# Appendix

This section summarizes the technical workflow behind the memo, outlining how sales data were cleaned, aggregated, and translated into operational insights.

It highlights the key analytical steps including normalization, scaling, and shift-based staffing logic and explains how each modeling and visualization choice connects directly to practical decisions around scheduling, inventory, and service efficiency.

## 1. Dataset Overview and Cleaning

The dataset `Coffe_sales_with_menu_price` consists of **3,547 transactional records** with columns such as:

- `money` : revenue per transaction (numeric, continuous)
- `hour_of_day` : 24-hour timestamp of purchase
- `Weekday` : day of week (categorical)
- `coffee_name` : product purchased
- `Time_of_Day` : derived categorical variable
- `Weekdaysort` : numeric column for weekday sorting

The dataset contained no missing values in the key variables used for analysis. Currency values were formatted as floats, rounded for readability in visualization. Outliers (very high single-transaction amounts) were retained since they likely correspond to bulk orders operationally relevant for sales volume planning.

## 2. Post-Processing and Derived Metrics

### 2.1 Shift-Based Normalization and Staffing Heuristic

After computing total hourly sales ( `sales_by_hour` ), transaction data were aggregated into **three operational shift blocks** to reflect realistic staffing windows rather than individual hours:

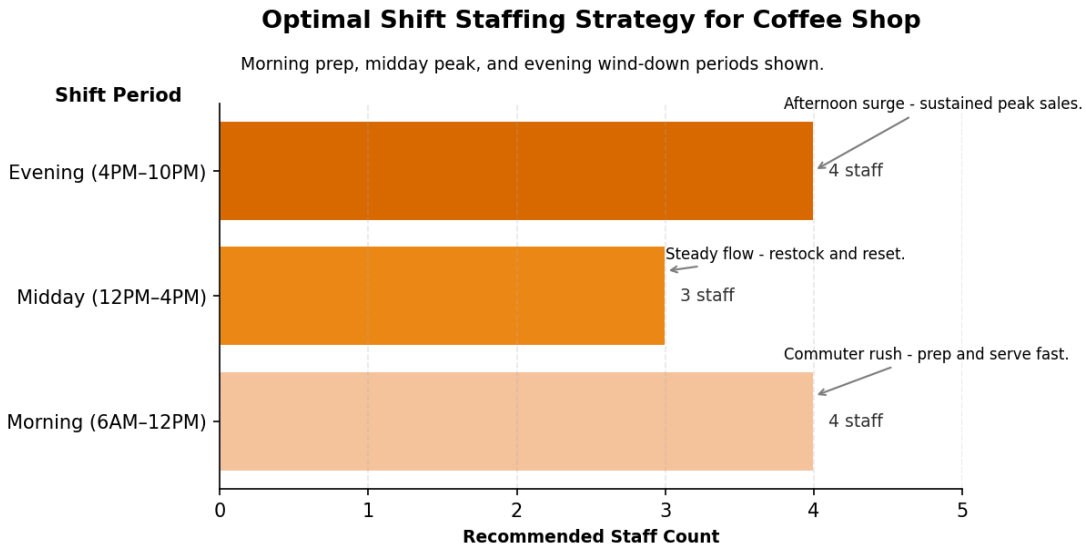
- **Morning (6 AM – 12 PM)** – prep + commuter rush
- **Midday (12 PM – 4 PM)** – steady flow + restock
- **Evening (4 PM – 10 PM)** – after-work surge + wind-down

This aggregation bridges sales analytics and workforce planning, converting revenue intensity into actionable staffing guidance for daily scheduling.

```
# Define shift boundaries
shift_bins = [6, 12, 16, 22]
shift_labels = ["Morning (6AM–12PM)", "Midday (12PM–4PM)", "Evening
(4PM–10PM)"]
df["Shift"] = pd.cut(df["hour_of_day"], bins=shift_bins,
labels=shift_labels, right=False)
```

```
# Aggregate total revenue by shift
sales_by_shift = df.groupby("Shift")["money"].sum().reset_index()

# Normalize and convert to recommended staff counts
sales_by_shift["normalized"] = sales_by_shift["money"] /
sales_by_shift["money"].max()
sales_by_shift["recommended_staff"] =
(np.round(sales_by_shift["normalized"] * 3) + 1).astype(int)
sales_by_shift
```

### Staffing recommendation Plot




| Shift | Sales ($) | Normalized | Recommended Staff |
|---|---|---|---|
| Morning (6AM–12PM) | 5300.9 | 0.89 | 4 |
| Midday (12PM–4PM) | 4201.8 | 0.70 | 3 |
| Evening (4PM–10PM) | 5971.1 | 1.00 | 4 |

## 2.2 Explanation of the Transformation

### Aggregation by Shift Block

Summing hourly revenue within the three shift ranges smooths local fluctuations and aligns the analysis with how managers actually schedule staff.

### Normalization

Each shift's sales are divided by the maximum shift total to scale values from 0–1:

$$\text{normalized}_i = \frac{\text{sales}_i}{\max(\text{sales})}$$

This expresses demand as a **relative intensity measure**, independent of absolute sales levels.

### Scaling and Conversion to Staff Counts

Multiplying normalized intensity by 3 translates workload into a practical staffing range (up to **3 incremental workers above baseline**).
Rounding and adding +1 guarantees a minimum coverage of one barista even in low-traffic periods:

$$\text{Recommended Staff}_i = \text{round}\left(\frac{\text{Sales}_i}{\text{Max Sales}} \times 3\right) + 1$$

### Operational Interpretation

- **Morning (4 staff):** High early demand from commuters → max coverage for speed and prep.
- **Midday (3 staff):** Moderate traffic → lean crew focused on restock and cleanup.
- **Evening (4 staff):** Renewed demand → scale back up for social and after-work orders.

### Actionability

The resulting heuristic links financial data directly to shift scheduling without complex forecasting models, giving managers a transparent and data-driven baseline for staffing.

## Example Calculation and Interpretation

To confirm the transformation, the following snippet inspects the computed recommendations for each shift:

```
sales_by_shift.loc[sales_by_shift["Shift"].isin([
    "Morning (6AM–12PM)", "Midday (12PM–4PM)", "Evening (4PM–10PM)"
])]
```

| Shift | Total Sales ($) | Normalized | Scaled (×3) | Rounded | +1 Baseline | Recommended Staff |
|---|---|---|---|---|---|---|
| Morning (6AM–12PM) | 5300.9 | 0.89 | 2.67 | 3 | +1 | 4 |
| Midday (12PM–4PM) | 4201.8 | 0.70 | 2.10 | 2 | +1 | 3 |
| Evening (4PM–10PM) | 5971.1 | 1.00 | 3.00 | 3 | +1 | 4 |

These results match the staffing chart, demonstrating **balanced coverage**:

- **4 staff** during morning and evening peaks to handle rush and sustained sales.
- **3 staff** midday for steady operations and reset activities.

## Analytical Rationale

**Normalization:**
Eliminates scale bias and makes demand patterns comparable across days or locations.

**Shift aggregation:**
Aligns data with human scheduling practices instead of hourly granularity.

**Scaling (+3) and baseline (+1):**
Provide a realistic, tunable heuristic for typical café staffing capacity.

This approach is not predictive but an empirical operational heuristic simple enough for daily use yet grounded in quantitative analysis.
It turns historical sales data into an **actionable staffing strategy** that balances **labor efficiency** and **customer service quality** throughout the day.

# 3. Analytical Assumptions

- **Assumptions:**

    1. Sales volume correlates linearly with staffing demand (sufficient for aggregate-level scheduling).
    2. Customer arrival patterns are consistent across stores in the region.
    3. No external seasonality or promotional data were included; patterns are purely temporal.

In [37]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from matplotlib.ticker import MaxNLocator, FuncFormatter
import math
```

In [38]:
```
df = pd.read_csv("Coffe_sales_with_menu_price.csv")
```

In [39]:
```
df.head()
```

Out[39]:

| | hour_of_day | cash_type | coffee_name | Time_of_Day | Weekday | Month_name | Weekda |
|---|---|---|---|---|---|---|---|
| **0** | 10 | card | Latte | Morning | Fri | Mar | |
| **1** | 12 | card | Hot Chocolate | Afternoon | Fri | Mar | |
| **2** | 12 | card | Hot Chocolate | Afternoon | Fri | Mar | |
| **3** | 13 | card | Americano | Afternoon | Fri | Mar | |
| **4** | 13 | card | Latte | Afternoon | Fri | Mar | |

In [40]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3547 entries, 0 to 3546
Data columns (total 11 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   hour_of_day  3547 non-null   int64
 1   cash_type    3547 non-null   object
 2   coffee_name  3547 non-null   object
 3   Time_of_Day  3547 non-null   object
 4   Weekday      3547 non-null   object
 5   Month_name   3547 non-null   object
 6   Weekdaysort  3547 non-null   int64
 7   Monthsort    3547 non-null   int64
 8   Date         3547 non-null   object
 9   Time         3547 non-null   object
 10  money        3547 non-null   float64
dtypes: float64(1), int64(3), object(7)
memory usage: 304.9+ KB
```

In [41]:
```
# convert to datetime
df["Date"] = pd.to_datetime(df["Date"], errors="coerce")
df["Time"] = pd.to_datetime(df["Time"], errors="coerce")
```

```
/tmp/ipykernel_82243/3093750455.py:3: UserWarning: Could not infer format, so eac
h element will be parsed individually, falling back to `dateutil`. To ensure pars
ing is consistent and as-expected, please specify a format.
  df["Time"] = pd.to_datetime(df["Time"], errors="coerce")
```

In [42]:
```
df
```

Out[42]:

| | hour_of_day | cash_type | coffee_name | Time_of_Day | Weekday | Month_name | Wee |
|---|---|---|---|---|---|---|---|
| **0** | 10 | card | Latte | Morning | Fri | Mar | |
| **1** | 12 | card | Hot Chocolate | Afternoon | Fri | Mar | |
| **2** | 12 | card | Hot Chocolate | Afternoon | Fri | Mar | |
| **3** | 13 | card | Americano | Afternoon | Fri | Mar | |
| **4** | 13 | card | Latte | Afternoon | Fri | Mar | |
| **...** | ... | ... | ... | ... | ... | ... | |
| **3542** | 10 | card | Cappuccino | Morning | Sun | Mar | |
| **3543** | 14 | card | Cocoa | Afternoon | Sun | Mar | |
| **3544** | 14 | card | Cocoa | Afternoon | Sun | Mar | |
| **3545** | 15 | card | Americano | Afternoon | Sun | Mar | |
| **3546** | 18 | card | Latte | Night | Sun | Mar | |

3547 rows × 11 columns

In [43]:
```
df[df.duplicated()]
```

Out[43]:

| | hour_of_day | cash_type | coffee_name | Time_of_Day | Weekday | Month_name | Weekday |
|---|---|---|---|---|---|---|---|

In [44]:
```
df.isnull().any()
```

Out[44]:
```
hour_of_day    False
cash_type      False
coffee_name    False
Time_of_Day    False
Weekday        False
Month_name     False
Weekdaysort    False
Monthsort      False
Date           False
Time           False
money          False
dtype: bool
```

In [45]:
```
df["money"] = pd.to_numeric(df["money"], errors="coerce")
```

In [46]:
```
weekday_order = ["Mon", "Tue", "Wed", "Thu", "Fri", "Sat", "Sun"]
month_order = [
    "Jan",
    "Feb",
    "Mar",
    "Apr",
    "May",
    "Jun",
    "Jul",
    "Aug",
    "Sep",
    "Oct",
    "Nov",
    "Dec",
]

df["Weekday"] = pd.Categorical(df["Weekday"], categories=weekday_order, ordered=
df["Month_name"] = pd.Categorical(
    df["Month_name"], categories=month_order, ordered=True
)
```

In [47]:
```
df.head()
```

Out[47]:

| | hour_of_day | cash_type | coffee_name | Time_of_Day | Weekday | Month_name | Weekda |
|---|---|---|---|---|---|---|---|
| **0** | 10 | card | Latte | Morning | Fri | Mar | |
| **1** | 12 | card | Hot Chocolate | Afternoon | Fri | Mar | |
| **2** | 12 | card | Hot Chocolate | Afternoon | Fri | Mar | |
| **3** | 13 | card | Americano | Afternoon | Fri | Mar | |
| **4** | 13 | card | Latte | Afternoon | Fri | Mar | |

# Question 1

What times of day and days of the week generate the highest sales volume, and how can staffing or store hours be optimized to match customer demand?

