Universität zu Köln
Seminar für Allgemeine Betriebswirtschaftslehre, Supply Chain Management und Management Science

Optimizing Crew Schedules with Fairness Preferences

CASPT 2015, Rotterdam, July 22

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THE FREIGHT RAILWAY CREW SCHEDULING PROBLEM

Freight Network

Freight Transport

- Trains operate between stations on a given timetable
- Trains segmented into trips (i.e., movements serviced by same driver)

Crew

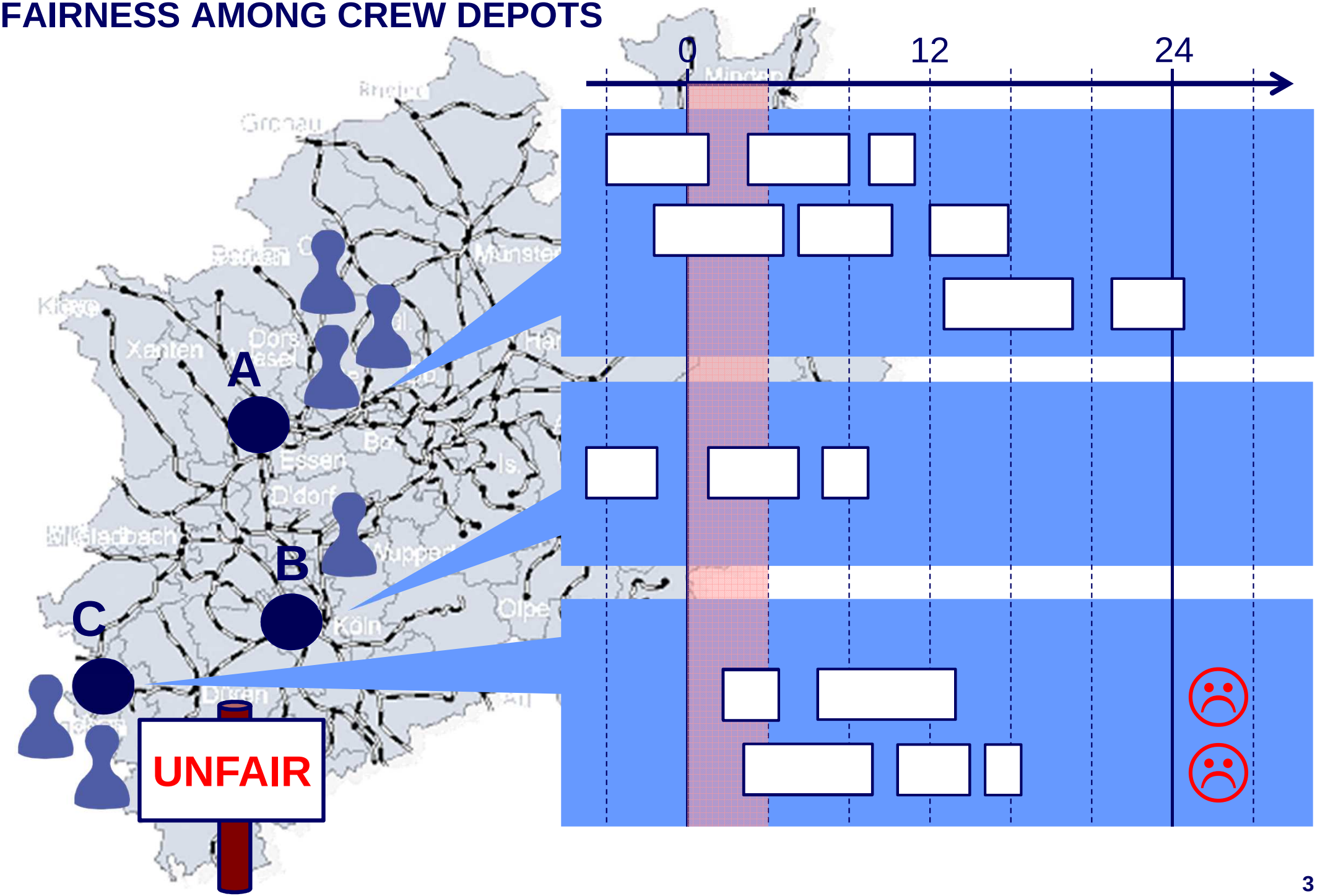
- Drivers needed to run locomotives
- Operational and contractual requirements
- Crew capacity limits at depots

