Income Statement and Balance Sheet Forecast

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December 27, 2024

Abstract

Financial statements are collections of interdependent fields that collectively illustrate a firm's financial position. A robust model for predicting financial statements should adhere to the identities established by accounting principles, such as the equation: assets = liabilities + equity. This report is organized as follows: Section 1 transforms a standard spreadsheet model of the balance sheet and income statement into a time series representation and implements this model using TensorFlow. Section 2 examines the model's performance and explores machine learning techniques that can enhance prediction accuracy.

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A balance sheet consists of three important indicators that aggregate key information representing the financial positions of a firm: assets, liabilities, and equity. Balance sheet forecasting involves predicting the future values of all three variables as well as their important components such as current assets and retained earnings. The balance sheet is designed in a way such that the fundamental accounting identity – namely, assets = liabilities + equity – always holds. A reasonable forecast model should respect this and other accounting identities when making predictions. In other words, the predicted output should satisfies some constraints imposed by basic accounting principles.

Mathematically, a balance sheet can be represented by a *state-space* model:

$$y(t+1) = f(x(t), y(t)) + n(t) \tag{0.1}$$

where $y(t)$ is a random vector that collects all fields of a balance sheet. For example, $y(t) = (\text{assets}_t, \text{liabilities}_t, \text{equity}_t)'$ is the most simplified version of a balance sheet[1]. $x(t)$ represents a vector of exogenous variables such as net income and/or cash flow from external financing. Exogenous variables are those that affect the balance sheet but not included in it. $n(t)$ is the noise term, reflecting the uncertainty in forecasting balance sheet fields. The forecasting function, denoted by $f(\cdot,\cdot)$, is the key element we aim to identify. It is crucial that the choice of $f(\cdot,\cdot)$ has to reflect all accounting identities in order to produce a reasonable predictive model.

Model 0.1 represents a one-step-ahead, multi-output problem which is straightforward to implement using Google's TensorFlow library in Python. The program, named `model_v1.py`, implements a financial forecasting model using deep learning techniques. It begins by reading financial statements for various companies and preprocessing the data to ensure completeness and consistency. The processed data is then scaled and divided into training and testing sets. A customized LSTM model is constructed to predict key financial metrics such as total equity based on historical data. This model utilizes a customized loss function designed to take accounting identities into account.

Income statement can also be modeled in a similar fashion. Apart from different target variables and accounting identities such as earnings, or net income = total revenue - total expenses, training an income statement model can be achieved by cloning the program for

[1] By default, all vectors are column vectors

training a balance sheet model.

Balance sheet, income statement, and cash flow data are sourced from Yahoo Finance using the yfinance data API. I obtain the financial statements for all companies included in the S&P 500 index – stocks of 500 large companies listed on stock exchanges in the United States and one of the most widely tracked stock index around the world. S&P 500 has a large concentration in blue chip stocks in the technology sector. In other words, a big fraction of companies in S&P 500 are industry-leading tech giants that have more stable financial health compared with small and medium cap companies. A notable data limitation is that the yfinance API only allows users to retrieve historical data of financial statements within the recent 4 years. Model implementation has to take the short history into account. Given this limitation, each company will provide 3 data points in the training process and the model is trained to make one-year-ahead prediction based on the historical data in the past 3 years.

Model performances are evaluated based on several metrics, including mean squared error (MSE), root mean squared error (RMSE), mean absolute error (MAE), and mean absolute percentage error (MAPE). Moreover, the mean squared error and mean absolute error for accounting identities are provided as another dimension of model evaluation. These additional metrics check whether a model respects the specified accounting identities.

I adopt Long Short-Term Memory (LSTM) networks, a variant in the class of recurrent neural networks (RNNs), to improve the modeling of balance sheets and income statements. LSTMs excel at analyzing time series data because they are able to capture patterns in historical financial variables like revenue and expenses. By learning from past data, LSTMs can provide more accurate forecasts of future financial performance.

Finally, enforcing a model to follow accounting identities come at the expenses of some predictive power. I compare the trained LSTM model with a simple random walk model which takes the observation from the last period as the forecast. The random walk model scores higher in model performance but its forecasts do not satisfy accounting identities. In other words, unsophisticated models that do not explicitly take accounting identities into account have an unfair advantage in forecast competitions. A reasonable model evaluation procedure should take this caveat into account.

Literature. Velez-Pareja (2010, 2011) provides a detailed description of the accounting identities built in standard financial statements. This balance sheet model formalizes the spreadsheet model in Velez-Pareja (2010) and Velez-Pareja (2011) as a time series representation and applied machine learning techniques to improve its predictability.