Purpose: Helps identify peak operational periods to guide shift scheduling and labor cost efficiency.

In [48]:
```
# general aggregations
sales_by_hour = (
    df.groupby("hour_of_day", as_index=False)["money"].sum().sort_values("hour_o
)
```

```
count_by_hour = (
    df.groupby("hour_of_day", as_index=False)
    .size()
    .rename(columns={"size": "transactions"})
)
sales_by_timeofday = (
    df.groupby("Time_of_Day", as_index=False)["money"]
    .sum()
    .sort_values("money", ascending=False)
)
sales_by_weekday = (
    df.groupby(["Weekday", "Weekdaysort"], as_index=False)["money"]
    .sum()
    .sort_values("Weekdaysort")
)
sales_by_coffee = (
    df.groupby("coffee_name", as_index=False)["money"]
    .sum()
    .sort_values("money", ascending=False)
)
```

```
/tmp/ipykernel_82243/1069618463.py:16: FutureWarning: The default of observed=Fal
se is deprecated and will be changed to True in a future version of pandas. Pass
observed=False to retain current behavior or observed=True to adopt the future de
fault and silence this warning.
  df.groupby(["Weekday", "Weekdaysort"], as_index=False)["money"]
```

In [49]:
```
pivot_df = df.pivot_table(
    index="hour_of_day", columns="Weekday", values="money", aggfunc="sum", fill_
)
```

```
/tmp/ipykernel_82243/1772292445.py:1: FutureWarning: The default value of observe
d=False is deprecated and will change to observed=True in a future version of pan
das. Specify observed=False to silence this warning and retain the current behavi
or
  pivot_df = df.pivot_table(
```

In [50]:
```
pivot_df
```

Out[50]:

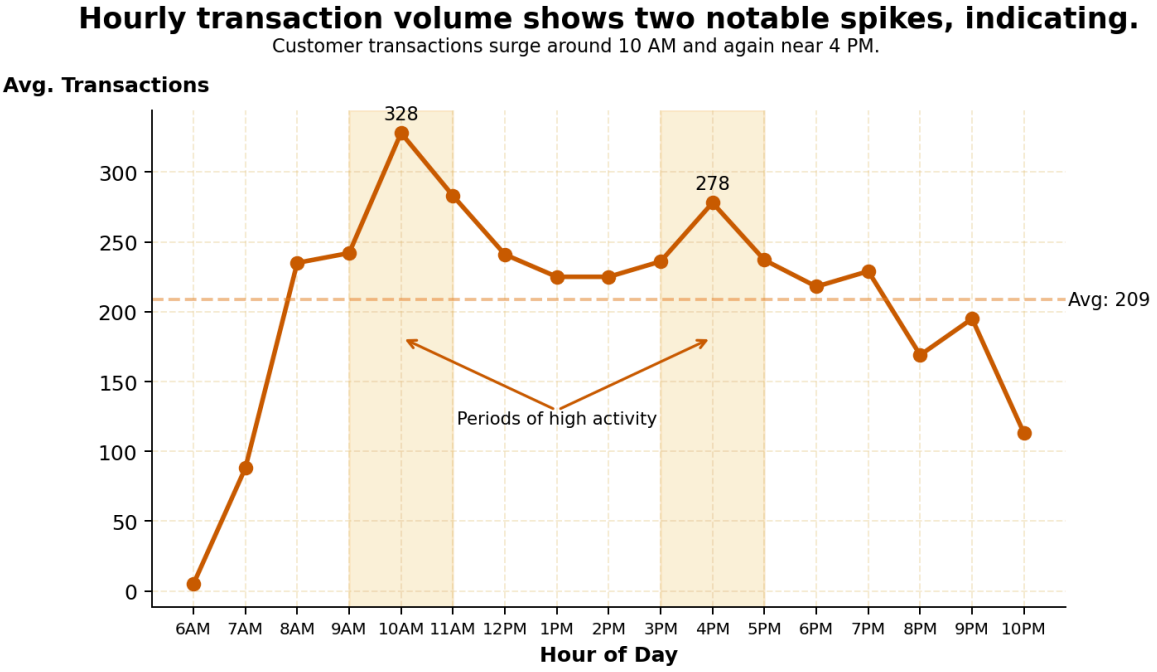
| Weekday | Mon | Tue | Wed | Thu | Fri | Sat | Sun |
|---|---|---|---|---|---|---|---|
| hour_of_day | | | | | | | |
| 6 | 9.70 | 0.00 | 0.00 | 0.00 | 13.35 | 0.00 | 0.00 |
| 7 | 105.45 | 69.50 | 84.45 | 63.45 | 82.85 | 9.70 | 8.90 |
| 8 | 188.25 | 220.85 | 131.65 | 102.20 | 216.55 | 107.10 | 88.70 |
| 9 | 165.80 | 175.75 | 117.25 | 146.70 | 225.15 | 149.15 | 95.05 |
| 10 | 232.90 | 213.95 | 211.10 | 217.55 | 189.35 | 183.65 | 228.05 |
| 11 | 173.25 | 247.50 | 203.50 | 125.65 | 124.10 | 242.35 | 130.50 |
| 12 | 112.15 | 134.75 | 149.05 | 129.25 | 163.60 | 207.30 | 188.75 |
| 13 | 124.95 | 99.45 | 195.35 | 138.75 | 163.70 | 147.45 | 148.20 |
| 14 | 190.90 | 147.60 | 68.45 | 150.85 | 148.35 | 169.45 | 142.85 |
| 15 | 170.15 | 119.45 | 141.05 | 163.90 | 158.45 | 168.30 | 159.35 |
| 16 | 218.65 | 211.10 | 194.30 | 177.55 | 139.05 | 193.65 | 111.55 |
| 17 | 160.55 | 157.25 | 156.70 | 162.25 | 184.50 | 129.50 | 108.70 |
| 18 | 162.70 | 147.70 | 155.10 | 138.25 | 138.80 | 85.05 | 153.20 |
| 19 | 203.10 | 236.95 | 164.05 | 193.05 | 116.25 | 89.30 | 46.45 |
| 20 | 94.40 | 165.40 | 108.10 | 135.05 | 70.55 | 103.65 | 81.50 |
| 21 | 117.70 | 144.55 | 140.05 | 192.80 | 76.45 | 52.15 | 153.50 |
| 22 | 60.65 | 54.25 | 45.50 | 57.95 | 152.70 | 95.95 | 38.80 |

In [51]:

```
tx_hour = count_by_hour.sort_values("hour_of_day")

fig, ax_tx = plt.subplots(figsize=(8, 5), dpi=180)

main_color = "#cc5c00"
light_color = "#f5c76e"
highlight_color = "#e67e22"

ax_tx.plot(
    tx_hour["hour_of_day"],
    tx_hour["transactions"],
    marker="o",
    linewidth=2.2,
    color=main_color,
)
ax_tx.grid(True, linestyle="--", alpha=0.25, color="#e0b35c")

spacing = tx_hour["transactions"].max() * 0.02
peak_hours = [10, 16]
for x, y in zip(tx_hour["hour_of_day"], tx_hour["transactions"]):
    if x in peak_hours:
        ax_tx.text(
            x,
            y + spacing,
            f"{y:,.0f}",
```

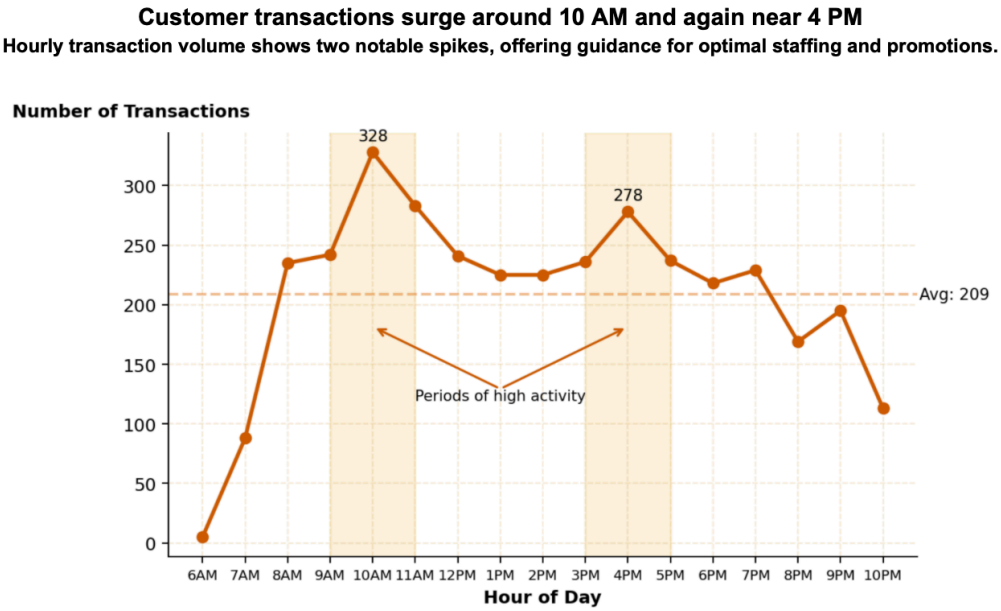
```
            ha="center",
            va="bottom",
            fontsize=9,
            fontweight="medium",
            color="black",
        )

plt.suptitle(
    "Customer transactions surge around 10 AM and again near 4 PM.",
    fontsize=9,
    fontweight="medium",
    y=0.872,
    x=0.5,
    ha="center",
    color="black",
)

plt.title(
    "Hourly transaction volume shows two notable spikes, indicating.",
    fontsize=14,
    fontweight="bold",
    pad=40,
    loc="center",
    color="black",
)

plt.xlabel("Hour of Day", fontsize=10, fontweight="bold", color="black")
plt.ylabel("", fontsize=10, fontweight="bold")

ax_tx.text(
    -0.05,
    1.03,
    "Avg. Transactions",
    transform=ax_tx.transAxes,
    ha="center",
    va="bottom",
    fontweight="bold",
    fontsize=10,
    color="black",
)

ax_tx.set_xticks(range(6, 23))
ax_tx.set_xticklabels(
    [f"{h%12 or 12}{'AM' if h < 12 else 'PM'}" for h in range(6, 23)],
    fontsize=8,
    fontweight="medium",
    color="black",
    family="sans-serif",
)

# get the avg line
avg_tx = tx_hour["transactions"].mean()
ax_tx.axhline(avg_tx, color=highlight_color, linestyle="--", alpha=0.5)
ax_tx.text(
    x=tx_hour["hour_of_day"].max() + 0.85,
    y=avg_tx,
    s=f"Avg: {avg_tx:,.0f}",
    va="center",
    ha="left",
    fontsize=9,
```

```
    color="black",
    fontweight="medium",
)

# highlight windows
ax_tx.axvspan(9, 11, color=light_color, alpha=0.25)
ax_tx.axvspan(15, 17, color=light_color, alpha=0.25)

label_y = avg_tx * 0.62
arrow_y = avg_tx * 0.87

ax_tx.text(
    13,
    label_y,
    "Periods of high activity",
    ha="center",
    va="top",
    fontsize=8.5,
    fontweight="medium",
    color="black",
)

ax_tx.annotate(
    "",
    xy=(10, arrow_y),
    xytext=(13, label_y),
    arrowprops=dict(arrowstyle="->", lw=1.3, color=main_color),
)
ax_tx.annotate(
    "",
    xy=(16, arrow_y),
    xytext=(13, label_y),
    arrowprops=dict(arrowstyle="->", lw=1.3, color=main_color),
)

sns.despine()
plt.tight_layout()
plt.show()
```