Railway Crew Scheduling Problem:

Build driver duties from trips such that

- all trips are covered
- all work regulations are met
- capacity limits are respected
- overall costs are minimized

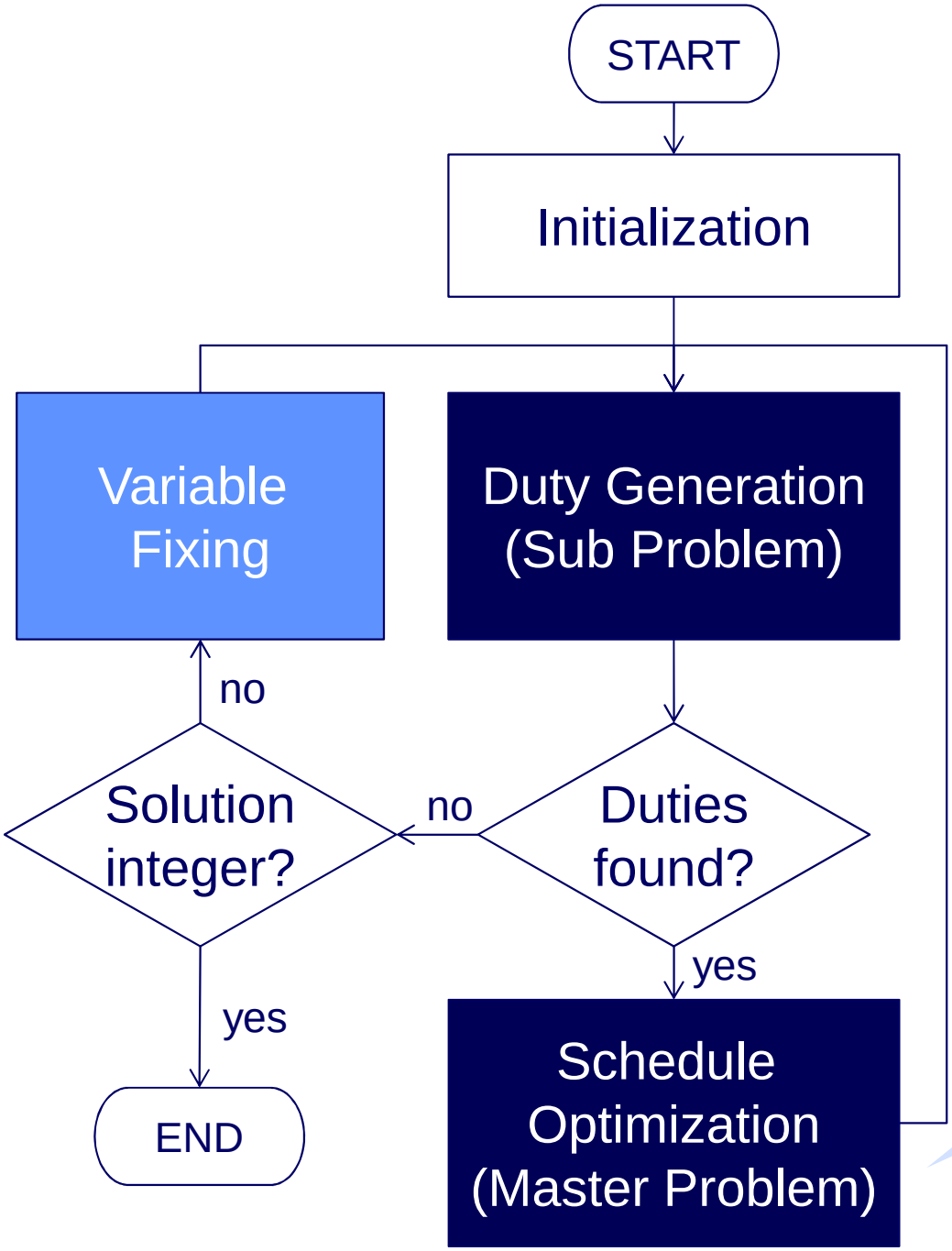
FAIRNESS AMONG CREW DEPOTS



CONTENTS

- Problem Description
- **Mathematical Model**
- Computational Results

MATHEMATICAL MODEL: BASIS



$d \in D$ duties
$j \in J$ depots
$t \in T$ trips

$$\min z = \sum_{d \in D} c_d x_d + \sum_{j \in J} \hat{c}_j \hat{y}_j$$

$$s.t.$$

$$\sum_{d \in D} a_{td} x_d \geq 1 \qquad \forall t \in T$$

$$\sum_{j \in J} b_{jd} x_d - \hat{y}_j \leq k_j \qquad \forall j \in J$$

$$x_d, \hat{y}_j \geq 0 \qquad \forall d \in D, j \in J$$

MATHEMATICAL MODEL: INCLUDING FAIRNESS

$$\min z = \sum_{d \in D} c_d x_d + \sum_{j \in J} \hat{c}_j \hat{y}_j + \sum_{j \in J} k_j \tilde{c} \tilde{y}_j$$

Schedule unfairness $F = \sum_{j \in J} k_j \left(U_j - U\right)^+$

s.t.

Duty unpopularity u_d

$$\sum_{d \in D} a_{td} x_d \geq 1 \qquad \forall t \in T$$

$$\sum_{j \in J} b_{jd} x_d - \hat{y}_j \leq k_j \qquad \forall j \in J$$

$$\frac{\sum_{d \in D} b_{jd} x_d \, u_d}{k_j} - \frac{\sum_{d \in D} x_d \, u_d}{\sum_{j \in J} k_j} - \tilde{y}_j \leq 0 \qquad \forall j \in J$$

