

## Impact Analyses (IMLS complete data set)

The impact analyses below were based on the full IMLS (n=1578) data set. These analyses controlled for unobserved book effects.

A linear mixed effects model with a book-specific random intercept was used.

In R notation...  $y \sim \text{Gel} + \log\text{Ca} + \log\text{K} + \log\text{S} + \log\text{Fe} + \log\text{Al} + (1 | \text{book})$ ,  
where the response variable  $y$  is one of Delta L\* or Delta A\*.

Results...

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### Effect on Delta L\*...

Covariate	Increment in Covariate	Change in Delta L*	Margin of Error	P-Value
Gel	2.83	1.320166	0.2546259	1.707297e-25
Ca	162.41%	1.259983	0.2635545	5.805079e-22
K	109.9%	-0.7944367	0.3076235	1.202234e-07
S	149.08%	-0.7355805	0.4878937	0.001283496
Fe	44.43%	-1.581318	0.2026856	3.437242e-55

$\text{sd}(\text{DeltaL}^*) = 4.845915$

To make the comparisons fair, all Increments in Covariates correspond to the respective covariate's standard deviation. Because Ca-Fe were entered into the model on the log scale, the increments are multiplicative.

As examples,

Controlling for the effects of all the other covariates and unobserved book effects, a 2.83 unit (i.e. one standard deviation) increase in Gelatin is associated with an estimated 1.32 unit increase in Delta L\*. The margin of error is 0.255 and the p-value is < .0001. (Note that the estimate +/- margin of error gives a 95% confidence interval.)

Controlling for the effects of all the other covariates and unobserved book effects, a 162% increase in Calcium (i.e. a one standard deviation increase in log Calcium) is associated with an estimated 1.26 unit increase in Delta L\*. The margin of error is 0.264 and the p-value is < .0001.

Note: All the factors are statistically related to Delta L\*.

Note: To get an idea of how big the change in Delta L\* is, compare it to the standard deviation  $\text{sd}(\text{Delta L}^*) = 4.85$ .

A rank ordering of the "impact of covariates" can be based on the absolute magnitudes of the values in the column labeled "Change in Delta L\*" and the margin of errors in the column labeled "Margin of Error."

Define the *conservative estimate of impact* as  $CEI = \text{minimum}\{|u|: d - me \leq u \leq d + me\}$ , where  $d$  is the estimate of the Change in Delta L\* (corresponding to a 1 standard deviation in the covariate) and  $me$  is the margin of error associated with this estimate.

As an example, suppose that the estimated change in Delta L\* is  $d = 1.320$ , with  $me = 0.255$ . Then plausible estimates of the actual change in Delta L\* include values between 1.065 and 1.575. Thus, a plausible estimate of the change in Delta L\* is as close to 0 as 1.065. By the definition of CEI, we have  $CEI = 1.065$ . (See the 3 number-line graphics below for other examples.)

-----0-----[1.065----1.320----1.575]---      Then CEI= 1.065 (plausible estimates as close to 0 as 1.065)  
 -----[-0.2---0-----1.2-----2.6]-----      Then CEI = 0 (0 is a plausible estimate)  
 -----[-1.2---- -1.0 ---- -0.8]-----0-----      Then CEI = 0.8 (plausible estimates as close to 0 as -0.8)

Based on CEI, we have the following:

Impact Ranking (Response=Delta L\*)... **Fe > Gel > Ca > K > S** [emboldened factors have positive effects]

Disclaimer: The impacts of the first three of these covariates are statistically similar.

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**Effect on Delta A\*...**

Covariate	Increment in Covariate	Change in Delta A*	Margin of Error	P-Value
Gel	2.83	-0.4982522	0.09838362	2.059121e-24
Ca	162.41%	-0.4874386	0.1017319	4.722019e-22
K	109.9%	0.2093307	0.1187848	0.0002121127
S	149.08%	0.2626452	0.1882787	0.00263571
Fe	44.43%	0.4761517	0.07823679	2.189246e-34

$sd(\text{DeltaA}^*) = 1.815362$

For example,

Controlling for the effects of all the other covariates and unobserved book effects, a 44.43% increase in Fe is associated with an estimated 0.476 unit increase in Delta A\*.

Based on CEI, Impact Ranking (Response = Delta A\*)... **Gel > Fe > Ca > K > S**

Disclaimer: The impacts of the first three are virtually identical.