, c, E) + R(N, c - m(N, c, E), E - M(N, c, E)) ,$$

where $m_i(N, c, E) = \max\{0, E - \sum_{j \in N \setminus \{i\}} c_j\}$, for each $i \in N$, and $M(N, c, E) = \sum_{i \in N} m_i(N, c, E)$.

We now move to axioms modeling the concept of lower and upper bounds, which have a long tradition of use within the theory of fair allocation. A focal lower bound is the so-called *Average Truncated Lower Bound on Awards*, which is somewhat related to the *Claims Truncation Invariance* axiom considered above. It ensures each agent a minimal share of her individual claim, no matter what the other claims are. In particular, for a problem involving n agents, it establishes that any agent holding a feasible claim (a claim not larger than the endowment) will get at least one n th of her claim. And also that those agents whose individual claims are

¹⁶These two axioms were studied first by Curiel et al. (1987).

unfeasible will get at least one n th of the endowment.¹⁷ Formally, a rule R satisfies *Average Truncated Lower Bound on Awards* if, for each $(N, c, E) \in \mathcal{D}$, $R_i(N, c, E) \geq \frac{1}{n} \min\{c_i, E\}$. Its dual property is also an interesting one. This property provides an upper bound to each claimant involved in the problem. Formally, a rule R satisfies *Average Truncated Lower Bound on Losses* if, for each $(N, c, E) \in \mathcal{D}$, $R_i(N, c, E) \leq c_i - \frac{1}{n} \min\{c_i, C - E\}$.

The following characterization results of the Talmud rule were proved by Dagan (1996) and Moreno-Tertero and Villar (2004, 2006).¹⁸

Proposition 3 *The Talmud rule is characterized by*

1. *Equal treatment of equals, Consistency, Minimal Rights First and Claims Truncation Invariance.*
2. *Consistency, Average Truncated Lower Bound on Awards and Average Truncated Lower Bound on Losses.*
3. *Consistency, Average Truncated Lower Bound on Awards and Minimal Rights First.*
4. *Consistency, Average Truncated Lower Bound on Losses and Claims Truncation Invariance.*

The proportional rule violates the last four properties. The constrained equal-awards and constrained equal-losses rules satisfy a pair each. More precisely, Dagan (1996) and Yeh (2008) provide the following characterization results, which are partially based on them.

Proposition 4 *The following statements hold:*

1. *A rule satisfies Consistency, Average Truncated Lower Bound on Awards and Composition Up if and only if it is the constrained equal-awards rule.*
2. *A rule satisfies Consistency, Average Truncated Lower Bound on Losses and Composition Down if and only if it is the constrained equal-losses rule.*
3. *A rule satisfies Equal treatment of equals, Claims Truncation Invariance and Composition Up if and only if it is the constrained equal-awards rule.*

¹⁷The property was introduced by Moreno-Tertero and Villar (2004) under the name of *Securement*.

¹⁸See also Moreno-Tertero (2006).

4. A rule satisfies Equal treatment of equals, Minimal Rights First and Composition Down if and only if it is the constrained equal-losses rule.

[Insert Table 4 about here]

7 References

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Table 1. Regions, Populations and ODA Allocations

Regions		ODA (\$millions)	Population (millions)	ODA (per head)
East Asia and Pacific	EAP	8559.9	2007.5	4.26
Europe and Central Asia	ECA	8806.5	482.3	18.26
Latin America and the Caribbean	LAC	9637.1	612.9	15.72
Middle East and North Africa	MNA	22977.4	358.4	64.11
South Asia	SAS	13835.8	1699.3	8.14
Sub-Saharan Africa	SSA	43700.1	947.6	46.12
Total		107516.8	6108.0	17.60