$$x_d, \hat{y}_j, \tilde{y}_j \geq 0 \qquad \forall d \in D, j \in J$$

Depot unpopularity U_j

Schedule unpopularity U

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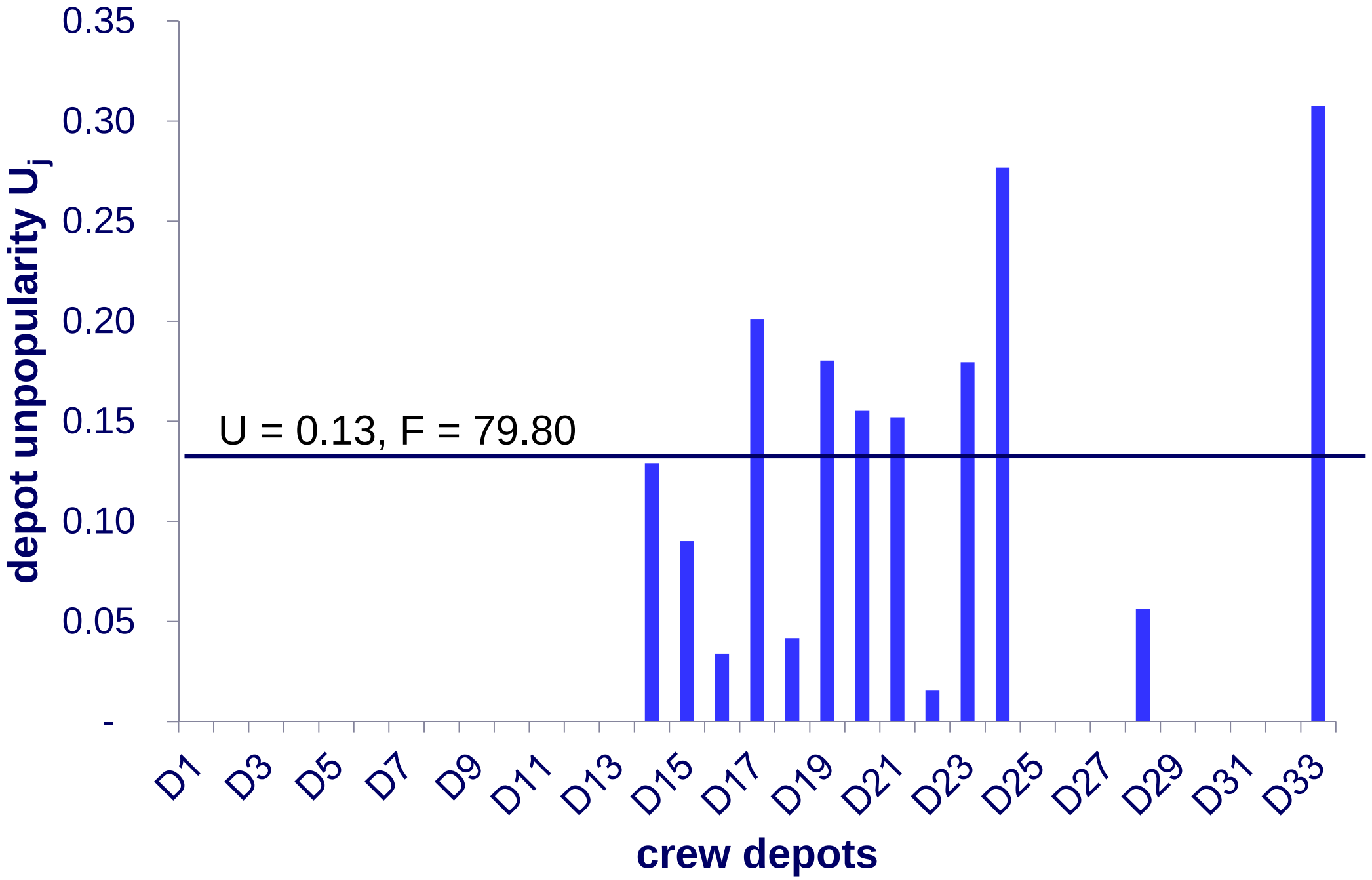
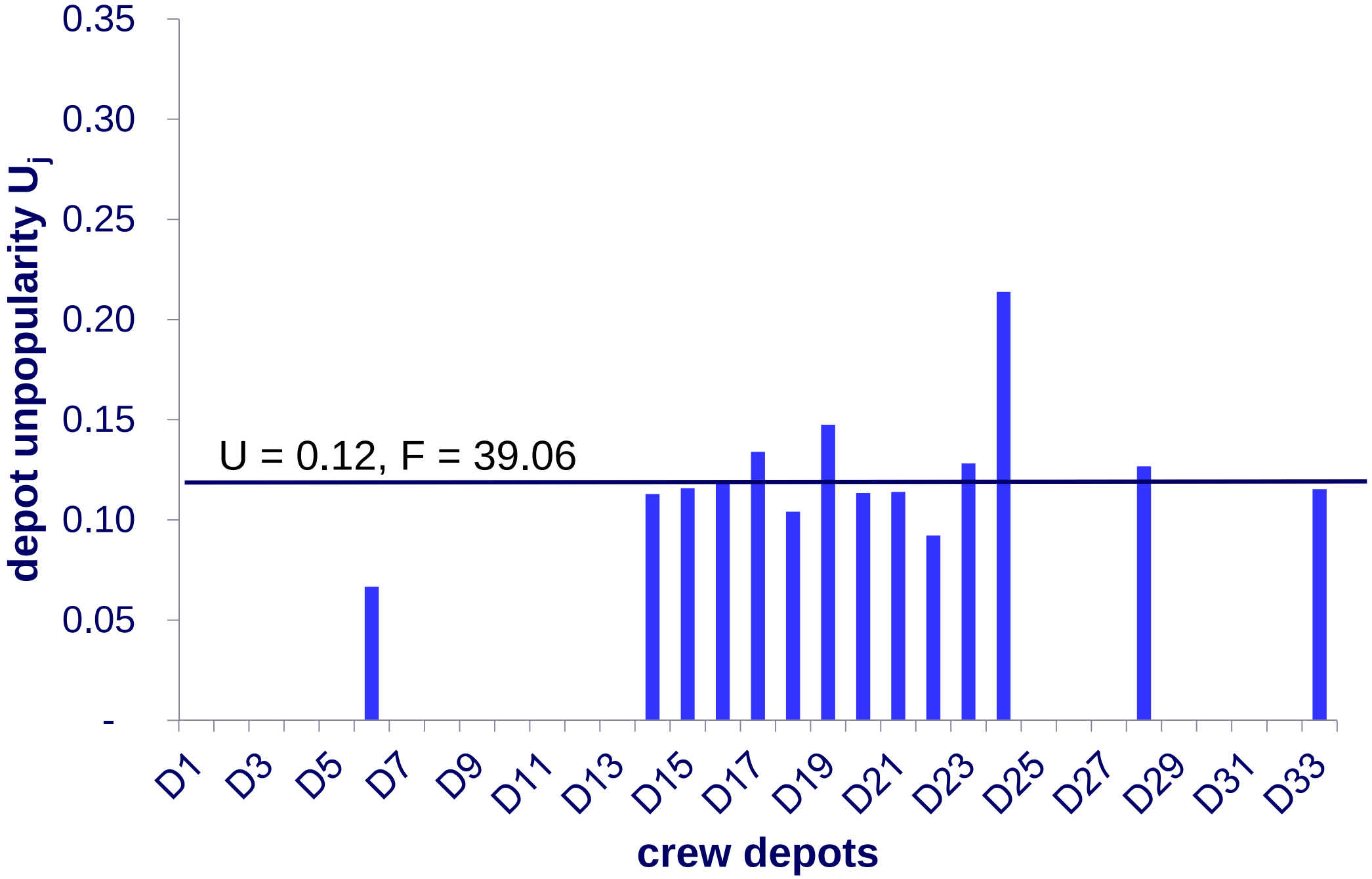
- Mathematical Model
- **Computational Results**