We need to post processes this for better labeling for which we move our plot above to a word document and then work on the labels

The is our plot post processing




In [52]:
```
weekday_order = ["Mon", "Tue", "Wed", "Thu", "Fri", "Sat", "Sun"]
pivot_df = pivot_df[weekday_order]

left_data = pivot_df.copy()


def get_time_of_day(hour):
    if 6 <= hour < 12:
        return "Morning"
    elif 12 <= hour < 17:
        return "Afternoon"
    elif 17 <= hour <= 22:
        return "Evening"
    else:
        return "Other"


df_long = pivot_df.reset_index().melt(
    id_vars="hour_of_day", var_name="Weekday", value_name="Revenue"
)
df_long["TimeOfDay"] = df_long["hour_of_day"].apply(get_time_of_day)
agg = df_long.groupby(["Weekday", "TimeOfDay"])["Revenue"].sum().reset_index()
time_order = ["Morning", "Afternoon", "Evening"]
right_data = (
    agg.pivot(index="Weekday", columns="TimeOfDay", values="Revenue")
    .reindex(index=weekday_order, columns=time_order)
    .fillna(0)
)
```

In [53]:
```
# prepare heatmap
td_map = {"Night": "Evening"}
df_for_heatmap = df.assign(Time_of_Day_plot=df["Time_of_Day"].replace(td_map))
```

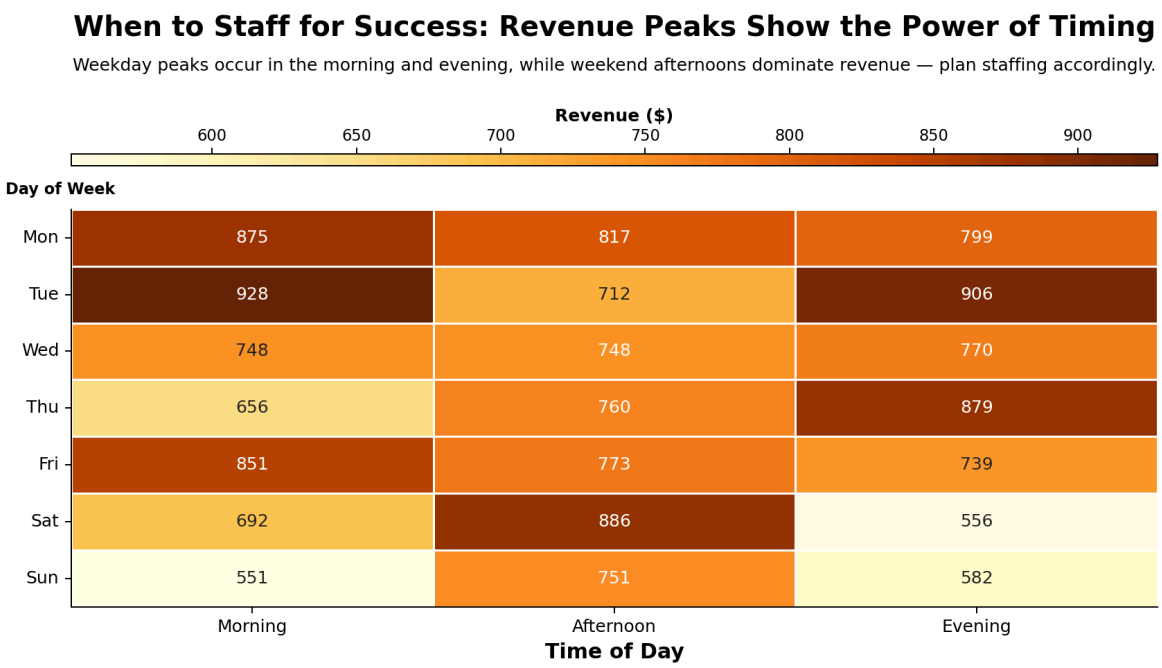
```
right_data = (
    df_for_heatmap.pivot_table(
        index="Weekday",
        columns="Time_of_Day_plot",
        values="money",
        aggfunc="sum",
        fill_value=0,
    )
    .reindex(index=weekday_order)
    .reindex(columns=time_order, fill_value=0)
    .astype(float)
)
```

```
/tmp/ipykernel_82243/1853107675.py:6: FutureWarning: The default value of observe
d=False is deprecated and will change to observed=True in a future version of pan
das. Specify observed=False to silence this warning and retain the current behavi
or
  df_for_heatmap.pivot_table(
```

In [54]:

```
weekday_order = ["Mon", "Tue", "Wed", "Thu", "Fri", "Sat", "Sun"]
time_order = ["Morning", "Afternoon", "Evening"]

fig, ax = plt.subplots(figsize=(10, 6), dpi=180)

heatmap = sns.heatmap(
    right_data,
    ax=ax,
    cmap="YlOrBr",
    annot=True,
    fmt=".0f",
    linewidths=0.5,
    linecolor="white",
    cbar=False,
)

# horizontal colorbar axis just above the heatmap
from mpl_toolkits.axes_grid1 import make_axes_locatable

divider = make_axes_locatable(ax)
cax = divider.append_axes("top", size="3%", pad=0.35)
norm = plt.Normalize(vmin=right_data.values.min(), vmax=right_data.values.max())
sm = plt.cm.ScalarMappable(cmap="YlOrBr", norm=norm)
cbar = fig.colorbar(sm, cax=cax, orientation="horizontal")
cbar.set_label("Revenue ($)", fontsize=10, fontweight="bold", labelpad=4)
cbar.ax.tick_params(labelsize=9, pad=2)
cbar.ax.xaxis.set_ticks_position("top")
cbar.ax.xaxis.set_label_position("top")

ax.set_title(
    "When to Staff for Success: Revenue Peaks Show the Power of Timing",
    fontsize=16,
    fontweight="bold",
    pad=100,
)
ax.text(
    0.5,
    1.35,
    "Weekday peaks occur in the morning and evening, while weekend afternoons do
    transform=ax.transAxes,
    ha="center",
```

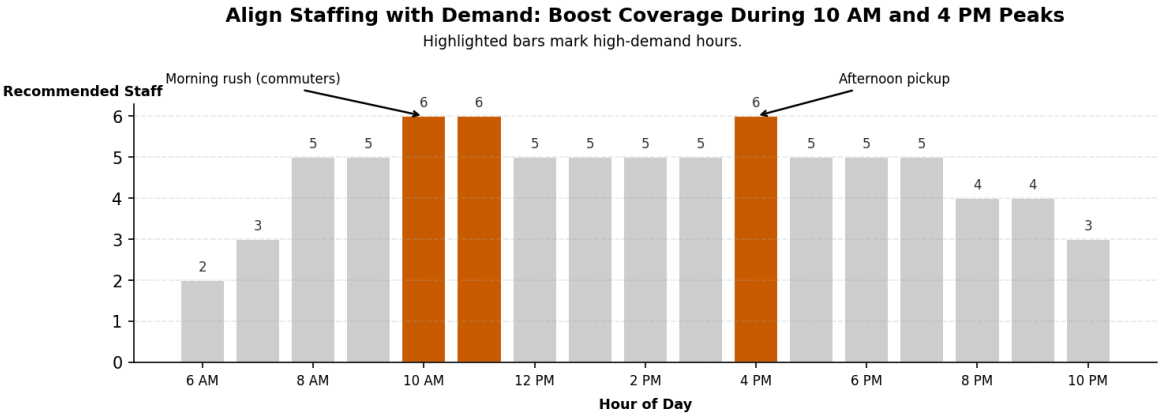
```
    fontsize=10,
)

ax.set_xlabel("Time of Day", fontsize=12, fontweight="bold")
ax.set_ylabel("", fontsize=10, fontweight="bold")
ax.text(
    -0.01,
    1.03,
    "Day of Week",
    transform=ax.transAxes,
    ha="center",
    va="bottom",
    fontweight="bold",
    fontsize=9,
)

ax.set_xticklabels(ax.get_xticklabels(), rotation=0)
ax.set_yticklabels(ax.get_yticklabels(), rotation=0)

sns.despine()
plt.tight_layout(rect=[0, 0.05, 1, 0.96])
plt.show()
```




In [55]:
```
hour_sales = sales_by_hour.set_index("hour_of_day")["money"]
normalized = hour_sales / hour_sales.max() if hour_sales.max() > 0 else hour_sal
recommended_staff = (normalized * 5).apply(math.ceil) + 1

recommended_df = recommended_staff.reset_index().rename(
    columns={"money": "recommended_staff"}
)

rec_hours = (
    pd.DataFrame({"hour_of_day": range(6, 23)})
    .merge(recommended_df, on="hour_of_day", how="left")
    .fillna(1)
)
rec_hours["recommended_staff"] = rec_hours["recommended_staff"].astype(int)
```

