Modelling Urban Street Vending Dynamics: Exploring Regulatory Policies to Balance Economic Trade-offs Between Informal and Formal Commerce

This model is useful for studying the tensions and coexistence between informal vendors and formal shop owners in urban settings. It captures how customer choices and vendor mobility impact shop owner emotions and market dynamics. The inclusion of police officers allows us to test enforcement levels. Using this model, we can explore the trade-off between police enforcement – which restricts mobile vendor trading and thus decreases their quality of life – and storeowner frustration – which decreases with increased enforcement.

This simulation aims to answer the following question: What enforcement level results in a balanced trade-off between economic opportunity for mobile vendors and the frustration experienced by storeowners in a competitive urban commercial space?

The Merchant-To-Customer Ratio

A key consideration that had to be made throughout the analysis is the merchant-to-customer ratio. The competitive tension between vendors and formal business owners is dependent on this ratio. Zambia's economy is very informal, with most of its GDP being generated by micro, small, and medium sized enterprises and businesses. There is limited information available online to establish a reliable ratio that truly reflects the country's informal market dynamics. For the purposes of this analysis, we will test the following merchant-to-customer ratios:

1. 1:1 ratio – a high saturation market which will likely result in higher conflict between vendors and storeowners e.g., 200 mobile vendors and 200 customers.
2. 1:3 ratio – a moderately competitive market which should yield better balance between vendor opportunity and storeowner competition e.g., 100 mobile vendors and 300 customers.
3. 1:5 ratio – a customer-rich market setting where traders face less competition e.g., 50 mobile vendors and 250 customers.

The key thing to observe in these three markets is variation in enforcement levels. We aim to explore which markets require more law enforcement and what level of enforcement.

Evaluating Economic Trade-Offs

In our simulation, we measure economic opportunity for mobile street vendors through their happiness levels, which increase as they successfully make sales. Conversely, we track how much storeowners are negatively affected by vendor competition using a frustration score, which rises when customers choose mobile vendors over their storefronts. These two metrics allow us to evaluate the trade-off between informal vendor success and formal business stability.

To understand this trade-off, we use the concept of Pareto efficiency. In simple terms, a solution is Pareto efficient if you cannot improve one outcome (e.g., vendor happiness) without making the other worse (e.g., increasing storeowner frustration). The set of all such efficient outcomes is called the

Pareto front. This forms a boundary of the best possible compromises between the two objectives, and will be represented as blue points in the visualisations to follow.

Instead of picking the absolute best for one group, we identify a balanced compromise: the point on the Pareto front that is closest to the centre of the outcome space. This “middle” point does not heavily favour one side, but instead represents a fair and satisfactory trade-off between vendor opportunity and storeowner stability. It helps avoid extreme policy bias toward either group because the reality is we cannot have both zero frustration for storeowners and the highest possible happiness levels for the vendors.

Finally, we examine the enforcement conditions - specifically the number of police agents and their enforcement radius - that produced these optimal points across the three different merchant-to-customer market configurations, discussed in the previous section.

This analysis helps us identify enforcement strategies that support a balanced urban market and sustainable coexistence between informal and formal economic actors.

Calculation Behind the Visualisations

To create the Pareto frontier plots, we varied the levels of enforcement – specifically, the number of police officers and their enforcement radii. For each enforcement configuration, we ran the simulation and recorded two key metrics at tick 2000: the average happiness of mobile vendors and the average frustration of storeowners. We chose tick 2000 because, across multiple runs, the general trend for both metrics was clear, reflecting the steady-state outcomes of the simulation. These paired values were then plotted for each market condition (merchant-to-customer ratios of 1:1, 1:3, and 1:5), allowing us to visualise the trade-offs between supporting vendor opportunity and minimising negative impacts on storeowners.

Results

The figure 1 below shows the Pareto frontier plots that were generated for each market configuration.

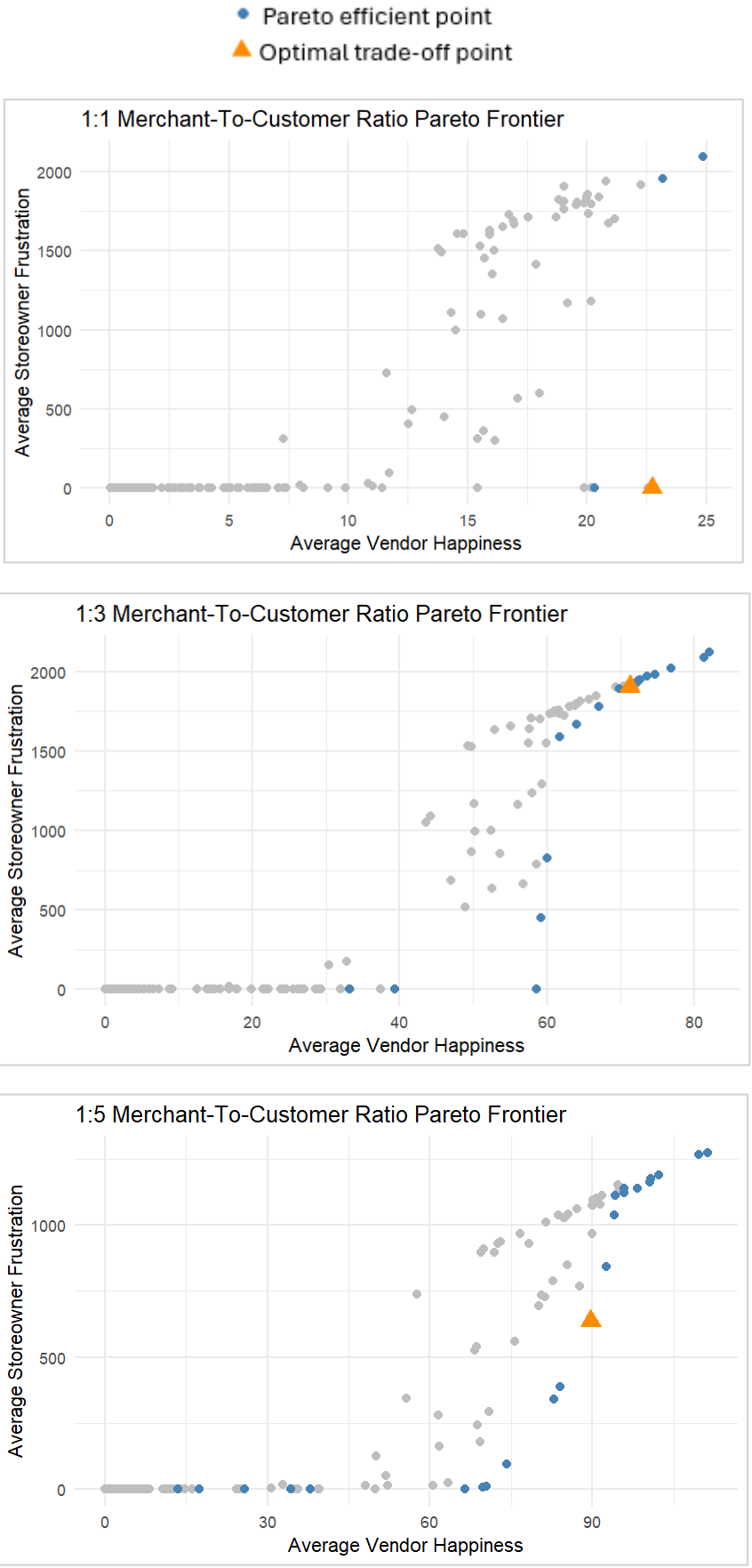

Figure 1 – Pareto Frontier plots for vendor economic opportunities and storeowner frustration.

The optimal points highlighted above resulted in the following for each market setup:

Market		Values at Optimal Pareto Efficient Point			
Description	**Merchant-To-Customer Ratio**	**Average Vendor Happiness**	**Average Storeowner Frustration**	**Number of Police Officers**	**Enforcement Radius**
High saturation	1:1	22.7	0.005	4	2
Moderately competitive	1:3	71.2	1905	None	0
Customer-rich and less competitive	1:5	89.6	636.2	None	0

Table 1 – Values across metrics for optimal Pareto efficient points across market types.

We observe that in the saturated market (1:1 ratio) there is low vendor happiness due to high competition. However, storeowner frustration is almost non-existent because of enforcement. Here we have 4 officers with an enforcement radius of 2. Across the tested enforcement levels (0 to 10 officers, with radius values ranging from 0 to 10), the ideal regulation appears to involve a moderate number of patrolling officers who do not enforce the law too strictly. Since this setup represents the optimal midpoint for both goals, it suggests that the presence of law enforcement is necessary to maintain order and efficiency in highly competitive markets.

In the 1:3 ratio market, vendor happiness increases significantly but leads to very high storeowner frustration. Notably, there is no police regulation in this scenario. This suggests that introducing enforcement in a moderately competitive market could unfairly tip the balance in favour of storeowners. Interestingly, allowing market dynamics to play out without enforcement seems to yield more ideal outcomes here. We observe a similar pattern in the 1:5 ratio market, where vendors thrive in a low-competition, customer-rich environment. However, storeowners still experience substantial levels of frustration.

Conclusion

The research question was: “What enforcement level results in a balanced trade-off between economic opportunity for mobile vendors and the frustration experienced by storeowners in a competitive urban commercial space?”. Based on the observed results, we can conclude that in highly competitive trading zones, a **moderate** level of law enforcement to regulate illegal street vending is necessary to maintain balance. In less competitive environments, storeowners tend to be heavily favoured when police are present to restrict vending. In these cases, allowing market dynamics to play out without enforcement actually results in fairer outcomes.

This model can be further improved by incorporating customer preferences (such as a dislike for crowded vending areas) and factoring in the negative externalities of street vending, like littering and pollution. For now, this provides a solid starting point for understanding how storeowner and vendor dynamics shift across different markets in response to varying law enforcement strategies.

Algorithm Diagram