In [24]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from scipy.optimize import curve_fit
```

In [25]:
```
import os

# Create folder if it doesn't exist
if not os.path.exists('img'):
    os.makedirs('img')
```

2025 Innovation: LG Signature OLED T – Transparent TV Similar Past Innovation: Flat-screen TVs. Flat-screen TVs transformed home entertainment by replacing bulky CRT TVs with thin, wall-mounted displays. The transparent TV represents the next step in display innovation. Because both are in the same product category and target similar consumers, historical adoption data for flat TVs provides a strong baseline for forecasting transparent TV diffusion.

Source: Statista (2021), Sales volume of flat-screen TVs in Germany from 2006 to 2020. Retrieved from https://www.statista.com/statistics/460190/sales-of-flat-screen-tvs-in-germany/?srsltid=AfmBOorVsGKKHOCKoSQPQ3RcssABzBdcMAFfkkTQn5sncreEAiZyeZQ

In [26]:
```
file_path = "data/flat_screen_sales.xlsx"
tv_data = pd.read_excel(file_path, sheet_name='Data', skiprows=4, usecols=[1, 2], names=['Year', 'Unit Sales'])
print(tv_data.head())
```

```
   Year  Unit Sales
0  2006         3.0
1  2007         4.4
2  2008         6.6
3  2009         8.3
4  2010         9.1
```

In [29]:
```
years = tv_data['Year'].values
annual_sales = tv_data['Unit Sales'].values
cumulative_sales = np.cumsum(annual_sales)
t = years - years.min()
```

In [71]:
```
plt.figure(figsize=(10, 6))
plt.plot(tv_data['Year'], tv_data['Unit Sales'], marker='o')
plt.title('Historical Flat-Screen TV Sales in Germany')
plt.xlabel('Year')
plt.ylabel('Units Sold (millions)')
plt.grid(True)
plt.savefig('img/sales_plot.png')
plt.show()
```

In [31]:
```
def bass_model(t, p, q, M):
    """Bass diffusion model cumulative adoption function.
    t: time (years since launch)
    p: coefficient of innovation
    q: coefficient of imitation
    M: total market potential
    """
    return M * (1 - np.exp(-(p + q) * t)) / (1 + (q / p) * np.exp(-(p + q) * t))
```

In [32]:
```
initial_guess = [0.03, 0.4, 120]  # p, q, M initial guesses
params, _ = curve_fit(bass_model, t, cumulative_sales, p0=initial_guess, bounds=(0, [1, 1, 1000]))
p, q, M = params

print("\n Estimated Bass Model Parameters:")
print(f"p (coefficient of innovation): {p:.4f}")
print(f"q (coefficient of imitation): {q:.4f}")
print(f"M (market potential, millions): {M:.2f}")
```

```
 Estimated Bass Model Parameters:
p (coefficient of innovation): 0.0493
q (coefficient of imitation): 0.1585
M (market potential, millions): 147.37
```

About 4.93% of potential adopters are influenced by external factors such as advertising, media, or early exposure to the innovation. About 11.05% of potential adopters adopt due to word-of-mouth or social influence from existing users. The total potential market size for this innovation is approximately 147.37 million devices.

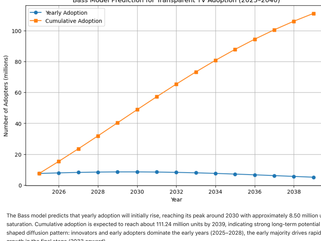
In [34]:
```
def bass_cumulative(t, p, q, M):
    return M * (1 - np.exp(-(p + q) * t)) / (1 + (q / p) * np.exp(-(p + q) * t))

def bass_yearly(t, p, q, M):
    return bass_cumulative(t, p, q, M) - bass_cumulative(t-1, p, q, M)
```

In [35]:
```
years = np.arange(2025, 2040)
t = np.arange(1, len(years) + 1)

yearly_adoption = bass_yearly(t, p, q, M)
cumulative_adoption = bass_cumulative(t, p, q, M)
```

In [36]:
```
forecast_df = pd.DataFrame({
    "Year": years,
    "Yearly Adoption (millions)": yearly_adoption,
    "Cumulative Adoption (millions)": cumulative_adoption
})

