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# On the Structure of the Inverse-Feasible Region of a Linear Program

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## Abstract.

Given a set of feasible solutions  $\mathcal{X}$  to a linear program, we study the set of objectives that make  $\mathcal{X}$  optimal, known as the inverse-feasible region. We show the relationship between the dimension of a face of a polyhedron and the dimension of the corresponding inverse-feasible region, which leads to necessary and sufficient conditions of the extreme, boundary, and inner points of a linear program. We also characterize the set of objectives that render a given solution uniquely optimal.

**Keywords:** Inverse Optimization - Linear Programming - Polyhedral Theory - Unique Solutions

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## 1 Introduction

Given a feasible solution to a linear program, inverse linear programming seeks to find an objective vector  $d$  that makes the solution optimal while minimizing an  $L_p$  norm from a target vector  $\hat{d}$  [1, 22]. Several special cases of inverse linear programming have been studied, such as minimum cost flow [21], shortest path [7], and facility location [23].

Inverse optimization has been studied for various types of optimization problems such as combinatorial optimization problems [11], conic programs [12], integer programs [18], convex programs [14], mixed-integer programs [15], countably infinite linear programs [10], and variational inequalities [5]. Inverse optimization has also found a wide variety of applications including production planning [20], finance [4], cancer treatment planning [8], medical decision making [3, 9], and electricity markets [6].

In this paper, we characterize the feasible region of an inverse linear programming problem where the input is a set of forward-feasible solutions, i.e., the set of objectives that make all the given

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