

比较、对比与预测疫情前后商业飞行特性

陈喆妍，甘瑞芯，唐哲轩，王寅，夏维昊（排序不分先后）

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NYU

TANDON SCHOOL
OF ENGINEERING

研究摘要



本研究基于2016 - 2024年的航班与客流数据，分析了COVID-19疫情前后商业航空业在机型使用、航线布局与客流恢复速度方面的变化，并使用高斯过程回归（GPR）预测未来恢复趋势。结果显示，疫情导致窄体飞机使用比例上升，长途航线恢复速度较慢，预计未来客流增长仍难回到疫情前的轨迹。

研究问题



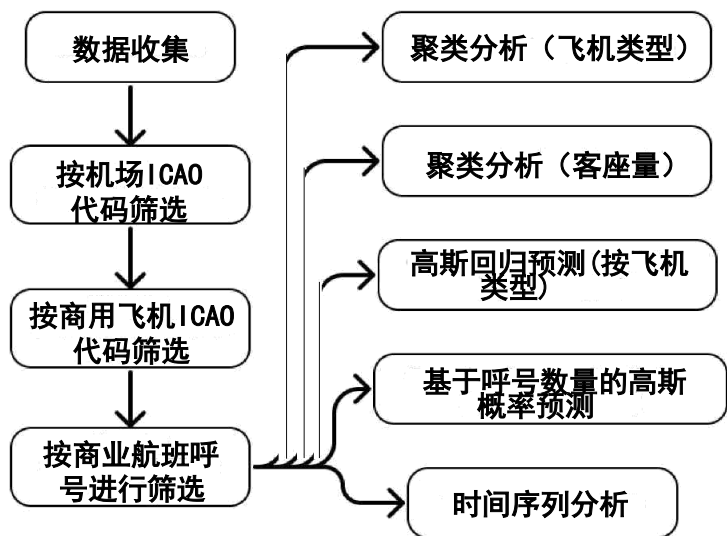
- 疫情前、疫情期间以及疫情后的客运趋势发生了怎样的变化？
- 所使用的飞机类型出现了哪些变化，这些变化又如何反映航空公司的运营策略和旅客偏好？
- 对疫情后客运量恢复的预测结果如何？与疫情前的增长预期相比有何差异？

研究假设



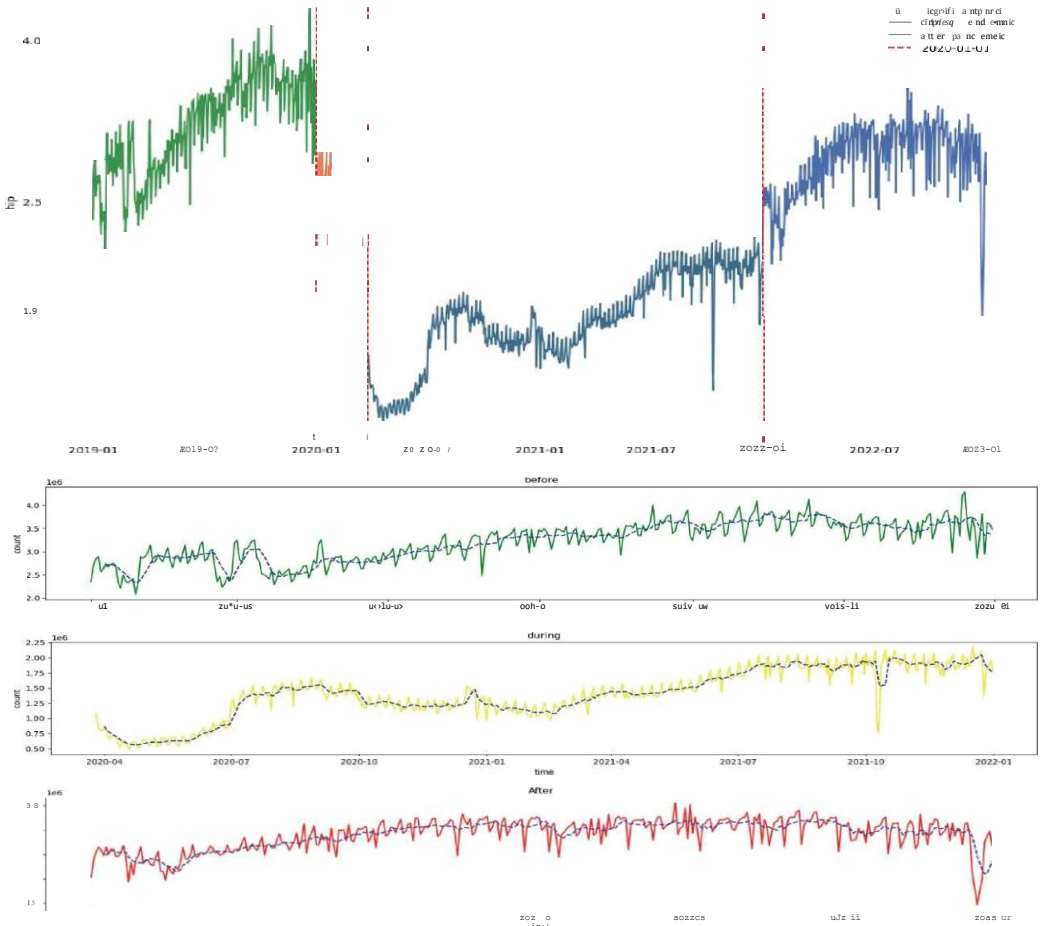
- 在疫情过后，窄体客机在航班群中的使用频率高于宽体/中型客机。
- 基于高斯预测（GP），疫情后的乘客出行量复苏趋势预计将持续上升，但很可能会难以达到疫情之前的增长水平，除非疫情从未发生过。