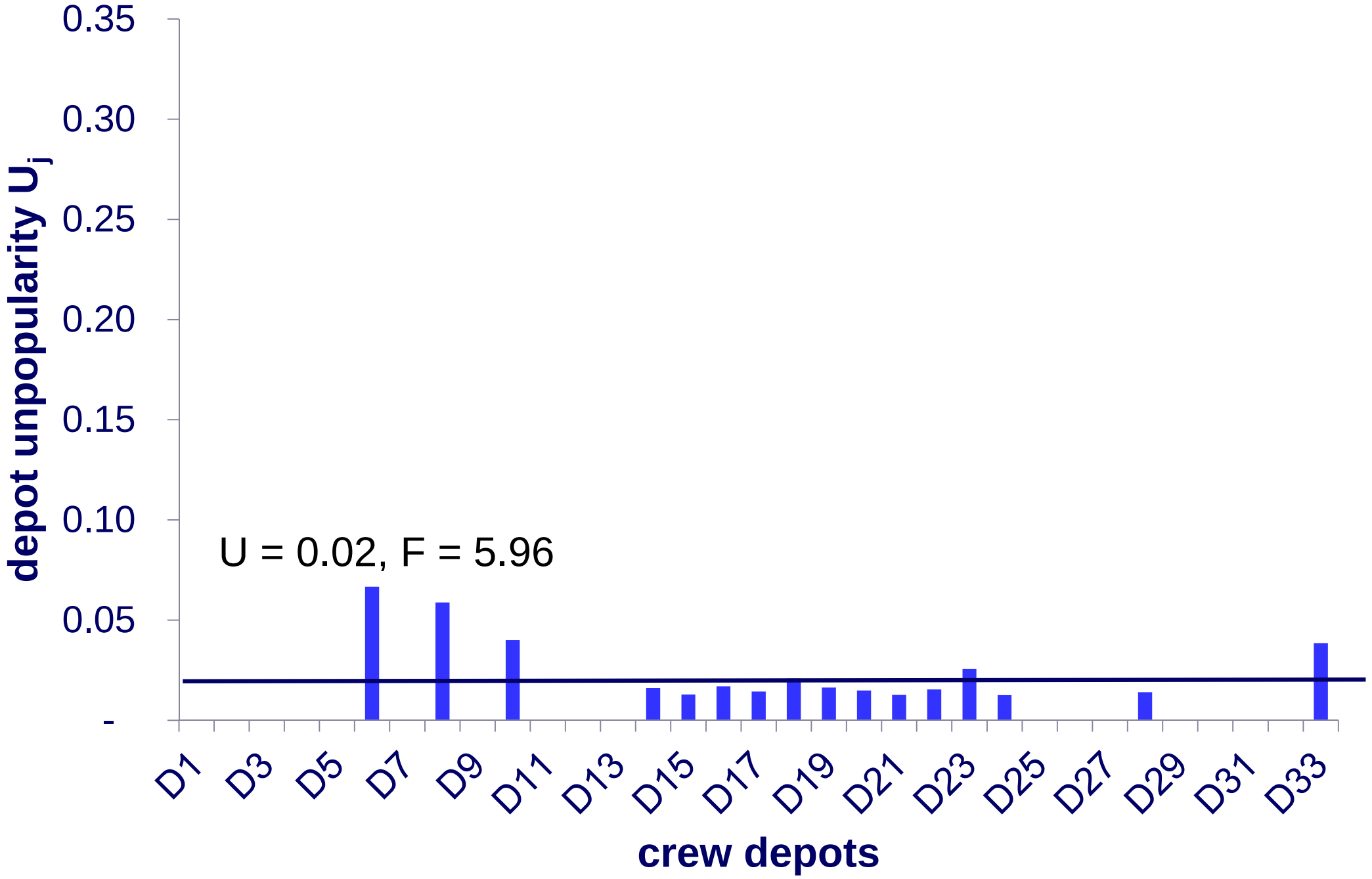
SAMPLE RESULTS: CIRCADIAN RHYTHM (1/5)