print("Predicted Diffusion Path for Transparent TV:")
print(forecast_df)
```

```
Predicted Diffusion Path for Transparent TV:
    Year  Yearly Adoption (millions)  Cumulative Adoption (millions)
0   2025                    7.472956                        7.472956
1   2026                    7.855568                       15.328517
2   2027                    8.161207                       23.489723
3   2028                    8.373085                       31.862808
4   2029                    8.488971                       40.354499
5   2030                    8.495867                       48.849566
6   2031                    8.393786                       57.243352
7   2032                    8.190185                       65.433538
8   2033                    7.894158                       73.327695
9   2034                    7.519438                       80.847134
10  2035                    7.082308                       87.929441
11  2036                    6.608195                       94.537636
12  2037                    6.098366                      100.636003
13  2038                    5.568844                      106.188846
14  2039                    5.049632                      111.238478
```

In [37]:
```
plt.figure(figsize=(10,6))
plt.plot(forecast_df["Year"], forecast_df["Yearly Adoption (millions)"], marker='o', label="Yearly Adoption")
plt.plot(forecast_df["Year"], forecast_df["Cumulative Adoption (millions)"], marker='s', label="Cumulative Adoption")
plt.title("Bass Model Prediction for Transparent TV Adoption (2025–2040)")
plt.xlabel("Year")
plt.ylabel("Number of Adopters (millions)")
plt.legend()
plt.grid(True)
plt.savefig('img/prediction_plot.png')

plt.show()
```



The Bass model predicts that yearly adoption will initially rise, reaching its peak around 2030 with approximately 8.50 million units sold that year, and then gradually decline as the market approaches saturation. Cumulative adoption is expected to reach about 111.24 million units by 2039, indicating strong long-term potential and wide consumer acceptance. This adoption curve follows the classic S-shaped diffusion pattern: innovators and early adopters dominate the early years (2025–2028), the early majority drives rapid growth around the peak (2029–2032), and late adopters contribute to slower growth in the final stage (2033 onward).

In [ ]:
```

```

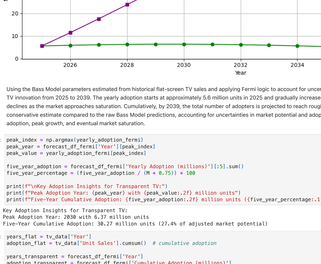
For this analysis, I choose a country-specific scope, focusing on Germany. The primary reason is that the historical sales data I am using comes from Statista's report on flat-screen TV sales in Germany from 2006 to 2020. A country-specific analysis allows for more realistic and actionable forecasts. For example, German households historically have had high penetration rates of TVs, but the adoption rate and peak timing can differ from other markets like the U.S. or China (Statista, 2021). By focusing on Germany, the predictions for the Transparent TV innovation will reflect market-specific adoption behavior, providing a more precise picture of diffusion dynamics within this country.

In [40]:
```
yearly_adoption = bass_yearly(t, p, q, M)
cumulative_adoption = bass_cumulative(t, p, q, M)

# Apply fermi adjustment: assume realistically 75% of market potential will adopt
fermi_factor = 0.75
yearly_adoption_fermi = yearly_adoption * fermi_factor
cumulative_adoption_fermi = np.cumsum(yearly_adoption_fermi)

forecast_df_fermi = pd.DataFrame({
    "Year": years,
    "Yearly Adoption (millions)": yearly_adoption_fermi,
    "Cumulative Adoption (millions)": cumulative_adoption_fermi
})

print("Estimated Number of Adopters by Period for Transparent TV (fermi-adjusted):")
print(forecast_df_fermi.round(2))
```

```
Estimated Number of Adopters by Period for Transparent TV (fermi-adjusted):
    Year  Yearly Adoption (millions)  Cumulative Adoption (millions)
0   2025                        5.60                            5.60
1   2026                        5.89                           11.50
2   2027                        6.12                           17.62
3   2028                        6.28                           23.90
4   2029                        6.37                           30.27
5   2030                        6.37                           36.64
6   2031                        6.30                           42.93
7   2032                        6.14                           49.08
8   2033                        5.92                           55.00
9   2034                        5.64                           60.64
10  2035                        5.31                           65.95
11  2036                        4.95                           70.90
12  2037                        4.57                           75.47
13  2038                        4.18                           79.64
14  2039                        3.79                           83.43
```

Because transparent TVs are a premium niche product and LG holds roughly 20–25% of the global premium TV market, I adjusted the potential market by 0.75 to reflect likely adoption constraints.

In [66]:
```
plt.figure(figsize=(12, 6))

plt.plot(forecast_df_fermi['Year'], forecast_df_fermi['Yearly Adoption (millions)'], marker='o', color='green', label='Yearly Adoption')

plt.plot(forecast_df_fermi['Year'], forecast_df_fermi['Cumulative Adoption (millions)'], marker='s', color='purple', label='Cumulative Adoption')

plt.title('Fermi-Adjusted Adoption Forecast: Transparent TV')
plt.xlabel('Year')
plt.ylabel('Number of Adopters (millions)')
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.savefig('img/fermi.png')

plt.show()
```



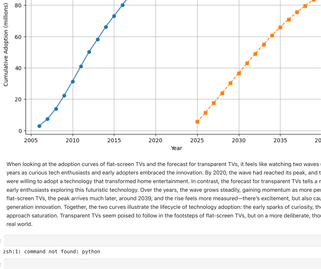
Using the Bass Model parameters estimated from historical flat-screen TV sales and applying Fermi logic to account for uncertainties in adoption, we forecasted the number of adopters of the Transparent TV innovation from 2025 to 2039. The yearly adoption starts at approximately 5.6 million units in 2025 and gradually increases, peaking around 6.37 million units in 2030. After the peak, adoption slowly declines as the market approaches saturation. Cumulatively, by 2039, the total number of adopters is projected to reach roughly 83.4 million units. This Fermi-adjusted approach provides a more conservative estimate compared to the raw Bass Model predictions, accounting for uncertainties in market potential and adoption speed. It illustrates the typical S-shaped diffusion curve, highlighting early adoption, peak growth, and eventual market saturation.

In [68]:
```
peak_index = np.argmax(yearly_adoption_fermi)
peak_year = forecast_df_fermi['Year'][peak_index]
peak_value = yearly_adoption_fermi[peak_index]

five_year_adoption = forecast_df_fermi['Yearly Adoption (millions)'][:5].sum()
five_year_percentage = (five_year_adoption / (M * 0.75)) * 100

print(f"\nKey Adoption Insights for Transparent TV:")
print(f"Peak Adoption Year: {peak_year} with {peak_value:.2f} million units")
print(f"Five-Year Cumulative Adoption: {five_year_adoption:.2f} million units ({five_year_percentage:.1f}% of adjusted market potential)")
```

```

Key Adoption Insights for Transparent TV:
Peak Adoption Year: 2030 with 6.37 million units
Five-Year Cumulative Adoption: 30.27 million units (27.4% of adjusted market potential)
```

In [69]:
```
years_flat = tv_data['Year']
adoption_flat = tv_data['Unit Sales'].cumsum()  # cumulative adoption

years_transparent = forecast_df_fermi['Year']
adoption_transparent = forecast_df_fermi['Cumulative Adoption (millions)']

plt.figure(figsize=(10,6))
plt.plot(years_flat, adoption_flat, 'o-', label="Flat-Screen TVs (Historical)")
plt.plot(years_transparent, adoption_transparent, 's--', label="Transparent TVs (Forecast)")

plt.title('📊 Adoption Curves: Flat-Screen vs Transparent TVs')
plt.xlabel("Year")
plt.ylabel("Cumulative Adoption (millions)")
plt.legend()
plt.grid(True)
plt.savefig('img/comparison_plot.png')

plt.show()
```

```
/var/folders/c2/km33_4x11k15fzhmth5vs0h0000gn/T/ipykernel_98289/3816044689.py:16: UserWarning: Glyph 128202 (\N{BAR CHART}) missing from font(s) DejaVu Sans.
  plt.savefig('img/comparison_plot.png')
/opt/anaconda3/lib/python3.12/site-packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 128202 (\N{BAR CHART}) missing from font(s) DejaVu Sans.
  fig.canvas.print_figure(bytes_io, **kw)
```



When looking at the adoption curves of flat-screen TVs and the forecast for transparent TVs, it feels like watching two waves unfold over time. Flat-screen TVs surged rapidly, climbing steadily in the early years as curious tech enthusiasts and early adopters embraced the innovation. By 2020, the wave had reached its peak, and the market was almost fully saturated, showing just how quickly households were willing to adopt a technology that transformed home entertainment. In contrast, the forecast for transparent TVs tells a more gradual story. The adoption starts off slowly, with only a small group of early enthusiasts exploring this futuristic technology. Over the years, the wave grows steadily, gaining momentum as more people become aware and intrigued by the novelty of transparent displays. Unlike flat-screen TVs, the peak arrives much later, around 2039, and the rise feels more measured—there's excitement, but also caution, reflecting the niche appeal and higher barriers to entry for this next-generation innovation. Together, the two curves illustrate the lifecycle of technology adoption: the early sparks of curiosity, the rush of mainstream acceptance, and eventually the slowdown as markets approach saturation. Transparent TVs seem poised to follow in the footsteps of flat-screen TVs, but on a more deliberate, thoughtful journey that mirrors how cutting-edge innovations often unfold in the real world.

In [73]:
```
zsh:1: command not found: python
```

In [ ]:
```

```