数据与方法



时间序列乘客数量预测

预计客流量与时间



参考文献

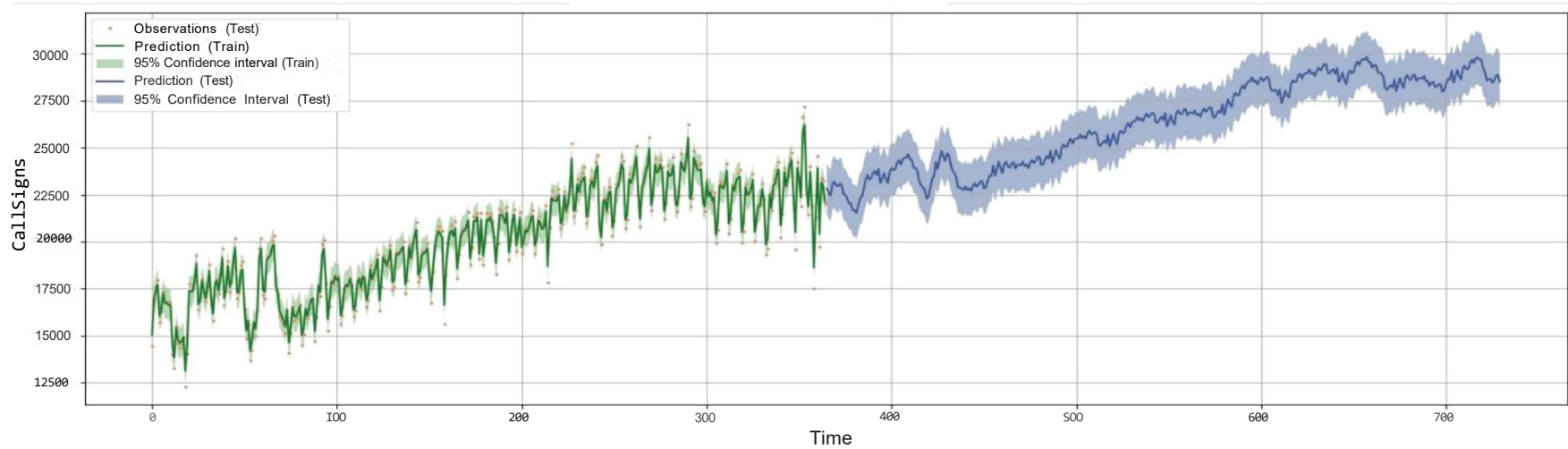


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分析结果



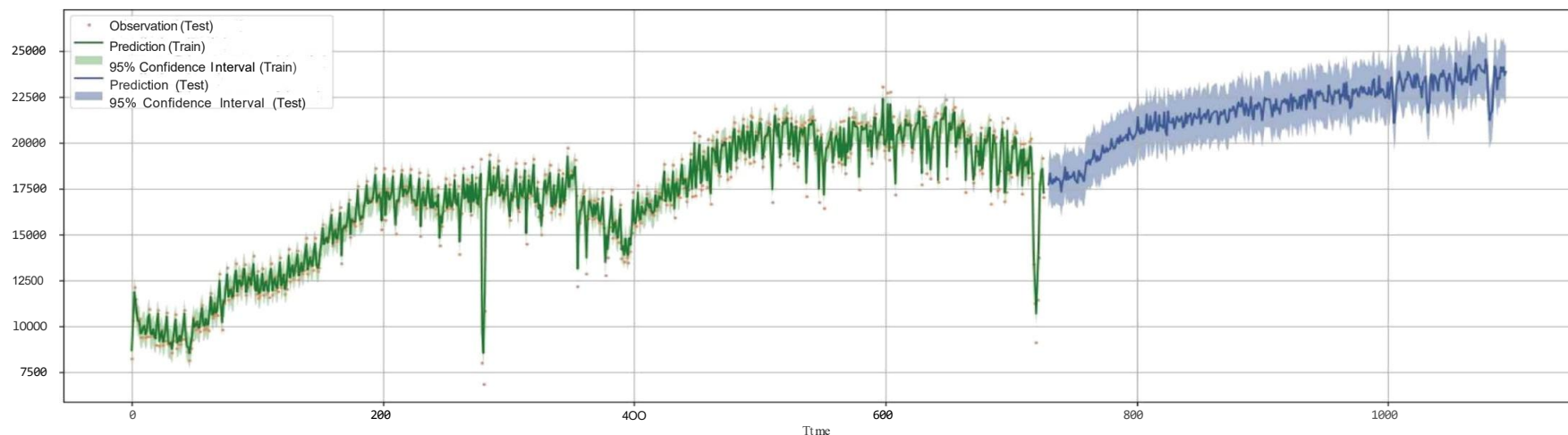
高斯过程回归预测-所有航班



Log Marginal Likelihood (optimized): -3749.470479552617

Optimized Kernel:

$316^{**2} * \text{Matern}(\text{length_scale}=7.27\text{e-}12, \text{nu}=1.5) + \text{DotProduct}(\text{sigma_0}=7.32\text{e+}04) + 