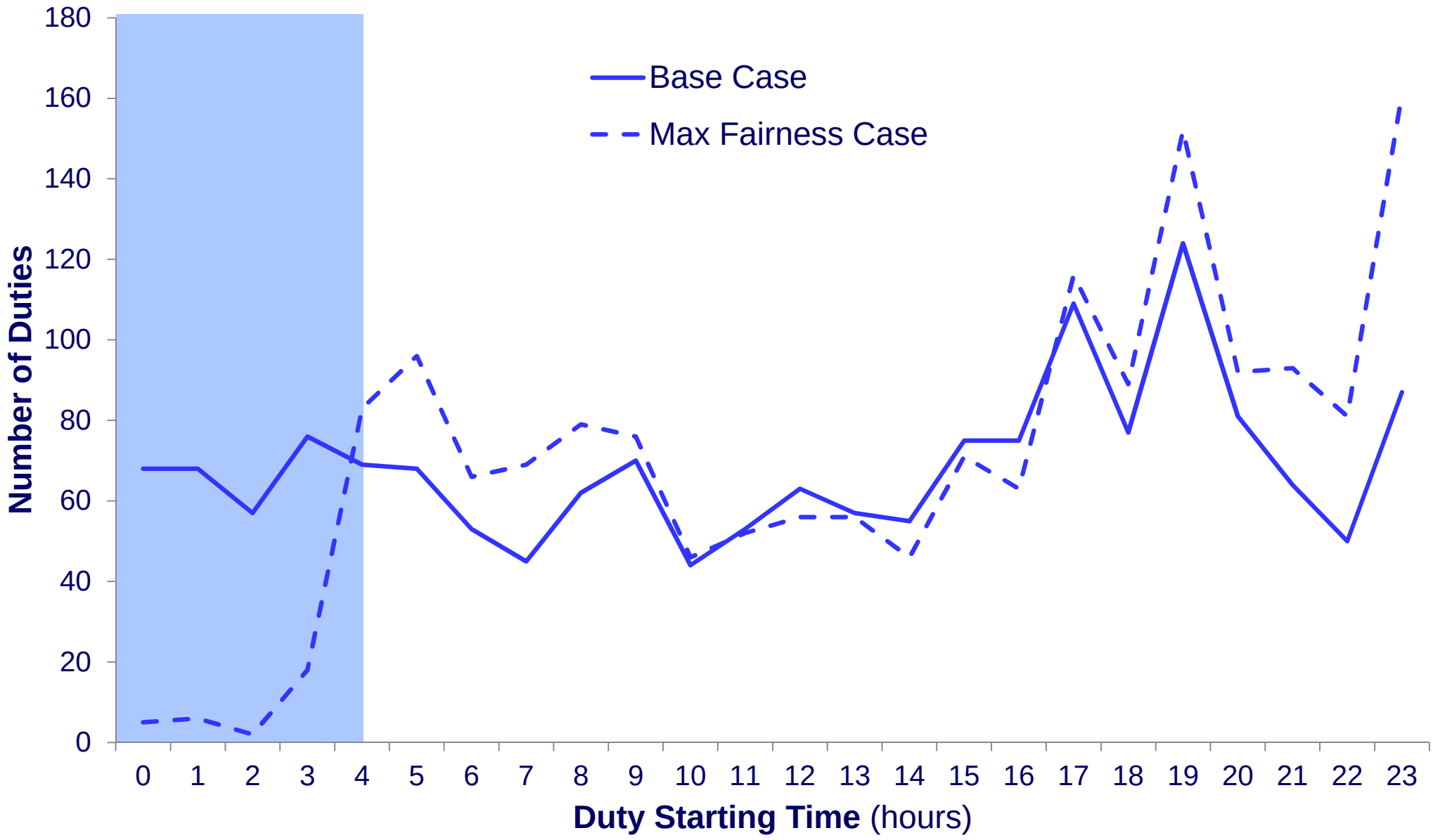
SAMPLE RESULTS: CIRCADIAN RHYTHM (2/5)