Table 2. Regions, Poverty and Claims at Various Poverty Levels per Day

Regions		Headcount (%)	Poverty gap (%)	Claim (\$ millions)	ODA (\$ millions)	Ratio (ODA/Claim)
<i>\$1.9 claim per day</i>						
East Asia and Pacific	EAP	3.64	0.69	350.0	8559.9	24.46
Europe and Central Asia	ECA	1.59	0.42	22.5	8806.5	391.88
Latin America and the Caribbean	LAC	4.54	1.75	337.8	9637.1	28.53
Middle East and North Africa	MNA	2.66	0.53	35.0	22977.4	657.0
South Asia	SAS	15.14	2.79	4976.1	13835.8	2.78
Sub-Saharan Africa	SSA	42.29	16.51	45899.0	43700.1	0.95
Total				51620.4	107516.8	2.08
<i>\$3.2 claim per day</i>						
East Asia and Pacific	EAP	17.56	4.57	18812.3	8559.9	0.46
Europe and Central Asia	ECA	5.75	1.7	550.0	8806.5	16.01
Latin America and the Caribbean	LAC	11.33	4.18	3391.1	9637.1	2.84
Middle East and North Africa	MNA	14.51	3.48	2115.5	22977.4	10.86
South Asia	SAS	52.58	15.72	164056.2	13835.8	0.08
Sub-Saharan Africa	SSA	67.47	32.68	244028.9	43700.1	0.18
Total				432954.0	107516.8	0.25
<i>\$5.5 claim per day</i>						
East Asia and Pacific	EAP	42.49	15.35	262840.9	8559.9	0.03
Europe and Central Asia	ECA	14.06	5.09	6925.2	8806.5	1.27
Latin America and the Caribbean	LAC	27.06	10.44	34752.3	9637.1	0.28
Middle East and North Africa	MNA	42.65	14.28	43795.6	22977.4	0.52
South Asia	SAS	83.47	38.93	1108544.9	13835.8	0.01
Sub-Saharan Africa	SSA	85.17	51.62	836377.8	43700.1	0.05
Total				2293236.7	107516.8	0.05

Table 3. Comparing Allocations at Various Poverty Levels per Day

Regions		ODA	Claim	CEA	PROP	TAL	CEL
<i>\$3.2 claim per day</i>							
East Asia and Pacific	EAP	8559.9	18812.3	18812.3	4671.7	9406.1	0.0
Europe and Central Asia	ECA	8806.5	550.0	550.0	136.6	275.0	0.0
Latin America and the Caribbean	LAC	9637.1	3391.1	3391.1	842.1	1695.6	0.0
Middle East and North Africa	MNA	22977.4	2115.5	2115.5	525.3	1057.7	0.0
South Asia	SAS	13835.8	164056.2	41324.0	40740.6	47541.2	13772.1
Sub-Saharan Africa	SSA	43700.1	244028.9	41324.0	60600.5	47541.2	93744.7
Total		107516.8	432954.0	107516.8	107516.8	107516.8	107516.8
<i>\$5.5 claim per day</i>							
East Asia and Pacific	EAP	8559.9	262840.9	20118.3	12323.1	21669.5	0.0
Europe and Central Asia	ECA	8806.5	6925.2	6925.2	324.7	3462.6	0.0
Latin America and the Caribbean	LAC	9637.1	34752.3	20118.3	1629.3	17376.2	0.0
Middle East and North Africa	MNA	22977.4	43795.6	20118.3	2053.3	21669.5	0.0
South Asia	SAS	13835.8	1108544.9	20118.3	51973.4	21669.5	107516.8
Sub-Saharan Africa	SSA	43700.1	836377.8	20118.3	39213.0	21669.5	0.0
Total		107516.8	2293236.7	107516.8	107516.8	107516.8	107516.8

Note: The \$1.9 poverty line does not appear in the table for reasons explained in the paper.

Table 4. Properties and Rules

	P	CEA	CEL	T
Union invariance	+			
Equal treatment of equals	(+)	(+){ \times }	(+)[\times]	*
Scale invariance	(+)	(+)	(+)	
Consistency	(+)	(+) \times	(+)(\times)	*{*}{*}{*}
Composition Up	(+)	(+) \times { \times }	(+)	
Composition Down	(+)	(+)	(+)(\times) [\times]	
Average Truncated Lower Bound on Awards		\times		{*}{*}
Average Truncated Lower Bound on Losses			(\times)	{*}{*}
Claims Truncation Invariance		{ \times }		*{*}
Minimal rights first			[\times]	*{*}

Note: + is for Proposition 1; (+) is for Proposition 2;

* is for Proposition 3.1; (*) is for Proposition 3.2; {*} is for Proposition 3.3; [*] is for Proposition 3.4;

\times is for Proposition 4.1; (\times) is for Proposition 4.2; { \times } is for Proposition 4.3; [\times] is for Proposition 4.4.