1 Model

A simplified balance sheet model comprises only four key equations: three that govern the evolution of total assets, liabilities, and equity, and one that represents the fundamental accounting identity: assets = liabilities + equity.

$$\begin{multline}\text{Total assets}_{t+1} \\ = f_1\left[\text{Total assets}_t, \text{Total liabilities}_t, \text{Total equity}_t, \text{Net income}_t, \text{Operating cash flow}_t\right] + n_1(t)\end{multline} \tag{1.1}$$

$$\begin{multline}\text{Total liabilities}_{t+1} \\ = f_2\left[\text{Total assets}_t, \text{Total liabilities}_t, \text{Total equity}_t, \text{Net income}_t, \text{Operating cash flow}_t\right] + n_2(t)\end{multline} \tag{1.2}$$

$$\begin{multline}\text{Total equity}_{t+1} \\ = f_3\left[\text{Total assets}_t, \text{Total liabilities}_t, \text{Total equity}_t, \text{Net income}_t, \text{Operating cash flow}_t\right] + n_3(t)\end{multline} \tag{1.3}$$

$$\text{Total assets}_t = \text{Total liabilities}_t + \text{Total equity}_t \tag{1.4}$$

This four-equation balance sheet model can be easily cast into Model 0.1 where

$$y(t) = \begin{pmatrix} \text{Total assets}_t \\ \text{Total liabilities}_t \\ \text{Total equity}_t \end{pmatrix}$$

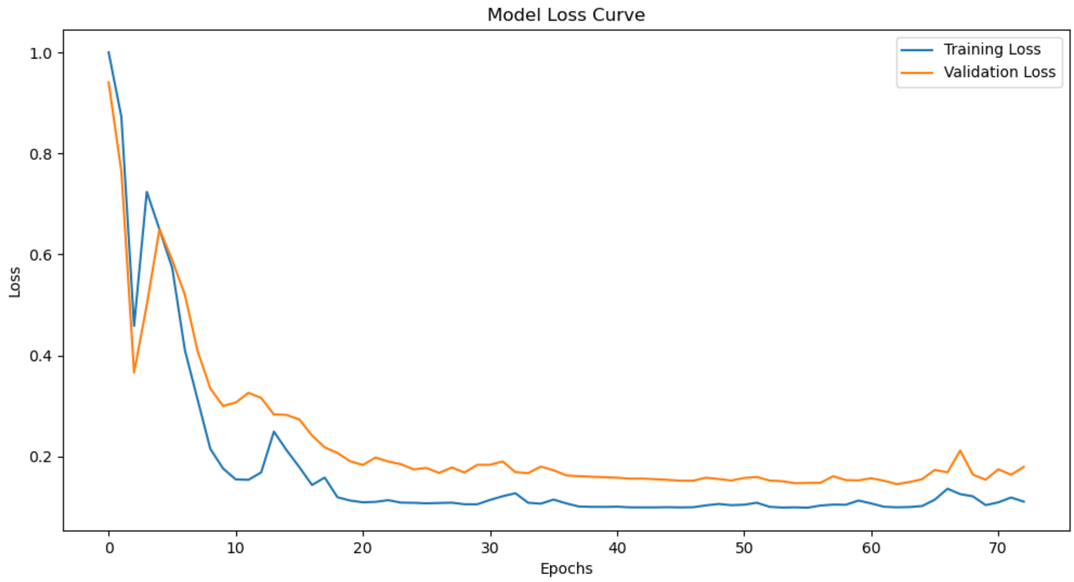
and $x(t)$ consists of net income (from income statement) and operating cash flow (from cash flow statement). The hypothesis posits that lagged values of both $y(t)$ and $x(t)$ are useful for predicting $y(t)$.

Forecasting Earnings. Likewise, earnings can also be forecasted with a state-space model. [2] To illustrate, I propose a four-equation income statement model much like the four-equation balance sheet model:

$$\begin{multline}\text{Revenues}_{t+1} \\ = f_1\left[\text{Revenues}_t, \text{Expenses}_t, \text{Net Income}_t, \text{Total assets}_t, \text{Operating cash flow}_t\right] + n_1(t)\end{multline} \tag{1.5}$$

[2] Earnings, or net income, is defined as profits after all expenses, taxes, and costs have been deducted from total revenue. Henceforth, earnings and net income are used interchangeably.

Figure 1: Balance Sheet Model Loss Curve: LSTM



$$\text{Expenses}_{t+1} = f_2\left[\text{Revenues}_t, \text{Expenses}_t, \text{Net Income}_t, \text{Total assets}_t, \text{Operating cash flow}_t\right] + n_1(t) \quad (1.6)$$