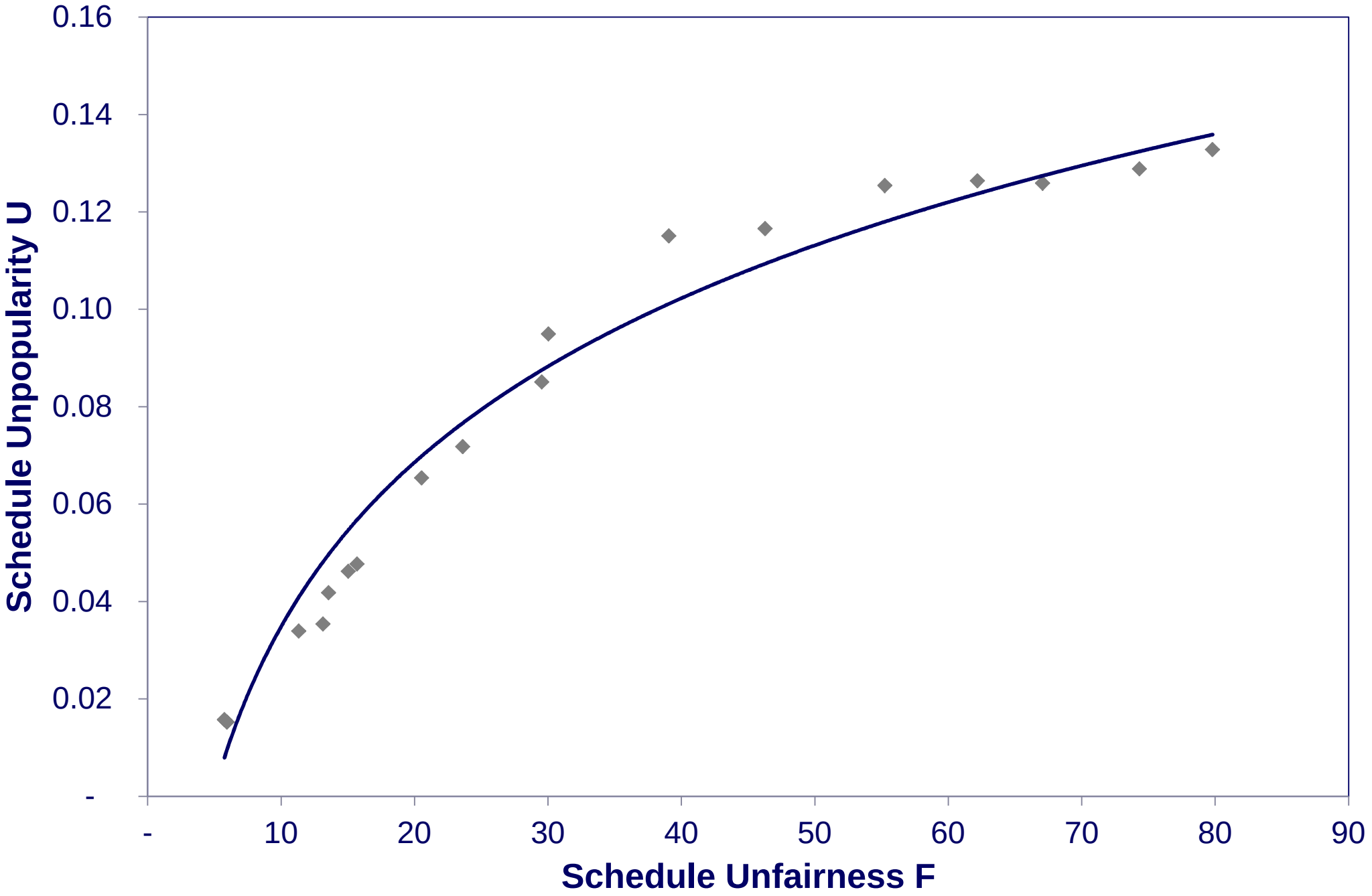
SAMPLE RESULTS: CIRCADIAN RHYTHM (3/5)