In [56]:
```
plt.figure(figsize=(10, 4), dpi=150)

non_peak_color = "#cfcfcf"
peak_color = "#cc5c00"

bars = plt.bar(
    rec_hours["hour_of_day"],
    rec_hours["recommended_staff"],
    color=non_peak_color,
    edgecolor="white",
)

for idx, val in enumerate(rec_hours["recommended_staff"]):
    plt.text(
        rec_hours["hour_of_day"].iloc[idx],
        val + 0.15,
        str(val),
        ha="center",
        va="bottom",
        fontsize=8,
        color="#333",
    )

# highlight peak bars
peak_hours = [10, 11, 16]
plt.bar(
    rec_hours.loc[rec_hours["hour_of_day"].isin(peak_hours), "hour_of_day"],
    rec_hours.loc[rec_hours["hour_of_day"].isin(peak_hours), "recommended_staff"
    color=peak_color,
    edgecolor="white",
)

plt.title(
    "Align Staffing with Demand: Boost Coverage During 10 AM and 4 PM Peaks",
    fontsize=12,
    fontweight="bold",
    pad=50,
)
plt.suptitle(
    "Highlighted bars mark high-demand hours.",
    fontsize=9,
    y=0.835,
)

plt.xlabel("Hour of Day", fontsize=8.5, fontweight="bold", labelpad=6)
plt.ylabel("")
plt.text(
    -0.05,
    1.02,
    "Recommended Staff",
    transform=plt.gca().transAxes,
    ha="center",
    va="bottom",
    fontweight="bold",
    fontsize=8.5,
)

ax = plt.gca()
ax.set_xticks(range(6, 23))
```

```
ax.set_xticklabels(
    [f"{h%12 or 12} {'AM' if h < 12 else 'PM'}" for h in range(6, 23)],
    rotation=0,
    fontsize=8,
    fontweight="medium",
    family="sans-serif",
)

plt.annotate(
    "Morning rush (commuters)",
    xy=(10, 6),
    xytext=(8.5, 6.8),
    arrowprops=dict(arrowstyle="->", color="black", lw=1.2),
    fontsize=8,
    color="black",
    ha="right",
)

plt.annotate(
    "Afternoon pickup",
    xy=(16, 6),
    xytext=(17.5, 6.8),
    arrowprops=dict(arrowstyle="->", color="black", lw=1.2),
    fontsize=8,
    color="black",
    ha="left",
)

ax.xaxis.set_major_locator(MaxNLocator(integer=True))
ax.grid(axis="y", linestyle="--", alpha=0.3)
ax.spines["top"].set_visible(False)
ax.spines["right"].set_visible(False)

plt.tight_layout()
plt.show()
```




In [57]:
```
rec_open_hours = rec_hours[rec_hours["recommended_staff"] > 1][
    ["hour_of_day", "recommended_staff"]
]
print("Recommended Staff by Hour (hours with >1 staff):")
print(rec_open_hours)
```

```
Recommended Staff by Hour (hours with >1 staff):
    hour_of_day  recommended_staff
0             6                 2
1             7                 3
2             8                 5
3             9                 5
4            10                 6
5            11                 6
6            12                 5
7            13                 5
8            14                 5
9            15                 5
10           16                 6
11           17                 5
12           18                 5
13           19                 5
14           20                 4
15           21                 4
16           22                 3
```

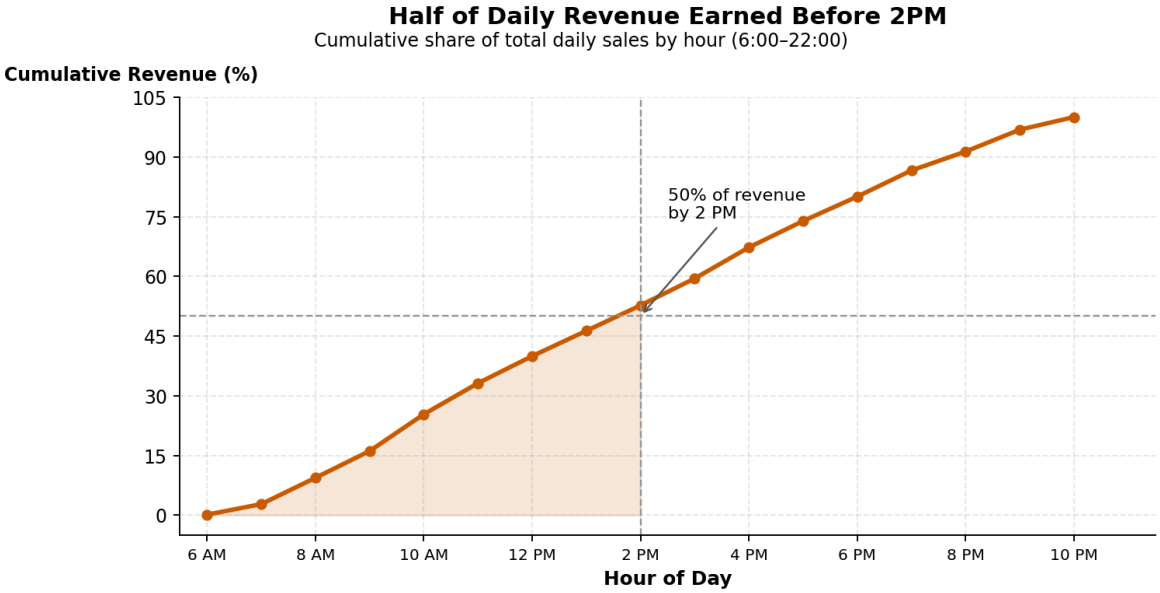
# Question 2

Which types of coffee are most popular during different times of the day, and how should inventory and promotions adjust accordingly? Purpose: Helps managers plan inventory and marketing by matching coffee types to customer habits (e.g., cappuccinos in the morning, iced drinks in the afternoon).

In [58]:
```
assert {"hour_of_day", "money"} <= set(df.columns), "Missing columns."

OPEN_HOUR = 6
CLOSE_HOUR = 23

h = (
    df.assign(hour_of_day=pd.to_numeric(df["hour_of_day"], errors="coerce"))
    .dropna(subset=["hour_of_day", "money"])
    .query("@OPEN_HOUR <= hour_of_day <= @CLOSE_HOUR")
    .groupby("hour_of_day", dropna=True)["money"]
    .sum()
    .sort_index()
)
if h.empty:
    print("No hourly data to plot within open hours.")
else:
    cum_pct = h.cumsum() / h.sum() * 100
    half_idx = (cum_pct >= 50).idxmax()

    plt.figure(figsize=(9, 5), dpi=170)
    ax = plt.gca()

    plt.plot(
        cum_pct.index,
        cum_pct.values,
        color="#cc5c00",
        lw=2.4,
        marker="o",
        markersize=5,
    )
```

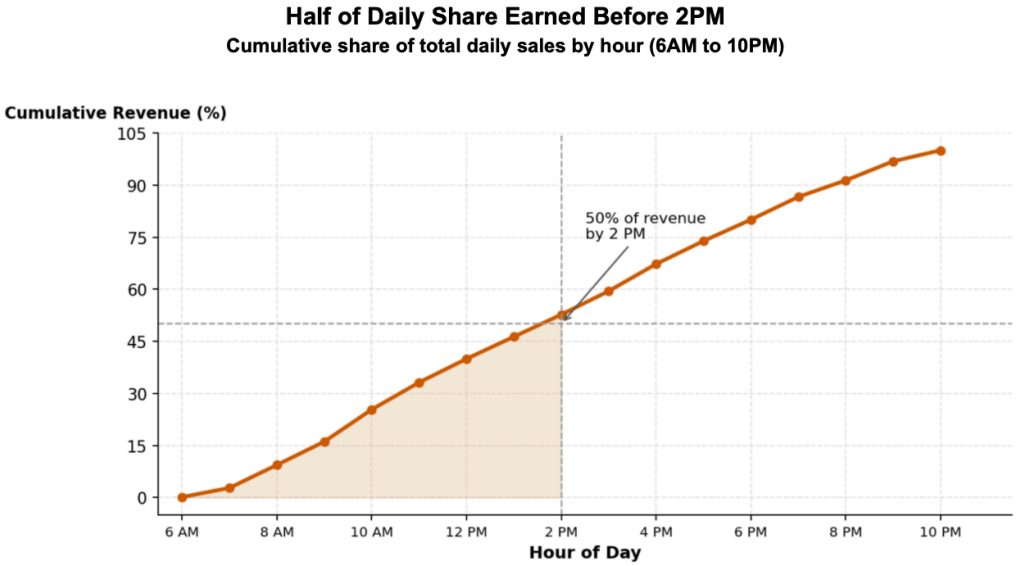
```
plt.fill_between(
    cum_pct.index,
    0,
    cum_pct.values,
    where=cum_pct.index <= half_idx,
    color="#cc5c00",
    alpha=0.15,
)

plt.axhline(50, ls="--", c="#999", lw=1)
plt.axvline(half_idx, ls="--", c="#999", lw=1)

hour_12 = half_idx % 12
hour_12 = 12 if hour_12 == 0 else hour_12
period = "AM" if half_idx < 12 else "PM"

plt.annotate(
    f"50% of revenue\nby {hour_12} {period}",
    xy=(half_idx, 50),
    xytext=(half_idx + 0.5, 78),
    arrowprops=dict(arrowstyle="->", color="#555", lw=1),
    fontsize=9.5,
    ha="left",
    va="center",
)

plt.title(
    "Half of Daily Revenue Earned Before 2PM",
    fontsize=13,
    fontweight="bold",
    pad=40,
)
plt.suptitle(
    f"Cumulative share of total daily sales by hour ({OPEN_HOUR}:00–{CLOSE_H
    fontsize=10,
    y=0.873,
)

ax.set_xlabel("Hour of Day", fontsize=10.5, fontweight="bold")

ax.text(
    -0.05,
    1.03,
    "Cumulative Revenue (%)",
    transform=ax.transAxes,
    ha="center",
    va="bottom",
    fontweight="bold",
    fontsize=10,
)

ax.set_xlim(OPEN_HOUR - 0.5, CLOSE_HOUR + 0.5)
ax.set_xticks(range(OPEN_HOUR, CLOSE_HOUR + 1, 2))
ax.set_xticklabels(
    [
        f"{h%12 or 12} {'AM' if h < 12 else 'PM'}"
        for h in range(OPEN_HOUR, CLOSE_HOUR + 1, 2)
    ],
    fontsize=8.5,
```

```
    )

    ax.yaxis.set_major_locator(MaxNLocator(integer=True))
    ax.grid(axis="both", linestyle="--", alpha=0.3)
    ax.spines["top"].set_visible(False)
    ax.spines["right"].set_visible(False)

    plt.tight_layout()
    plt.show()
```




We need to post processes this for better labeling for which we move our plot above to a word document and then work on the labels

The is our plot post processing




In [59]:
```
DAYPART_ORDER = ["Morning", "Afternoon", "Night"]
DAYPART_DESC = {"Morning": "Open–10am", "Afternoon": "10am–2pm", "Night": "6pm–C
TOP_N = 8
CMAP = "Blues"
CURRENCY = FuncFormatter(lambda x, p: f"${x:,.0f}")
```

```
sales_by_coffee_ord = sales_by_coffee.sort_values("money", ascending=True).tail(
overall_top = sales_by_coffee_ord.iloc[-1]["coffee_name"]
overall_top_amt = sales_by_coffee_ord.iloc[-1]["money"]

coffee_heatmap = (
    df[df["coffee_name"].isin(sales_by_coffee_ord["coffee_name"])]
    .pivot_table(
        index="coffee_name",
        columns="Time_of_Day",
        values="money",
        aggfunc="sum",
        fill_value=0,
    )
    .reindex(index=sales_by_coffee_ord["coffee_name"].tolist())
    .reindex(columns=[d for d in DAYPART_ORDER if d in df["Time_of_Day"].unique(
)

daypart_leads = coffee_heatmap.idxmax(axis=0)
lead_morn = daypart_leads.get("Morning", None)
lead_aft = daypart_leads.get("Afternoon", None)
lead_night = daypart_leads.get("Night", None)
```