316^{**2} * \text{RationalQuadratic}(\text{alpha}=7.24, \text{length_scale}=5.79\text{e-}15) + 316^{**2} * \text{RBF}(\text{length_scale}=0.625) + \text{WhiteKernel}(\text{noise_level}=1\text{e+}05) + 316^{**2} * \text{ExpSineSquared}(\text{length_scale}=0.01, \text{periodicity}=31) + 316^{**2} * \text{ExpSineSquared}(\text{length_scale}=0.0667, \text{periodicity}=365)$

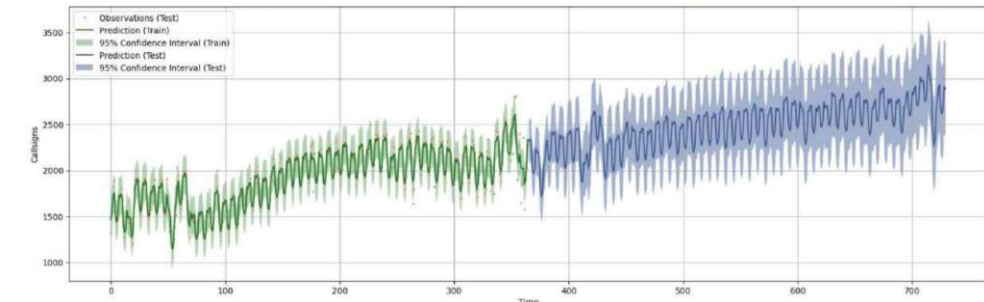


Log Marginal Likelihood (optimized): -682d.B33668898841

Optimized Kernel:

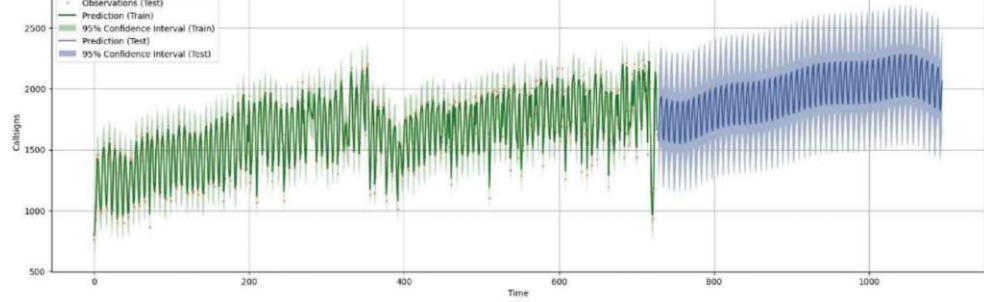
$316^{**2} * \text{Matern}(\text{length_scale}=0.0048, \text{nu}=1.5) + \text{DotProduct}(\text{sigma_0}=1.15\text{e+}04) + 316^{**2} * \text{RationalQuadratic}(\text{alpha}=1\text{e+}05, \text{length_scale}=1.17) + 316^{**2} * \text{RBF}(\text{length_scale}=35.6) + \text{WhiteKernel}(\text{noise_level}=1\text{e+}05) + 316^{**2} * \text{ExpSineSquared}(\text{length_scale}=0.01, \text{periodicity}=30.1) + 316^{**2} * \text{ExpSineSquared}(\text{length_scale}=0.0103, \text{periodicity}=363)$

中型机预测



Log Marginal Likelihood (optimized): -2285.928166757763

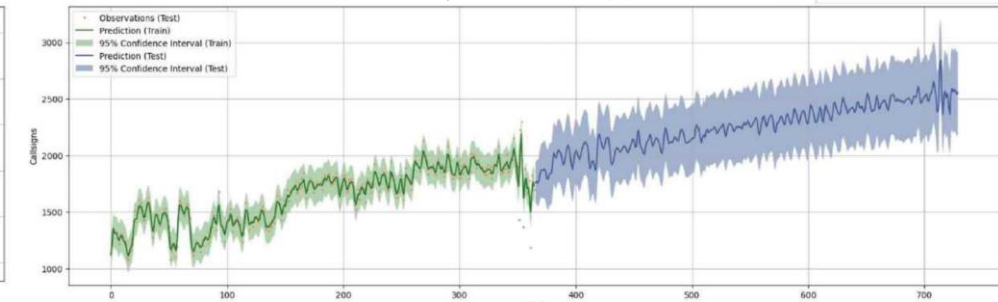
$5.28^{**2} * \text{Matern}(\text{length_scale}=20, \text{nu}=1.5) + \text{DotProduct}(\text{sigma_0}=1.52\text{e+}03) + 113^{**2} * \text{RationalQuadratic}(\text{alpha}=1.19, \text{length_scale}=20) + 7.61^{**2} * \text{RBF}(\text{length_scale}=20) + \text{WhiteKernel}(\text{noise_level}=0.09\text{e+}03) + 151^{**2} * \text{ExpSineSquared}(\text{length_scale}=0.189, \text{periodicity}=7) + 110^{**2} * \text{ExpSineSquared}(\text{length_scale}=0.043, \text{periodicity}=980)$



Log Marginal Likelihood (optimized): -4788.536994459281

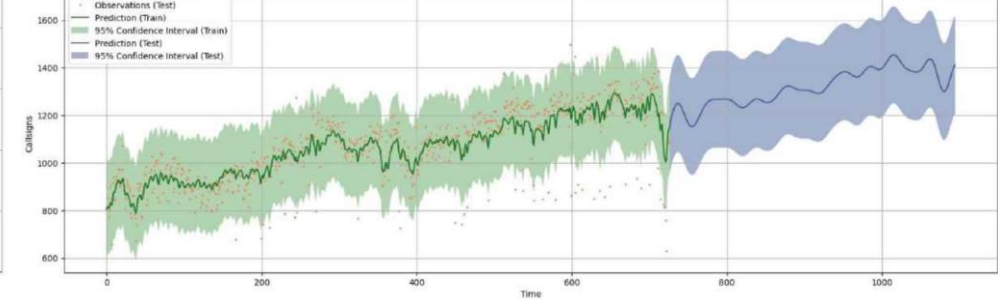
$130^{**2} * \text{Matern}(\text{length_scale}=1, \text{nu}=1.5) + \text{DotProduct}(\text{sigma_0}=1.29\text{e+}03) + 140^{**2} * \text{RBF}(\text{length_scale}=1) + \text{WhiteKernel}(\text{noise_level}=5.26\text{e+}03) + 160^{**2} * \text{ExpSineSquared}(\text{length_scale}=1.49, \text{periodicity}=7) + 143^{**2} * \text{ExpSineSquared}(\text{length_scale}=900, \text{periodicity}=30.2) + 125^{**2} * \text{ExpSineSquared}(\text{length_scale}=0.824, \text{periodicity}=363)$