SAMPLE RESULTS: CIRCADIAN RHYTHM (4/5)

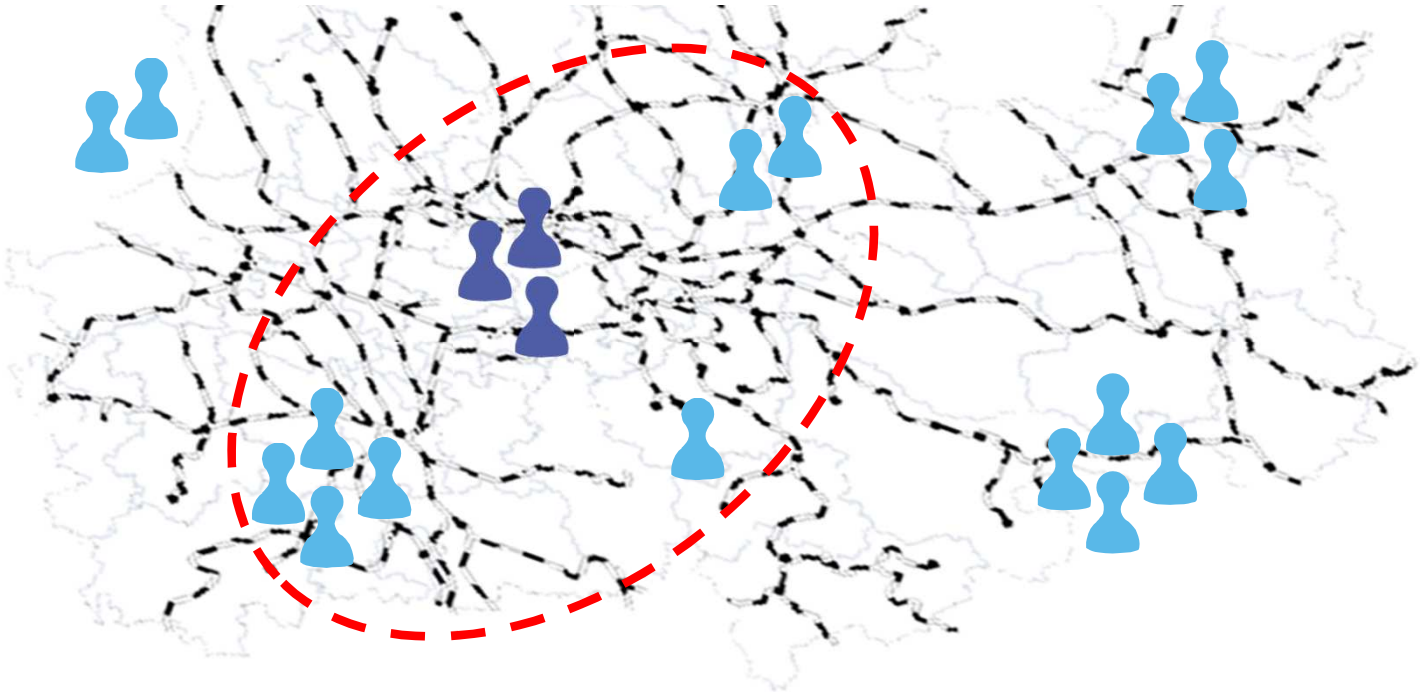


SAMPLE RESULTS: CIRCADIAN RHYTHM (5/5)



FUTURE RESEARCH INTERESTS

- **Fairness vs. unpopularity:** interdependence of fairness and unpopularity, comparison to pure unpopularity minimization, integration of unpopularity restrictions
- **Fairness perception:** include advantageous inequality, vary fairness perception among depots
- **Local fairness:** even distribution of unpopular properties within given geographical distances



Thank you for your attention.