**Sensitivity analysis**

**The Performance of Our Solution in Light and Heavy Traffic**

Here，we think that only the parameter, p\_in defined in our CA model whether it is in light or heavy traffic. If p\_in is large enough, the situation can be regarded as heavy traffic. As we describe in the CA model, p\_in reflects traffic flow density. So we can determine the effect that p\_in causes on our solution [qualitatively](link:qualitatively) and intuitively.

If the traffic is light, that is, hard to cause traffic jam, then these are no visible advantages can be detected. In this case, the merging system can be temporarily closed. If our solution is in heavy traffic, it is able to show its superiority to maintain the optimal throughput under a larger flow density (p\_in). Once the traffic turns fairly heavy, the function of our solution fades. But this condition is not worth discussing here. Thus, our model is not sensitive to the fluctuation of p\_in when p\_in is less than a certain value.

**Autonomous Vehicles**

Similarly, the mix of autonomous vehicles will influence the parameter, p\_v in our CA model. Since autonomous vehicles are intelligent enough to decrease the probability of random deceleration, the throughput will increase apparently (Figure comfirms). Therefore, we can also conclude that our solution is sensitive to p\_v.

**The Proportions of Different Tollbooths**

In our solution, no matter what kind of tollbooths vehicles choose to pass through, they are regulated by the PID-based merging control system. The three coefficients for the proportional, integral, and derivative terms K\_p, K\_i and K\_d are the key points to affect results. As previous literature states, the control result (i.e., our solution) is little sensitive to the specific value of K\_p, K\_i and K\_d within a broad range of values.

In conclusion, our solution is robust.