宽体机预测



Log Marginal Likelihood (optimized): -2171.689322737707

$10.1^{**2} * \text{Matern}(\text{length_scale}=20, \text{nu}=1.5) + \text{DotProduct}(\text{sigma_0}=1.29\text{e+}03) + 183^{**2} * \text{RationalQuadratic}(\text{alpha}=1.65, \text{length_scale}=7.1) + 17.6^{**2} * \text{RBF}(\text{length_scale}=20) + \text{WhiteKernel}(\text{noise_level}=3.81\text{e+}03) + 88.8^{**2} * \text{ExpSineSquared}(\text{length_scale}=0.0177, \text{periodicity}=361)$



Log Marginal Likelihood (optimized): -4322.678825253027

$17.4^{**2} * \text{Matern}(\text{length_scale}=1, \text{nu}=1.5) + \text{DotProduct}(\text{sigma_0}=1.66\text{e+}03) + 28^{**2} * \text{RBF}(\text{length_scale}=1) + \text{WhiteKernel}(\text{noise_level}=0.51\text{e+}03) + 60.4^{**2} * \text{ExpSineSquared}(\text{length_scale}=1\text{e+}03, \text{periodicity}=30) + 70.5^{**2} * \text{ExpSineSquared}(\text{length_scale}=0.289, \text{periodicity}=368)$

未来研究方向



扩大数据范围

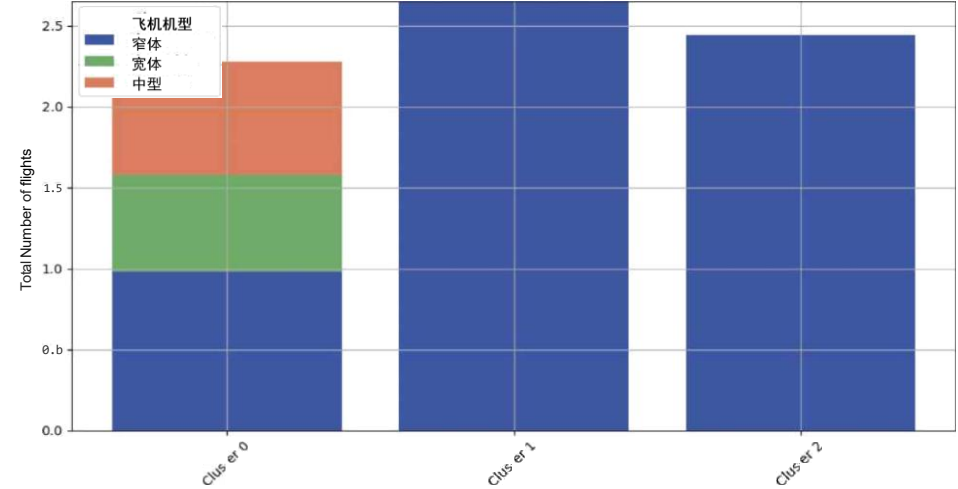
- 使用2016年至2018年符合国际民航组织标准的飞行数据将有助于建立更精确的模型，并能实现更准确的预测
- 利用2024年的数据进一步推断未来恢复趋势

扩大数据的粒度

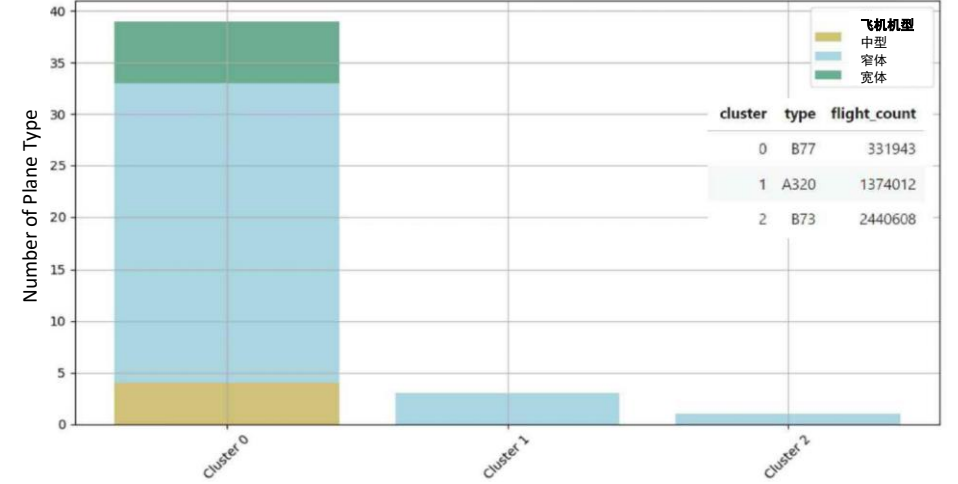
- 根据出发地和目的地的组合对数据进行区域划分，以分析疫情对航空公司载客率的具体影响
- 整合严重程度指数以直观呈现不同影响情况