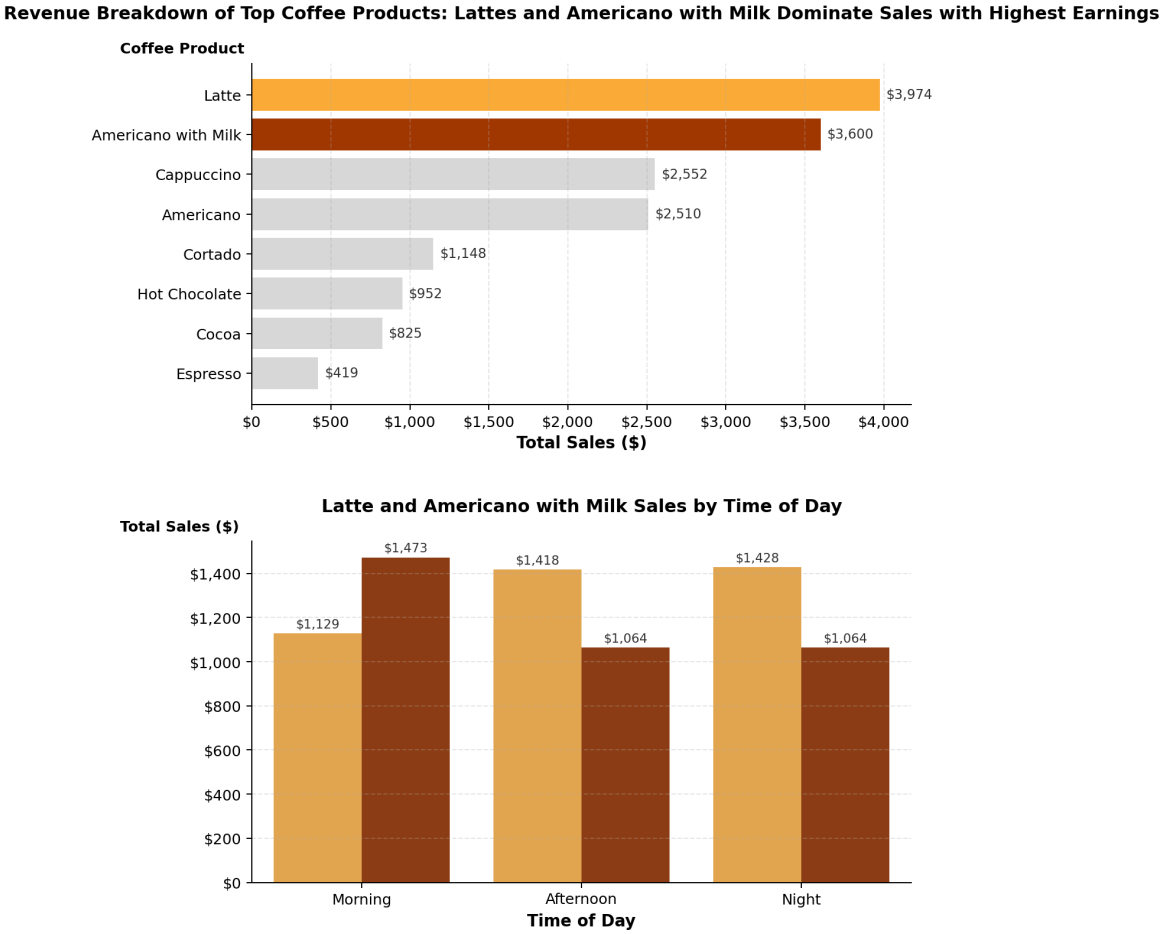
In [60]:

```
cmap = plt.cm.YlOrBr
latte_color = cmap(0.45)
americano_color = cmap(0.85)

fig, (ax1, ax2) = plt.subplots(
    2, 1, figsize=(8, 10), dpi=180, gridspec_kw={"hspace": 0.4}
)

y = np.arange(len(sales_by_coffee_ord))
colors = []
for name in sales_by_coffee_ord["coffee_name"]:
    if name == "Latte":
        colors.append(latte_color)
    elif name == "Americano with Milk":
        colors.append(americano_color)
    else:
        colors.append("#D9D9D9")

bars = ax1.barh(y, sales_by_coffee_ord["money"].values, color=colors)

xmax = sales_by_coffee_ord["money"].max()
for yi, v in zip(y, sales_by_coffee_ord["money"].values):
    ax1.text(v + xmax * 0.01, yi, f"${v:,.0f}", va="center", fontsize=9, color="

ax1.set_yticks(y)
ax1.set_yticklabels(sales_by_coffee_ord["coffee_name"])
ax1.set_xlabel("Total Sales ($)", fontsize=11, fontweight="bold")
ax1.set_ylabel("")
ax1.xaxis.set_major_formatter(CURRENCY)
ax1.grid(axis="x", linestyle="--", alpha=0.3)
ax1.spines["top"].set_visible(False)
ax1.spines["right"].set_visible(False)

ax1.set_title(
    "Revenue Breakdown of Top Coffee Products: Lattes and Americano with Milk Do
    fontsize=12,
    fontweight="bold",
    pad=30,
```

```
)
ax1.text(
    -0.2,
    1.02,
    "Coffee Product",
    transform=ax1.transAxes,
    fontsize=10,
    ha="left",
    va="bottom",
    fontweight="bold",
)

focus_products = ["Latte", "Americano with Milk"]
focus_df = coffee_heatmap.loc[focus_products]

focus_long = focus_df.reset_index().melt(
    id_vars="coffee_name", var_name="Time of Day", value_name="Sales ($)"
)
focus_long.rename(columns={"coffee_name": "Coffee"}, inplace=True)

sns.barplot(
    data=focus_long,
    x="Time of Day",
    y="Sales ($)",
    hue="Coffee",
    ax=ax2,
    palette=[latte_color, americano_color],
)

for container in ax2.containers:
    ax2.bar_label(
        container,
        labels=[f"${h.get_height():,.0f}" for h in container],
        fmt="%d",
        label_type="edge",
        padding=2,
        fontsize=8.5,
        color="#333",
    )

ax2.set_title(
    "Latte and Americano with Milk Sales by Time of Day",
    fontsize=12,
    fontweight="bold",
    pad=20,
)
ax2.text(
    -0.2,
    1.02,
    "Total Sales ($)",
    transform=ax2.transAxes,
    fontsize=10,
    ha="left",
    va="bottom",
    fontweight="bold",
)

ax2.set_xlabel("Time of Day", fontsize=11, fontweight="bold")
ax2.set_ylabel("")
ax2.yaxis.set_major_formatter(CURRENCY)
```

```
ax2.grid(axis="y", linestyle="--", alpha=0.3)
ax2.spines["top"].set_visible(False)
ax2.spines["right"].set_visible(False)

ax2.legend_.remove()

fig.tight_layout(rect=[0, 0, 1, 0.97], pad=2.0)
plt.show()
```

```
/tmp/ipykernel_82243/3469133764.py:105: UserWarning: This figure includes Axes th
at are not compatible with tight_layout, so results might be incorrect.
  fig.tight_layout(rect=[0, 0, 1, 0.97], pad=2.0)
```

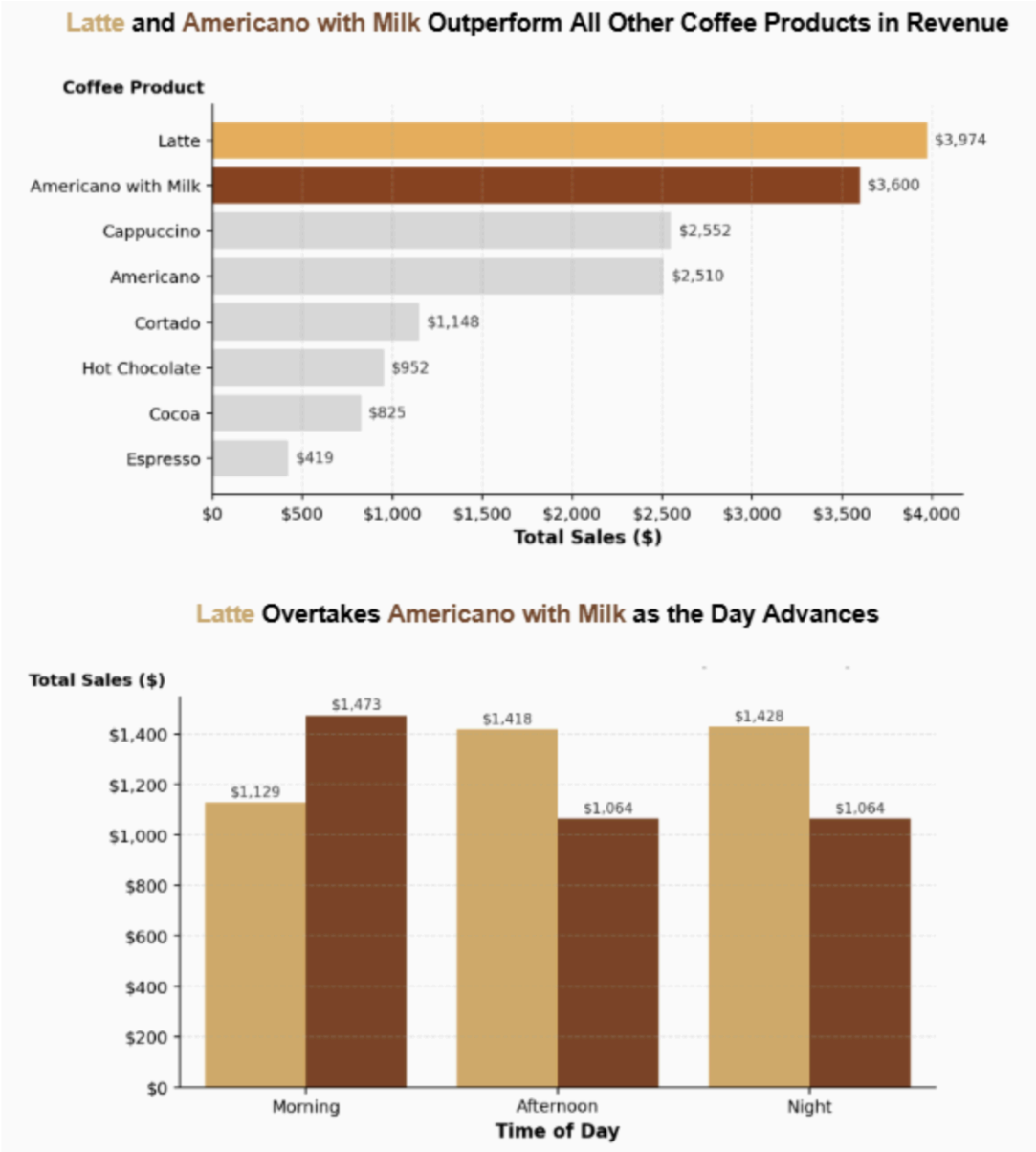






We need to post processes this for better labeling for which we move our facetted plot above to a word document and then work on the labels