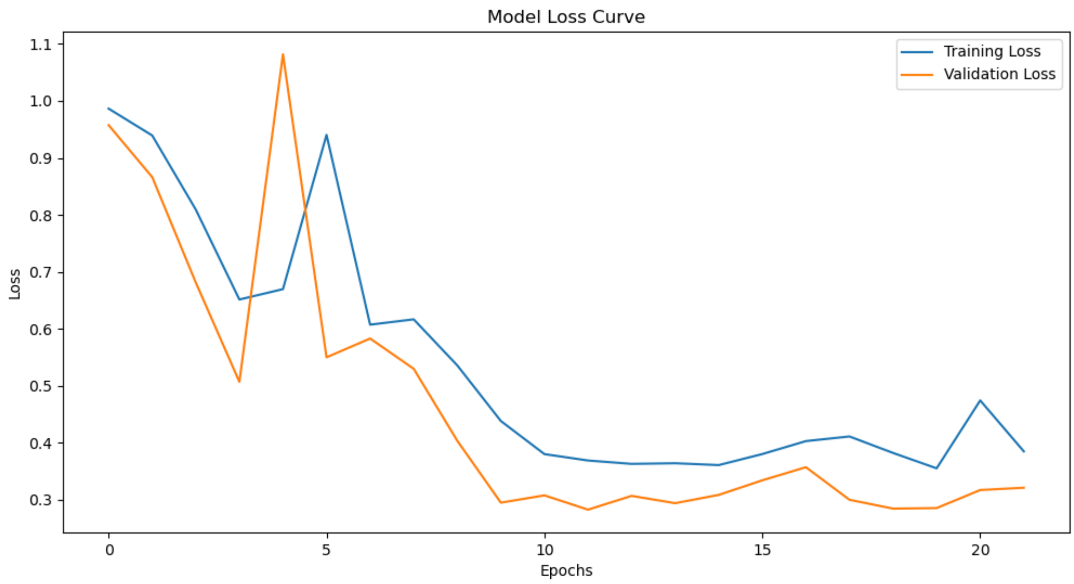
$$\text{Net income}_{t+1} = f_3\left[\text{Revenues}_t, \text{Expenses}_t, \text{Net Income}_t, \text{Total assets}_t, \text{Operating cash flow}_t\right] + n_1(t) \quad (1.7)$$

$$\text{Net Income}_t = \text{Revenues}_t - \text{Expenses}_t \quad (1.8)$$

Constraint 1.8 reflects the definition of net income, which is the difference between revenues and expenses. Appendix B specifies a comprehensive model that contains all detailed fields from a balance sheet, an income statement, a cash flow statement, and intermediate tables that are used to produce them (such as loan schedules). This model is the same as the spreadsheet model outlined by Velez-Pereja (2010).

Implementation in TensorFlow. The program begins by importing necessary libraries, including TensorFlow for deep learning and PyTickerSymbols to fetch ticker symbols. The script defines functions to retrieve financial statements (balance sheet, income statement, and cash flow) for each ticker and preprocesses this data by merging the statements, handling missing values, and converting figures to billions of USD. Key features and targets for modeling are specified, and valid tickers are filtered based on the presence of required data. The

Figure 2: Income Statement Model Loss Curve: LSTM



program then constructs a dataset for training a Long Short-Term Memory (LSTM) model to predict financial outcomes, while also implementing a custom loss function that ensures the accounting equation (e.g., Total Assets = Total Liabilities + Equity) is satisfied. An early stopping will be triggered if the validation losses no longer improve after iterating over 10 consecutive epchos. Figure 1 and 2 depicts the loss functions for the balance sheet and income statement model, respectively. After training the model, it evaluates performance using several metrics, such as mean squared error and R-squared, and compares the results with a simple random walk model. Finally, the script exports the evaluation metrics to a CSV file for further analysis.

The LSTM model consists of four layersL

- **Layer 1**: The first layer consists of 128 LSTM units with a ReLU activation function. This layer captures temporal dependencies in the input data, allowing the model to learn patterns over time.

- **Layer 2:** The second layer has 64 LSTM units, further refining the model's ability to learn complex sequences.

- **Dense Layer:** A fully connected layer with 64 units follows, providing additional processing before the output.

Table 1: Model Evaluation: Balance Sheet

Metric	LSTM	Random Walk
MSE	785.96	65.22
RMSE	26.62	7.76
MAE	13.17	4.78
MAPE	1.55	0.42
R-squared	0.82	0.98
MSE Constraint	0	13.83
MAE Constraint	0	1.84

Table 2: Model Evaluation: Income Statement

Metric	LSTM	Random Walk
MSE	750.83	206.85
RMSE	24.88	12.99
MAE	14.44	6.11
MAPE	2.19	0.8
R-squared	0.53	0.87
MSE Constraint	0	26.96
MAE Constraint	0	2.56

- **Output Layer:** The final layer outputs predictions for the specified targets, which include fields such as total assets and liabilities.

2 Evaluation

Model performances are evaluated based on multiple metrics. The first set of metrics provide evaluation in traditional sense by calculating the standardized forecast errors on the testing set. I split the training-testing set by 80-20. For mean squared error (MSE), root mean squared error (RMSE), mean absolute error (MAE), and mean absolute percentage error (MAPE), smaller values indicate smaller forecast errors which are favorable. Higher R-squared means better goodness-of-fit. The second set of metrics evaluate to what extend the model's forecast respect accounting identities. A lower MSE and/or MAE for accounting constraint means the model's output are closer to following the specified identity. If the identity hold exactly, the MSE and MAE for the accounting constraint should be precisely 0.

The machine learning models for financial statements obtain decent performances in the testing sets. Table 1 and Table 2 presents the model performances for the balance sheet and income statement model. In both cases, the LSTM model is compared with a benchmark random walk model. The MAPEs for the LSTM balance sheet model is 1.55% and for the LSTM income statement model is 2.19%. This result suggests that, on average, the forecast miss the actual value by only 2 percent. Moreover, it is worth point out that both model respect the corresponding accounting identities, as indicated by the MSE and MAE for constraint in the last two rows.

Nonetheless, adhering to accounting identities can reduce predictive power. In my comparison, the trained LSTM model was outperformed by a simple random walk model in the traditional metrics. The caveat is that while the random walk model achieved higher performances, it does not comply with accounting identities. This highlights that simpler models, which ignore these identities, may have an unfair advantage in forecasting competitions. Therefore, a comprehensive model evaluation should consider this limitation.

Reference

Velez-Pareja, I. (2010). Constructing Consistent Financial Planning Models for Valuation. IIMS Journal of Management of Science, 1.

Vélez-Pareja, I. (2011). Forecasting Financial Statements with No Plugs and No Circularity. The IUP Journal of Accounting Research & Audit Practices, 10(1).

Appendix

A Question 2: Income Statement and Balance Sheet Forecast

Part 1

1) We would like to forecast the balance sheet of a company. Unfortunately, the different fields of a balance sheet are not independent. Hence we have to construct a model that respects these identities. For a short introduction to the problem, please consider the papers Velez-Pareja(09) and Velez-Pareja(10). For a much more detailed exposition of the problem, please consult Shahnazarian(04) and the textbook "Financial Forecasting, Analysis and Modelling" by Samonas, as well as other standard accounting textbooks.

2) Construct a very simple model of the balance sheet based on the tools of Velez-Pareja(09) and Velez-Pareja(10). Please write down the mathematical equations governing the evolution of the fields of balance sheet. Is it possible to model this problem as a time series? How do we handle the accounting identities?

3) Implement the model in TensorFlow and Python.

4) You can get income statement and balance sheet data from Yahoo Finance. This blog post may help you: `https://rfachrizal.medium.com/how-to-obtain-financial-statements-from-s`

5) Choose some companies to apply your model to. How are you going to train your model? How can you test if your model is good at forecasting the balance sheet of the company? How can you ensure that your forecast at least respects the accounting identities and at least satisfies the asset = liability + equity identity as other relationships stated in the papers quoted here?

6) Can you use your model to forecast earnings?

7) What are the ML techniques we can use to make your model better?

8) Hint: simulation is highly related to prediction. Suppose that you can simulate $y(t+1)$ given $y(t)$. The prediction problem is very simple to implement numerically. A general form of the model can be written as $y(t+1) = f(x(t), y(t)) + n(t)$, where $n(t)$ is some noise term to be specified, and $x(t)$ are additional sets of variables that are relevant for the simulation. What should $x(t)$ be?

Part 2

a) Choose your favourite LLM to apply the problem of financial statement analysis.

b) Let's try the task of balance sheet forecast using the same set of data as collected in part 1, does the LLM you picked perform better or worse than your model?

c) Is it possible to combine your model in part 1 and LLM to create an ensemble model that performs better than the individual model in balance sheet forecast?

d) Given the results of your analysis, pick a company you have analysed, what would you recommend to the CFO or CEO of this particular company given your results?

B Full Model

Table 2 Nominal increase

$$\text{Selling}_t = (1 + \text{Inflation rate}_t)(1 + \text{Real increase in selling price}_t) - 1 \tag{.1}$$

$$\text{Purchasing}_t = (1 + \text{Inflation rate}_t)(1 + \text{Real increase in purchase price}_t) - 1 \tag{.2}$$

$$\text{Overhead expenses}_t = (1 + \text{Inflation rate}_t)(1 + \text{Real increase in overhead expenses}_t) - 1 \tag{.3}$$

$$\text{Payroll expenses}_t = (1 + \text{Inflation rate}_t)(1 + \text{Real increase in payroll expenses}_t) - 1 \tag{.4}$$

$$\begin{cases} \text{Minimum cash required}_0 = \text{Minimum cash required for initial year} & t = 0 \\ \text{Minimum cash required}_t = \text{\% of sales as cash} \times \text{Total sales}_t & t \geq 1 \end{cases} \tag{.5}$$

Table 3 Forecasting volume, prices and sales revenues

$$\text{Increase factor in volume}_t = 1 + \text{Increase in sales volume (units)}_t,\ t \geq 1 \tag{.6}$$

$$\begin{cases} \text{Sales in units}_0 = b_0 \times \text{Price}^b & t = 0 \\ \text{Sales in units}_t = \text{Sales in units}_{t-1} \times \text{Increase factor in volume}_t & t \geq 1 \end{cases} \quad (.7)$$

$$\begin{cases} \text{Selling price}_0 = \text{selling price} & t = 0 \\ \text{Selling price}_t = \text{Selling price}_{t-1} \times (1 + \text{selling}_t) & t \geq 1 \end{cases} \quad (.8)$$

$$\text{Total sales}_t = \text{Selling price}_t \times \text{sales in units}_t,\ t \geq 1 \quad (.9)$$

Table 4 Forecasting Risk free rate and cost of debt and investment return

$$\text{Risk free rate, } R_{f,t} = (1 + \text{inflation rate}_t)(1 + \text{Real interest rate}_t) - 1 \quad (.10)$$

$$\text{Return on ST investment}_t = \text{Risk free rate, } R_{f,t} + \text{Risk premium for return on ST investment}_t \quad (.11)$$

$$\text{Cost of debt, } K_{d,t} = \text{Risk free rate, } R_{f,t} + \text{Risk premium for cost of debt}_t \quad (.12)$$

Table 5 Depreciation schedule and investment in fixed assets

$$\begin{cases} \text{Beginning Net fixed assets}_0 = 0 \\ \text{Beginning Net fixed assets}_t = \text{Beginning Net fixed assets}_{t-1} + \text{New fixed assets}_{t-1} - \text{Annual deprecia} \end{cases} \quad (.13)$$

$$\begin{cases} \text{Annual depreciation for investment in year } 0_1 = \dfrac{\text{New fixed assets}_0}{\text{Lineal depreciation (4 years)}} & t = \\ \text{Annual depreciation for investment in year } 0_t = \text{Annual depreciation for investment in year } 0_1 & t = \end{cases} \quad (.14)$$

$$\begin{cases} \text{Annual depreciation for investment in year } 1_2 = \dfrac{\text{New fixed assets}_1}{\text{Lineal depreciation (4 years)}} & t = 2 \\ \text{Annual depreciation for investment in year } 1_t = \text{Annual depreciation for investment in year } 1_2 & t = 3 \end{cases} \tag{.15}$$

$$\begin{cases} \text{Annual depreciation for investment in year } 2_3 = \dfrac{\text{New fixed assets}_2}{\text{Lineal depreciation (4 years)}} & t = 3 \\ \text{Annual depreciation for investment in year } 2_t = \text{Annual depreciation for investment in year } 2_3 & t = 4 \end{cases} \tag{.16}$$

$$\text{Annual depreciation for investment in year } 3_4 = \frac{\text{New fixed assets}_3}{\text{Lineal depreciation (4 years)}} \tag{.17}$$

$$\begin{cases} \text{Annual depreciation}_0 = 0 & t = 0 \\ \text{Annual depreciation}_t = \sum_{k=\max(0,t-4)}^{t-1} \text{Annual depreciation for investment in year } k_t & t \geq 1 \end{cases} \tag{.18}$$

$$\text{Cumulated depreciation}_t = \text{Cumulated depreciation}_{t-1} + \text{Annual depreciation}_{t+1} \tag{.19}$$

(not available for the last period)

$$\begin{cases} \text{Investment to keep fixed assets constant}_{-1} = \text{Fixed assets}_0 & t = 0 \\ \text{Investment to keep fixed assets constant}_t = \text{Annual depreciation}_{t+1} & t \geq 1 \end{cases} \tag{.20}$$

(up to second last period)

$$\text{Investment in fixed assets for growth}_t = \text{Net fixed assets}_{t-1} \times \text{Increase in sales volume (units)}_{t+1} \tag{.21}$$

$$\text{New fixed assets}_t = \text{Investment in fixed assets for growth}_t + \text{Investment to keep fixed assets constant}_{t-1} \tag{.22}$$

$$\text{Net fixed assets}_t = \text{Beginning Net fixed assets}_t + \text{New fixed assets}_t - \text{Annual depreciation}_t \tag{.23}$$

Table 6a Inventory and purchases in units

$$\text{Units sold}_t = \text{Sales in units}_t \tag{.24}$$

$$\begin{cases} \text{Final inv.}_0 = \text{Initial investing (units)}_0 & t = 0 \\ \text{Final inv.}_t = \text{Units sold}_t \times \text{Inventory as \% of volume in units sold}_t & t \geq 1 \end{cases} \tag{.25}$$

$$\text{In. inv.}_t = \text{Final inv.}_{t-1} \tag{.26}$$

$$\text{Purchases}_t = \text{Units sold}_t + \text{Final inv.}_t - \text{In. inv.}_t \tag{.27}$$

Table 6b Inventory valuation and cost of goods sold in dollars

$$\begin{cases} \text{Unit cost}_0 = \text{Initial purchase price}_0 & t = 0 \\ \text{Unit cost}_t = \text{Unit cost}_{t-1} \times (1 + \text{Purchasing}_t) & t \geq 1 \end{cases} \tag{.28}$$

$$\text{In. inv.}_t = \text{Final inv.}_{t-1} \tag{.29}$$

$$\text{Purchases}_t = \text{Purchases}_t \times \text{unit cost}_t \quad \text{(purchase on RHS is unit)} \tag{.30}$$

$$\text{Final inv.}_t = \text{Unit cost}_t \times \text{Final inv.}_t \tag{.31}$$

$$\text{COGS}_t = \text{In. inv.}_t + \text{Purchases}_t - \text{Final inv.}_t \tag{.32}$$

Table 7 Administrative and selling A&S expenses

$$\text{Sales commissions}_t = \text{Total sales}_t \times \text{Selling commissions}_{t-1} \tag{.33}$$

$$\begin{cases} \text{Overhead expenses}_0 = \text{Estimated overhead expenses}_0 & t = 0 \\ \text{Overhead expenses}_t = \text{Overhead expenses}_{t-1} \times (1 + \text{Overhead expenses}_t) & t \geq 1 \end{cases} \tag{.34}$$

$$\begin{cases} \text{Payroll expenses}_0 = \text{Administrative and sales payroll} & t = 0 \\ \text{Payroll expenses}_t = \text{Payroll expenses}_{t-1} \times (1 + \text{Payroll expenses}_t) & t \geq 1 \end{cases} \tag{.35}$$

$$\text{Advertising expenses}_t = \text{Total sales}_t \times \text{Promotion and advertising as a fraction of sales} \tag{.36}$$

$$\text{A \& S expenses}_t = \text{Sales commissions}_t + \text{Overhead expenses}_t + \text{Payroll expenses}_t + \text{Advertising expenses}_t \tag{.37}$$

Table 8a Sales and purchases disaggregated according to the timing of flows

$$\text{Total sales revenues}_t = \text{Total sales}_t \tag{.38}$$

$$\text{Inflow from current year}_t = \text{Total sales}_t \times (1 - \text{Account receivable as \% of sales} - \text{advanced payment fro}$$

(.39)

$$\text{Credit sales}_t = \text{Total sales revenues}_t \times \text{Account receivable as \% of sales} \qquad (.40)$$

$$\text{Payment in advance}_t = \text{Total sales revenues}_t \times \text{advanced payment from customers as \% of next year sale}$$

(.41)

$$\text{Total purchases}_t = \text{Purchases}_t \qquad (.42)$$

$$\begin{cases} \text{Purchases paid the same year}_0 = \text{Total purchases}_0 \\ \text{Purchases paid the same year}_t = \text{Total purchases} \times (1 - \text{Accounts payable as \% of purchases} - \text{Adva} \end{cases}$$

(.43)

$$\begin{cases} \text{Purchases on credit}_0 = \text{Purchases}_0 - \text{Purchases paid the same year}_0 & t = 0 \\ \text{Purchases on credit}_t = \text{Total purchases}_t \times \text{Account payable as \% of purchases} & t \geq 1 \end{cases} \qquad (.44)$$

$$\text{Payment in advance}_t = \text{Total purchases}_t \times \text{Advance payments to suppliers as a \% of next year purchases}$$

(.45)

Table 8b Flows from sales and purchases

$$\text{Sales revenues from current year}_t = \text{Inflow from current year}_t \qquad (.46)$$

$$\text{Account Receivable}_t = \text{Credit sales}_{t-1} \tag{.47}$$

$$\text{Advance payments}_t = \text{Payment in advance}_{t+1} \tag{.48}$$

$$\text{Total inflows}_t = \text{Account Receivable}_t + \text{Sales revenue from current year}_t + \text{Advance payments}_t \tag{.49}$$

$$\text{Purchases paid the current year}_t = \text{Purchases paid the same year}_t \tag{.50}$$

$$\text{Payment of Accounts Payable}_t = \text{Purchases on credit}_{t-1} \tag{.51}$$

Table 9a Cash budget module 1 operating activities

$$\text{Inflows from sales}_t = \text{Total inflows}_t \tag{.52}$$

$$\text{Total inflows}_t = \text{Inflows from sales}_t \tag{.53}$$

$$\text{Payments for purchases}_t = \text{Total outflows}_t \tag{.54}$$

$$\text{Administrative and Selling expenses}_t = \text{A\&S expenses}_t \tag{.55}$$

$$\text{Income taxes}_t = \text{Income Taxes}_t \tag{.56}$$

(RHS from table 12)

$$\text{Total cash outflows}_t = \text{Payments for purchases}_t + \text{Administrative and selling expenses}_t + \text{Income Taxes}_t \quad (.57)$$

$$\text{Operating NCB}_t = \text{Total inflows}_t - \text{Total cash outflows}_t \quad (.58)$$

net cash balance NCB

Table 9b Cash budget module 2 investing activities

$$\text{Investment in fixed assets}_t = \text{New fixed assets}_t \quad (.59)$$

$$\text{NCB of investment in assets}_t = -\text{Investment in fixed assets}_t \quad (.60)$$

$$\text{NCB after Capex}_t = \text{NCB of investment in assets}_t + \text{operating NCB}_t \quad (.61)$$

Table 9c Cash budget module 3 external financing

$$\text{ST Loan}_t = \begin{cases} 0 \\ -\big(\text{cumulated NCB}_{t-1} + \text{Operating NCB}_t - \text{Total ST loan payment}_t - \text{Minimum cash req} \end{cases} \quad (.62)$$

$$\text{LT Loan}_t = \begin{cases} 0 \\ -\big(\text{cumulated NCB}_{t-1} + \text{NCB after Capex}_t + \text{ST Loan}_t - \text{Total loan payment}_t - \text{Payments} \end{cases} \quad (.63)$$

$$\text{Principal ST Loan}_t = \text{ST loan}_{t-1} \quad (.64)$$

$$\text{Interest ST loan}_t = \text{IP}_t \quad (.65)$$

(from Table 11a)

$$\text{Total ST loan payment}_t = \text{Interest ST loan}_t + \text{Principal ST loan}_t \tag{.66}$$

$$\text{Principal LT loan}_t = \text{Total PP LT}_t \quad \text{(from Table 11b)} \tag{.67}$$

$$\text{Interest LT loan}_t = \text{Total Interest}_t \quad \text{(from Table 11b)} \tag{.68}$$

$$\text{Total loan payment}_t = \text{Total ST loan payment}_t + \text{Principal LT loan}_t + \text{Interest LT loan}_t \tag{.69}$$

$$\text{NCB of financing activities}_t = \text{ST loan}_t + \text{LT loan}_t - \text{Total loan payment}_t \tag{.70}$$

Table 9d Cash budget module 4 transactions with owners

$$IE_t = \frac{LT \text{ loan}_t}{\text{\% of financing with debt, the rest is financed by equity}} \times (1 - \text{\% of financing with debt, the rest is} \tag{.71}$$

$$Div_t = \text{Next year dividends}_{t-1} \tag{.72}$$

$$RS_t = \text{Annual depreciation}_t \times \text{Stock Repurchases as a \% of depreciation}_t \tag{.73}$$

$$\text{Payments to owners}_t = Div_t + RS_t \tag{.74}$$

$$\text{NCB with owners}_t = IE_t - \text{Payments to owners}_t \tag{.75}$$

$$\text{NCB of previous modules}_t = \text{NCB with owners}_t + \text{NCB of financing activities}_t + \text{NCB after Capex}_t \quad (.76)$$

Table 9e Cash budget module 5 discretionary transactions

$$\text{Redemption of ST investments}_t = \text{ST Investments}_t \quad (.77)$$

$$\text{Return from ST Investments}_t = \text{Return on ST Investments}_t \times \text{Redemption of ST Investments}_t \quad (.78)$$

$$\text{Total inflow from ST Investments}_t = \text{Return from ST Investments}_t + \text{Redemption of ST Investments}_t \quad (.79)$$

$$\text{ST Investments}_t = \begin{cases} 0 \\ \text{Cumulatively NCB}_{t-1} + \text{NCB of previous modules}_t + \text{Total inflow from ST Investm} \end{cases} \quad (.80)$$

$$\text{NCB of discretionary transactions}_t = \text{Total inflow from ST Investments}_t - \text{ST Investments}_t \quad (.81)$$

$$\text{Year NCB}_t = \text{NCB at previous modules}_t + \text{NCB of discretionary transactions}_t \quad (.82)$$

$$\text{Cumulated NCB} = \text{Minimum required cash}_{t-1} \quad (.83)$$

Table 10 Checking the cumulated NCB and the minimum cash target

$$\begin{cases} \text{Calculated Cumulated NCB}_0 = \text{Year NCB}_0 \\ \text{Calculated Cumulated NCB}_t = \text{Calculated Cumulated NCB}_{t-1} + \text{Year NCB}_t \quad t \geq 1 \end{cases} \tag{.84}$$

$$\text{Check with MCT} = \text{Calculated Cumulated NCB}_t - \text{Minimum cash require}_t \tag{.85}$$

Table 11a Short-term loan schedules

$$\text{BB}_t = \text{EB}_{t-1} \tag{.86}$$

$$\text{IP}_t = \text{EB}_{t-1} \times \text{Kd}_t \tag{.87}$$

$$\text{PP}_t = \frac{\text{EB}_{t-1}}{\text{Short-term loan 2 (1 year)}} \tag{.88}$$

$$\begin{cases} \text{EB}_0 = \text{ST loan}_0 \\ \text{EB}_t = \text{EB}_{t-1} - \text{PP}_t + \text{ST loan}_t \quad t \geq 1 \end{cases} \tag{.89}$$

$$\text{Kd}_t = \text{Cost of debt, Kd}_t \tag{.90}$$

Table 11b Long-term loan schedules

$$\text{BB LT debt}_t = \text{EB LT debt}_{t-1} \tag{.91}$$

$$\text{LT loan yr 0} = \text{LT loan}_0 \tag{.92}$$

$$\begin{cases} \text{PP loan yr } 0_1 = \dfrac{\text{LT loan yr 0}}{\text{Long-term (LT) years Loan 3 (M years)}} & t = 1 \\ \text{PP loan yr } 0_t = \text{PP loan yr } 0_1 & t \geq 2 \end{cases} \tag{.93}$$

$$\text{New loan yr 1} = \text{LT loan}_1 \tag{.94}$$

$$\begin{cases} \text{PP loan yr } 1_2 = \dfrac{\text{New loan yr 1}}{\text{Long-term (LT) years Loan 3 (M years)}} & t = 2 \\ \text{PP loan yr } 1_t = \text{PP loan yr } 1_2 & t \geq 3 \end{cases} \tag{.95}$$

$$\text{New loan yr 2} = \text{LT loan}_2 \tag{.96}$$

$$\begin{cases} \text{PP loan yr } 2_3 = \dfrac{\text{New loan yr 2}}{\text{Long-term (LT) years Loan 3 (M years)}} & t = 3 \\ \text{PP loan yr } 2_t = \text{PP loan yr } 2_3 & t \geq 4 \end{cases} \tag{.97}$$

$$\text{New loan yr 3} = \text{LT loan}_3 \tag{.98}$$

$$\begin{cases} \text{PP loan yr } 3_4 = \dfrac{\text{New loan yr 3}}{\text{Long-term (LT) years Loan 3 (M years)}} & t = 4 \\ \text{PP loan yr } 3_t = \text{PP loan yr } 3_4 & t \geq 5 \end{cases} \tag{.99}$$

$$\text{New loan yr 4} = \text{LT loan}_4 \tag{.100}$$

$$\text{Total Interest}_t = \text{EB LT debt}_{t-1} \times \text{Kd}_t \quad t \geq 1 \tag{.101}$$

$$\text{New debt LT}_t = \text{New loan yr t} \tag{.102}$$

$$\text{Total PP LT}_t = \sum_{k=0}^{t} \text{PP loan year k} \tag{.103}$$

$$\text{EB LT debt}_t = \text{BB LT debt}_t + \text{New debt LT}_t - \text{Total PP LT}_t \tag{.104}$$

Table 12 Income Statement

$$\text{Sales revenues}_t = \text{Total sales}_t \tag{.105}$$

$$\text{COGS}_t = \text{COGS}_t \tag{.106}$$

RHS from Table 6b

$$\text{Gross Income}_t = \text{Sales revenues}_t - \text{COGS}_t \tag{.107}$$

$$\text{A\&S expenses}_t = \text{A\&S expenses}_t \tag{.108}$$

RHS from Table 7

$$\text{Depreciation}_t = \text{Annual depreciation}_t \tag{.109}$$

$$\text{EBIT}_t = \text{Gross Income}_t - \text{A\&S expenses}_t - \text{Depreciation}_t \tag{.110}$$

$$\text{Interest payments}_t = \text{Total interest}_{t+\text{IP}_t} \tag{.111}$$

$$\text{Return from ST investment}_t = \text{Return from ST investments}_t \tag{.112}$$

RHS from Table 9e

$$\text{EBT}_t = \text{EBIT}_t + \text{Return from ST investment}_t - \text{Interest payments}_t \tag{.113}$$

$$\text{Income Taxes}_t = \begin{cases} 0 & \text{EBT}_t \leq 0 \\ \text{EBT}_t \times \text{Corporate tax rate} & \text{otherwise} \end{cases} \tag{.114}$$

$$\text{Net Income}_t = \text{EBT}_t - \text{Income Taxes}_t \tag{.115}$$

$$\text{Next year Dividends}_t = \text{Net Income}_t \times \text{Payout ratio} \tag{.116}$$

$$\text{CRE}_t = \text{CRE}_{t-1} + \text{Net Income}_{t-1} + \text{Next year Dividends}_{t-1} \tag{.117}$$

Table 13 The Balance Sheet

$$\text{Cash CB}_t = \text{Cumulated NCB}_t \tag{.118}$$

$$\text{AR IT}_t = \text{Credit sales}_t \tag{.119}$$

$$\text{Inventory IT}_t = \text{Final inv.}_t \tag{.120}$$

$$\text{APP}_t = \text{Advance payment to suppliers}_t \tag{.121}$$

$$\text{ST investment CB}_t = \text{ST investments.}_t \tag{.122}$$

$$\text{Current assets}_t = \text{Cash CB}_t + \text{AR IT}_t + \text{Inventory IT}_t + \text{APP}_t + \text{ST investment CB}_t \tag{.123}$$

$$\text{Net fixed assets IT}_t = \text{Net fixed assets}_t \tag{.124}$$

$$\text{Total}_t = \text{Net fixed assets IT}_t + \text{Current assets}_t \tag{.125}$$

$$\text{AP IT}_t = \text{Purchases on credit}_t \tag{.126}$$

$$\text{APR}_t = \text{Advance payments}_t \tag{.127}$$

$$\text{Short-term debt CB}_t = \text{EB}_t \tag{.128}$$

$$\text{Current liabilities}_t = \text{AP IT}_t + \text{APR}_t + \text{Short-term debt CB}_t \tag{.129}$$

$$\text{Long-term debt CB}_t = \text{EB LT debt}_t \tag{.130}$$

$$\text{Total Liabilities}_t = \text{Long-term debt CB}_t + \text{Current liabilities}_t \tag{.131}$$

$$\text{Equity investment CB}_t = \text{Equity investment CB}_{t-1} + \text{IE}_t \tag{.132}$$

$$\text{Retained earnings IS}_t = \text{CRE}_t \tag{.133}$$

$$\text{Current year NI}_t = \text{Net Income}_t \tag{.134}$$

$$\text{Repurchase of equity}_t = \text{Repurchase of equity}_{t-1} - \text{RS}_t \tag{.135}$$

$$\text{Liabilities and equity}_t = \text{Equity investment CB}_t + \text{Retained earnings IS}_t + \text{Current year NI}_t + \text{Repurchase} \tag{.136}$$

$$\text{Check}_t = \text{Liabilities and equity}_t - \text{Total}_t \tag{.137}$$