疫情前航班数量

按集群与机型尺寸划分

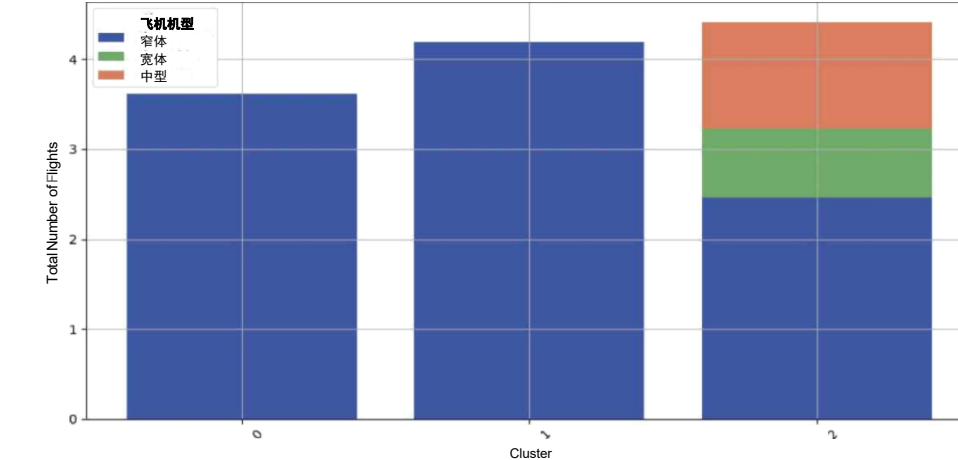


疫情前飞机类型（按集群与机型尺寸）

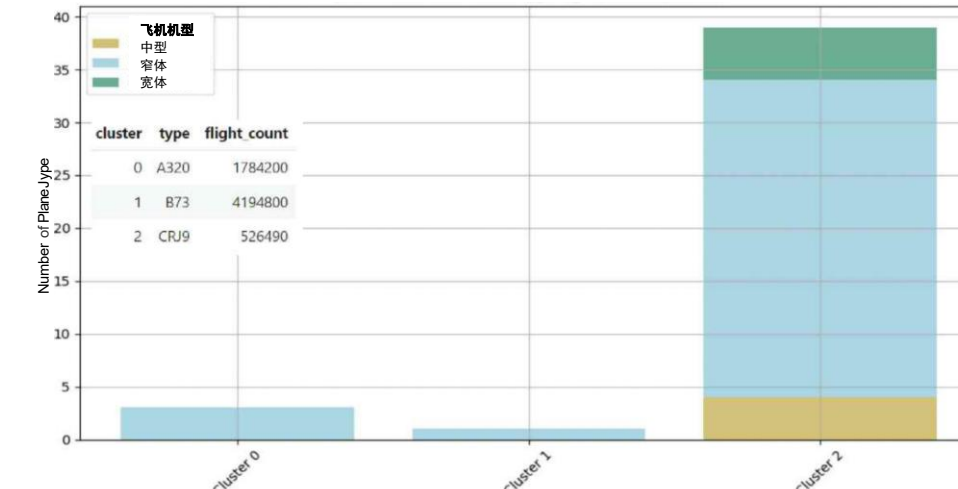


疫情后航班数量

按集群与机型尺寸划分



疫情后飞机类型（按集群与机型尺寸）



总结



- 疫情后，乘客量恢复速度约为疫情前（2018 - 2019年）预测水平的75%。
- 在疫情过后，宽体客机恢复速度略快于中型客机，而窄体飞机取代宽体机，成为飞行次数占比最高的机型。
- 航空公司应保持灵活机队结构，优先布局短中程高需求航线建议结合区域市场细分与疫情严重程度指数，提升预测精度

数据来源