The is our plot post processing

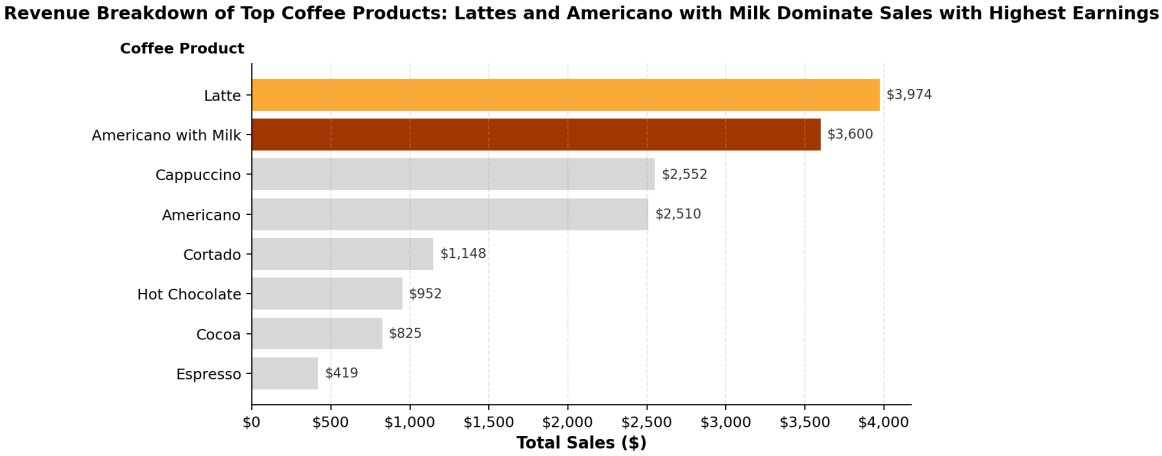


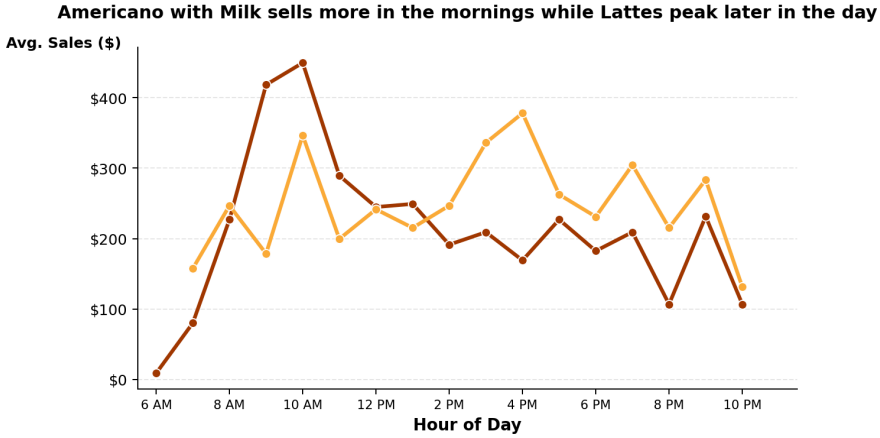

In [61]:
```
cmap = plt.cm.YlOrBr
latte_color = cmap(0.45)
americano_color = cmap(0.85)

fig, (ax1, ax2) = plt.subplots(
    2, 1, figsize=(8, 10), dpi=180, gridspec_kw={"hspace": 0.4}
)

y = np.arange(len(sales_by_coffee_ord))
colors = []
for name in sales_by_coffee_ord["coffee_name"]:
    if name == "Latte":
        colors.append(latte_color)
    elif name == "Americano with Milk":
        colors.append(americano_color)
    else:
        colors.append("#D9D9D9")

bars = ax1.barh(y, sales_by_coffee_ord["money"].values, color=colors)

xmax = sales_by_coffee_ord["money"].max()
```

```
for yi, v in zip(y, sales_by_coffee_ord["money"].values):
    ax1.text(v + xmax * 0.01, yi, f"${v:,.0f}", va="center", fontsize=9, color="

ax1.set_yticks(y)
ax1.set_yticklabels(sales_by_coffee_ord["coffee_name"])
ax1.set_xlabel("Total Sales ($)", fontsize=11, fontweight="bold")
ax1.set_ylabel("")
ax1.xaxis.set_major_formatter(CURRENCY)
ax1.grid(axis="x", linestyle="--", alpha=0.3)
ax1.spines["top"].set_visible(False)
ax1.spines["right"].set_visible(False)

ax1.set_title(
    "Revenue Breakdown of Top Coffee Products: Lattes and Americano with Milk Do
    fontsize=12,
    fontweight="bold",
    pad=30,
)
ax1.text(
    -0.2,
    1.02,
    "Coffee Product",
    transform=ax1.transAxes,
    fontsize=10,
    ha="left",
    va="bottom",
    fontweight="bold",
)

focus_products = ["Latte", "Americano with Milk"]

# Aggregate df by hour_of_day for each coffee type
focus_long = (
    df[df["coffee_name"].isin(focus_products)]
    .groupby(["coffee_name", "hour_of_day"], as_index=False)["money"]
    .sum()
    .rename(columns={"coffee_name": "Coffee", "money": "Sales ($)"})
)

# Sort numerically by hour
focus_long.sort_values("hour_of_day", inplace=True)

# --- Line plot (no labels above points) ---
sns.lineplot(
    data=focus_long,
    x="hour_of_day",
    y="Sales ($)",
    hue="Coffee",
    ax=ax2,
    palette=[americano_color, latte_color],
    linewidth=2.5,
    marker="o",
)

ax2.set_title(
    "Americano with Milk sells more in the mornings while Lattes peak later in t
    fontsize=12,
    fontweight="bold",
    pad=20,
)
```

```
ax2.text(
    -0.2,
    0.99,
    "Avg. Sales ($)",
    transform=ax2.transAxes,
    fontsize=10,
    ha="left",
    va="bottom",
    fontweight="bold",
)
ax2.set_xlim(OPEN_HOUR - 0.5, CLOSE_HOUR + 0.5)
ax2.set_xticks(range(OPEN_HOUR, CLOSE_HOUR + 1, 2))
ax2.set_xticklabels(
    [
        f"{h%12 or 12} {'AM' if h < 12 else 'PM'}"
        for h in range(OPEN_HOUR, CLOSE_HOUR + 1, 2)
    ],
    fontsize=8.5,
)
ax2.set_xlabel("Hour of Day", fontsize=11, fontweight="bold")
ax2.set_ylabel("")
ax2.yaxis.set_major_formatter(CURRENCY)
ax2.grid(axis="y", linestyle="--", alpha=0.3)
ax2.spines["top"].set_visible(False)
ax2.spines["right"].set_visible(False)
ax2.legend_.remove()

fig.tight_layout(rect=[0, 0, 1, 0.97], pad=2.0)
plt.show()
```

```
/tmp/ipykernel_82243/3991993281.py:109: UserWarning: This figure includes Axes th
at are not compatible with tight_layout, so results might be incorrect.
  fig.tight_layout(rect=[0, 0, 1, 0.97], pad=2.0)
```




In [62]:
```
focus_long
```

Out[62]:

| | Coffee | hour_of_day | Sales ($) |
|---|---|---|---|
| **0** | Americano with Milk | 6 | 8.90 |
| **1** | Americano with Milk | 7 | 80.10 |
| **17** | Latte | 7 | 157.50 |
| **2** | Americano with Milk | 8 | 226.95 |
| **18** | Latte | 8 | 246.75 |
| **19** | Latte | 9 | 178.50 |
| **3** | Americano with Milk | 9 | 418.30 |
| **4** | Americano with Milk | 10 | 449.45 |
| **20** | Latte | 10 | 346.50 |
| **5** | Americano with Milk | 11 | 289.25 |
| **21** | Latte | 11 | 199.50 |
| **22** | Latte | 12 | 241.50 |
| **6** | Americano with Milk | 12 | 244.75 |
| **23** | Latte | 13 | 215.25 |
| **7** | Americano with Milk | 13 | 249.20 |
| **8** | Americano with Milk | 14 | 191.35 |
| **24** | Latte | 14 | 246.75 |
| **25** | Latte | 15 | 336.00 |
| **9** | Americano with Milk | 15 | 209.15 |
| **26** | Latte | 16 | 378.00 |
| **10** | Americano with Milk | 16 | 169.10 |
| **11** | Americano with Milk | 17 | 226.95 |
| **27** | Latte | 17 | 262.50 |
| **12** | Americano with Milk | 18 | 182.45 |
| **28** | Latte | 18 | 231.00 |
| **29** | Latte | 19 | 304.50 |
| **13** | Americano with Milk | 19 | 209.15 |
| **14** | Americano with Milk | 20 | 106.80 |
| **30** | Latte | 20 | 215.25 |
| **15** | Americano with Milk | 21 | 231.40 |
| **31** | Latte | 21 | 283.50 |
| **16** | Americano with Milk | 22 | 106.80 |
| **32** | Latte | 22 | 131.25 |

In [63]:
```
df
```

Out[63]:

| | hour_of_day | cash_type | coffee_name | Time_of_Day | Weekday | Month_name | Wee |
|---|---|---|---|---|---|---|---|
| **0** | 10 | card | Latte | Morning | Fri | Mar | |
| **1** | 12 | card | Hot Chocolate | Afternoon | Fri | Mar | |
| **2** | 12 | card | Hot Chocolate | Afternoon | Fri | Mar | |
| **3** | 13 | card | Americano | Afternoon | Fri | Mar | |
| **4** | 13 | card | Latte | Afternoon | Fri | Mar | |
| **...** | ... | ... | ... | ... | ... | ... | |
| **3542** | 10 | card | Cappuccino | Morning | Sun | Mar | |
| **3543** | 14 | card | Cocoa | Afternoon | Sun | Mar | |
| **3544** | 14 | card | Cocoa | Afternoon | Sun | Mar | |
| **3545** | 15 | card | Americano | Afternoon | Sun | Mar | |
| **3546** | 18 | card | Latte | Night | Sun | Mar | |

3547 rows × 11 columns

In [64]:
```
import pandas as pd
import matplotlib.pyplot as plt
import math

# --- Define realistic shift ranges ---
shift_bins = [6, 12, 16, 22]
shift_labels = ["Morning (6AM–12PM)", "Midday (12PM–4PM)", "Evening (4PM–10PM)"]
df["Shift"] = pd.cut(
    df["hour_of_day"], bins=shift_bins, labels=shift_labels, right=False
)

# --- Aggregate sales by shift ---
transactions_by_shift = df.groupby("Shift")["Time"].count().reset_index()
```

```
/tmp/ipykernel_82243/2485832390.py:13: FutureWarning: The default of observed=Fal
se is deprecated and will be changed to True in a future version of pandas. Pass
observed=False to retain current behavior or observed=True to adopt the future de
fault and silence this warning.
  transactions_by_shift = df.groupby("Shift")["Time"].count().reset_index()
```

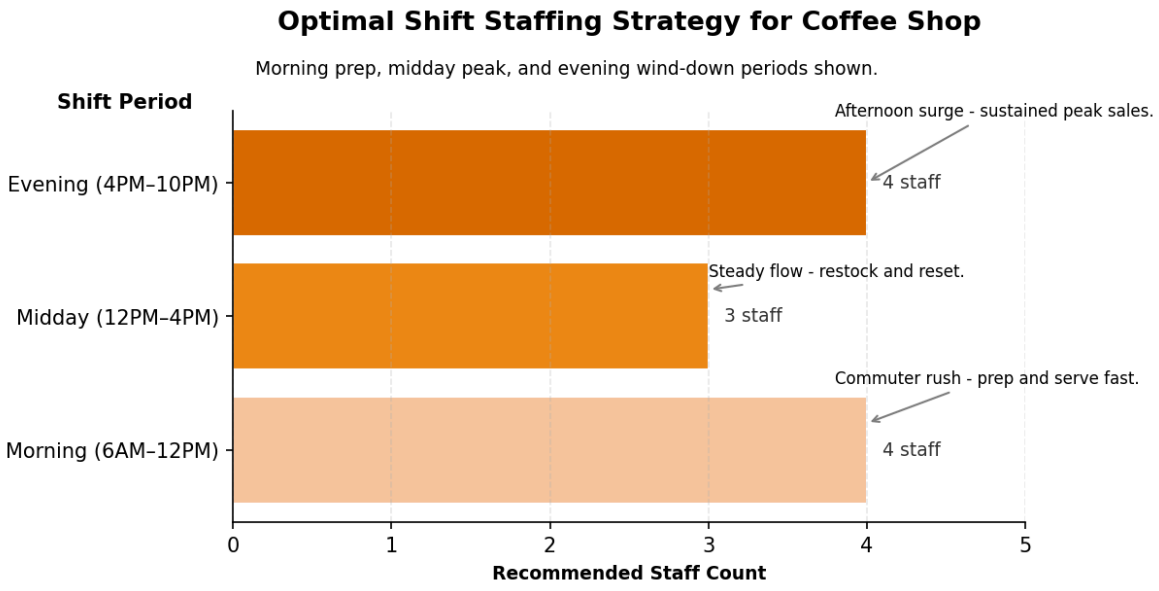
In [65]:
```
transactions_by_shift
```

Out[65]:

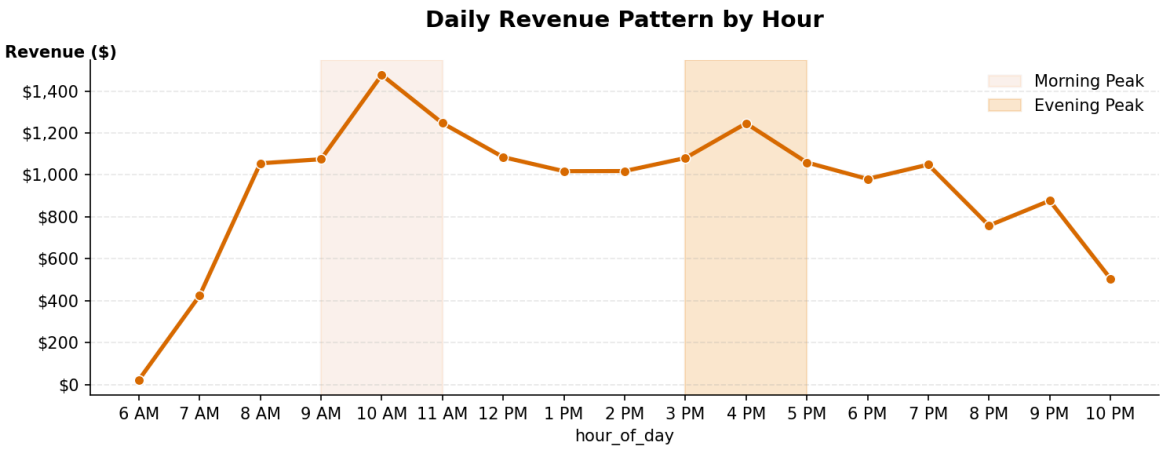
| | Shift | Time |
|---|---|---|
| **0** | Morning (6AM–12PM) | 1181 |
| **1** | Midday (12PM–4PM) | 927 |
| **2** | Evening (4PM–10PM) | 1326 |

In [66]:
```
# --- Normalize and assign recommended staff ---
transactions_by_shift["normalized"] = (
    transactions_by_shift["Time"] / transactions_by_shift["Time"].max()
)
transactions_by_shift["recommended_staff"] = (
    np.round(transactions_by_shift["normalized"] * 3) + 1
).astype(int)

# --- Plot ---
plt.figure(figsize=(8, 4.5), dpi=150)
colors = ["#f7c59f", "#ef8a17", "#d96b00"]

bars = plt.barh(
    transactions_by_shift["Shift"],
    transactions_by_shift["recommended_staff"],
    color=colors,
    edgecolor="white",
)

# Annotate each bar with staff count
for bar in bars:
    plt.text(
        bar.get_width() + 0.1,
        bar.get_y() + bar.get_height() / 2,
        f"{int(bar.get_width())} staff",
        va="center",
        ha="left",
        fontsize=9,
        color="#333",
    )

# Titles and annotations
plt.title(
    "Optimal Shift Staffing Strategy for Coffee Shop",
    fontsize=13,
    fontweight="bold",
    pad=40,
)
plt.suptitle(
    "Morning prep, midday peak, and evening wind-down periods shown.",
    fontsize=9,
    y=0.83,
)

plt.xlabel("Recommended Staff Count", fontsize=9, fontweight="bold")
plt.ylabel("", fontsize=9, fontweight="bold")

plt.xlim(0, transactions_by_shift["recommended_staff"].max() + 1)
plt.grid(axis="x", linestyle="--", alpha=0.3)
```

```
# Add contextual annotations
plt.annotate(
    "Commuter rush - prep and serve fast.",
    xy=(4, 0.2),
    xytext=(3.8, 0.5),
    fontsize=8,
    arrowprops=dict(arrowstyle="->", lw=1, color="gray"),
    color="black",
)
plt.annotate(
    "Steady flow - restock and reset.",
    xy=(3, 1.2),
    xytext=(3, 1.3),
    fontsize=8,
    arrowprops=dict(arrowstyle="->", lw=1, color="gray"),
    color="black",
)
plt.annotate(
    "Afternoon surge - sustained peak sales.",
    xy=(4, 2),
    xytext=(3.8, 2.5),
    fontsize=8,
    arrowprops=dict(arrowstyle="->", lw=1, color="gray"),
    color="black",
)
ax = plt.gca()
ax.text(
    -0.1,
    0.52,
    "Shift Period",
    transform=ax2.transAxes,
    fontsize=10,
    ha="left",
    va="bottom",
    fontweight="bold",
)
ax.spines["top"].set_visible(False)
ax.spines["right"].set_visible(False)
plt.tight_layout()
plt.show()
```



In [68]:
```
import matplotlib.ticker as mtick

plt.figure(figsize=(10, 4), dpi=150)
ax = plt.gca()

hourly_revenue = df.groupby("hour_of_day")["money"].sum().reset_index()

# Line plot
sns.lineplot(
    data=hourly_revenue,
    x="hour_of_day",
    y="money",
    marker="o",
    linewidth=2.5,
    color="#d96b00",
    ax=ax,
)

# Highlight morning and evening peaks
plt.axvspan(9, 11, color="#f7c59f", alpha=0.2, label="Morning Peak")
plt.axvspan(15, 17, color="#ef8a17", alpha=0.2, label="Evening Peak")

# Title
plt.title("Daily Revenue Pattern by Hour", fontsize=14, fontweight="bold", pad=2

# X-axis labels in 12-hour format
ax.set_xticks(range(6, 23))
ax.set_xticklabels([f"{h%12 or 12} {'AM' if h < 12 else 'PM'}" for h in range(6,

# Remove default y-axis label
ax.set_ylabel("")

# Add custom y-axis label using ax.text (like your shift example)
ax.text(
    -0.08,  # x-position (slightly outside the axis)
    1.02,  # y-position (center)
    "Revenue ($)",  # label text
    transform=ax.transAxes,
    fontsize=10,
    ha="left",
    va="center",
    fontweight="bold",
)

# Format y-axis as currency
ax.yaxis.set_major_formatter(mtick.StrMethodFormatter("${x:,.0f}"))

# Grid, legend, and clean spines
ax.grid(axis="y", linestyle="--", alpha=0.3)
ax.spines["top"].set_visible(False)
ax.spines["right"].set_visible(False)
plt.legend(frameon=False)

plt.tight_layout()
plt.show()
```




In [69]:
```
hourly_revenue
```

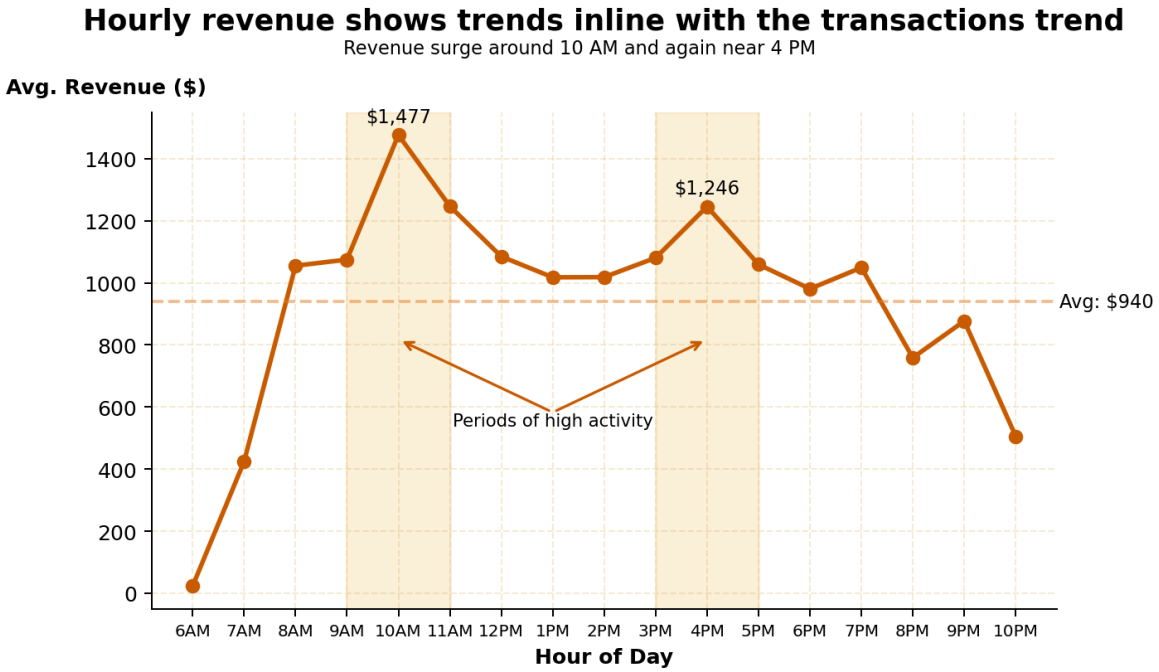
Out[69]:

| | hour_of_day | money |
|---|---|---|
| **0** | 6 | 23.05 |
| **1** | 7 | 424.30 |
| **2** | 8 | 1055.30 |
| **3** | 9 | 1074.85 |
| **4** | 10 | 1476.55 |
| **5** | 11 | 1246.85 |
| **6** | 12 | 1084.85 |
| **7** | 13 | 1017.85 |
| **8** | 14 | 1018.45 |
| **9** | 15 | 1080.65 |
| **10** | 16 | 1245.85 |
| **11** | 17 | 1059.45 |
| **12** | 18 | 980.80 |
| **13** | 19 | 1049.15 |
| **14** | 20 | 758.65 |
| **15** | 21 | 877.20 |
| **16** | 22 | 505.80 |

In [70]:
```
fig, ax_tx = plt.subplots(figsize=(8, 5), dpi=180)

main_color = "#cc5c00"
light_color = "#f5c76e"
highlight_color = "#e67e22"

ax_tx.plot(
    hourly_revenue["hour_of_day"],
    hourly_revenue["money"],
    marker="o",
```

```
    linewidth=2.2,
    color=main_color,
)
ax_tx.grid(True, linestyle="--", alpha=0.25, color="#e0b35c")

spacing = hourly_revenue["money"].max() * 0.02
peak_hours = [10, 16]
for x, y in zip(hourly_revenue["hour_of_day"], hourly_revenue["money"]):
    if x in peak_hours:
        ax_tx.text(
            x,
            y + spacing,
            f"${y:,.0f}",
            ha="center",
            va="bottom",
            fontsize=9,
            fontweight="medium",
            color="black",
        )

plt.suptitle(
    "Revenue surge around 10 AM and again near 4 PM",
    fontsize=9,
    fontweight="medium",
    y=0.872,
    x=0.5,
    ha="center",
    color="black",
)

plt.title(
    "Hourly revenue shows trends inline with the transactions trend",
    fontsize=14,
    fontweight="bold",
    pad=40,
    loc="center",
    color="black",
)

plt.xlabel("Hour of Day", fontsize=10, fontweight="bold", color="black")
plt.ylabel("", fontsize=10, fontweight="bold")

ax_tx.text(
    -0.05,
    1.03,
    "Avg. Revenue ($)",
    transform=ax_tx.transAxes,
    ha="center",
    va="bottom",
    fontweight="bold",
    fontsize=10,
    color="black",
)

ax_tx.set_xticks(range(6, 23))
ax_tx.set_xticklabels(
    [f"{h%12 or 12}{'AM' if h < 12 else 'PM'}" for h in range(6, 23)],
    fontsize=8,
    fontweight="medium",
    color="black",
```

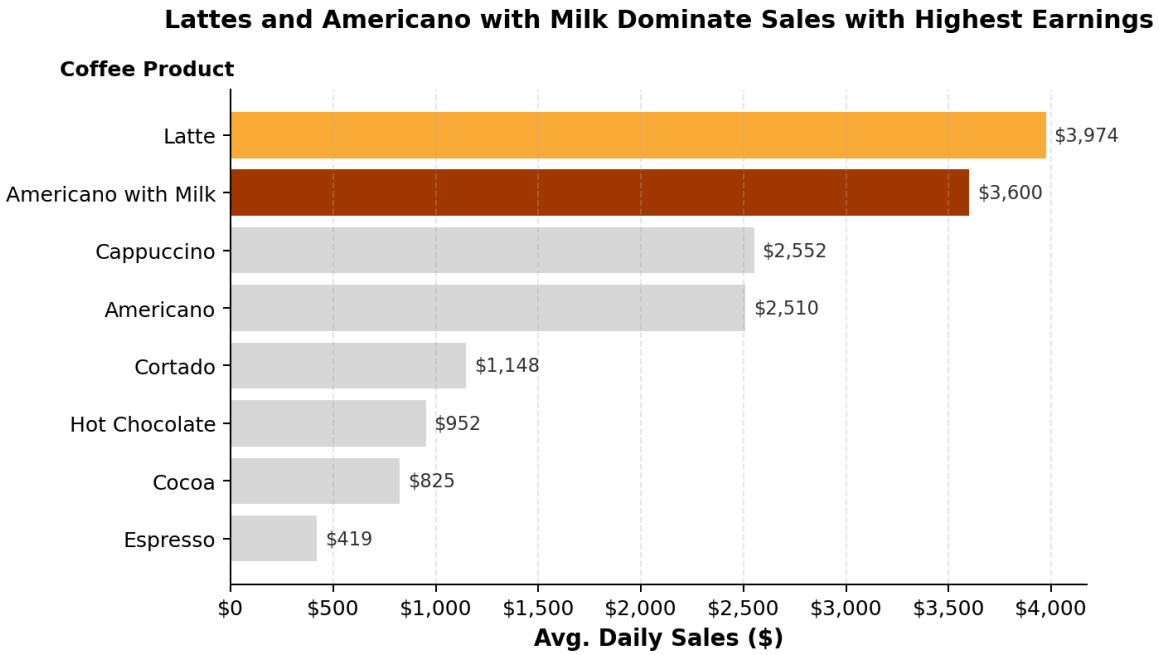
```
    family="sans-serif",
)

# get the avg line
avg_tx = hourly_revenue["money"].mean()
ax_tx.axhline(avg_tx, color=highlight_color, linestyle="--", alpha=0.5)
ax_tx.text(
    x=hourly_revenue["hour_of_day"].max() + 0.85,
    y=avg_tx,
    s=f"Avg: ${avg_tx:,.0f}",
    va="center",
    ha="left",
    fontsize=9,
    color="black",
    fontweight="medium",
)

# highlight windows
ax_tx.axvspan(9, 11, color=light_color, alpha=0.25)
ax_tx.axvspan(15, 17, color=light_color, alpha=0.25)

label_y = avg_tx * 0.62
arrow_y = avg_tx * 0.87

ax_tx.text(
    13,
    label_y,
    "Periods of high activity",
    ha="center",
    va="top",
    fontsize=8.5,
    fontweight="medium",
    color="black",
)

ax_tx.annotate(
    "",
    xy=(10, arrow_y),
    xytext=(13, label_y),
    arrowprops=dict(arrowstyle="->", lw=1.3, color=main_color),
)
ax_tx.annotate(
    "",
    xy=(16, arrow_y),
    xytext=(13, label_y),
    arrowprops=dict(arrowstyle="->", lw=1.3, color=main_color),
)

sns.despine()
plt.tight_layout()
plt.show()
```

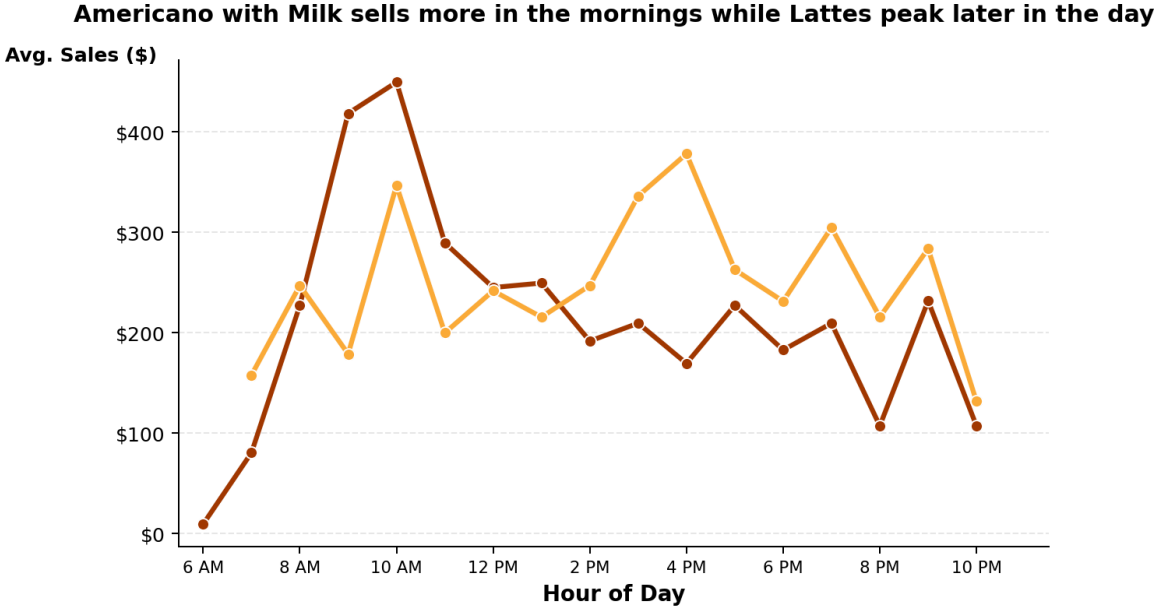



In [71]:
```
cmap = plt.cm.YlOrBr
latte_color = cmap(0.45)
americano_color = cmap(0.85)

# ========================
# Plot 1: Revenue Breakdown
# ========================
fig, ax1 = plt.subplots(figsize=(8, 5), dpi=180)

y = np.arange(len(sales_by_coffee_ord))
colors = []
for name in sales_by_coffee_ord["coffee_name"]:
    if name == "Latte":
        colors.append(latte_color)
    elif name == "Americano with Milk":
        colors.append(americano_color)
    else:
        colors.append("#D9D9D9")

bars = ax1.barh(y, sales_by_coffee_ord["money"].values, color=colors)

xmax = sales_by_coffee_ord["money"].max()
for yi, v in zip(y, sales_by_coffee_ord["money"].values):
    ax1.text(v + xmax * 0.01, yi, f"${v:,.0f}", va="center", fontsize=9, color="

ax1.set_yticks(y)
ax1.set_yticklabels(sales_by_coffee_ord["coffee_name"])
ax1.set_xlabel("Avg. Daily Sales ($)", fontsize=11, fontweight="bold")
ax1.set_ylabel("")
ax1.xaxis.set_major_formatter(CURRENCY)
ax1.grid(axis="x", linestyle="--", alpha=0.3)
ax1.spines["top"].set_visible(False)
ax1.spines["right"].set_visible(False)

ax1.set_title(
    "Lattes and Americano with Milk Dominate Sales with Highest Earnings",
    fontsize=12,
    fontweight="bold",
```

```
    pad=30,
)
ax1.text(
    -0.2,
    1.02,
    "Coffee Product",
    transform=ax1.transAxes,
    fontsize=10,
    ha="left",
    va="bottom",
    fontweight="bold",
)

fig.tight_layout(rect=[0, 0, 1, 0.97], pad=2.0)
plt.show()


# ========================
# Plot 2: Hourly Sales Trend
# ========================
focus_products = ["Latte", "Americano with Milk"]

# Aggregate df by hour_of_day for each coffee type
focus_long = (
    df[df["coffee_name"].isin(focus_products)]
    .groupby(["coffee_name", "hour_of_day"], as_index=False)["money"]
    .sum()
    .rename(columns={"coffee_name": "Coffee", "money": "Sales ($)"})
)
focus_long.sort_values("hour_of_day", inplace=True)

fig, ax2 = plt.subplots(figsize=(8, 5), dpi=180)

sns.lineplot(
    data=focus_long,
    x="hour_of_day",
    y="Sales ($)",
    hue="Coffee",
    ax=ax2,
    palette=[americano_color, latte_color],
    linewidth=2.5,
    marker="o",
)

ax2.set_title(
    "Americano with Milk sells more in the mornings while Lattes peak later in t
    fontsize=12,
    fontweight="bold",
    pad=20,
)
ax2.text(
    -0.2,
    0.99,
    "Avg. Sales ($)",
    transform=ax2.transAxes,
    fontsize=10,
    ha="left",
    va="bottom",
    fontweight="bold",
)
```

```
ax2.set_xlim(OPEN_HOUR - 0.5, CLOSE_HOUR + 0.5)
ax2.set_xticks(range(OPEN_HOUR, CLOSE_HOUR + 1, 2))
ax2.set_xticklabels(
    [
        f"{h%12 or 12} {'AM' if h < 12 else 'PM'}"
        for h in range(OPEN_HOUR, CLOSE_HOUR + 1, 2)
    ],
    fontsize=8.5,
)
ax2.set_xlabel("Hour of Day", fontsize=11, fontweight="bold")
ax2.set_ylabel("")
ax2.yaxis.set_major_formatter(CURRENCY)
ax2.grid(axis="y", linestyle="--", alpha=0.3)
ax2.spines["top"].set_visible(False)
ax2.spines["right"].set_visible(False)
ax2.legend_.remove()

fig.tight_layout(rect=[0, 0, 1, 0.97], pad=2.0)
plt.show()
```



In [ ]: