Article

The *Split-Screen* Approach for Project Appraisal (Part II: Spreadsheet Modeling)

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Abstract: This paper employs the newly conceived accounting-and-finance engineering system (AFES) described in a previous paper (Magni 2023, "The Split-Screen Approach for Project Appraisal (Part I: The Theory)"), addressed to the analysis of capital asset investments. In this second part, we show how to implement this theoretical framework onto a spreadsheet software. We guide the analyst step by step, cell by cell, to the creation of the Split-Screen Matrices describing the project film. Because the AFES is based on two arithmetic relations (law of motion and law of conservation), we can use a minimal approach to modeling, with a frugal use of the most common spreadsheet functions (essentially INDEX and MATCH) and no use of the traditional financial functions, yet fulfilling the requisite of clearness, transparency, consistency, and ease of use. Starting from the informal description of the project, we build the model by breaking it down to 7 modules. The spreadsheet model is available online (see link provided in the paper).

Keywords: capital budgeting; engineering economics; project; accounting-and-finance engineering system; spreadsheet modeling; financial model

Introduction

This paper is the second, applicative part of a work addressed to illustrate the accounting-and-finance engineering system (AFES) for project appraisal, developed in Magni (2023). The latter describes the theory underlying the AFES for project appraisal.[1] The AFES is grounded on two principles. First, the Balance Sheet (BS), Income Statement (IS), and Cash Flow Statement (CFS) show, respectively, the capital invested, the income generated, and the cash flow extracted, which are dynamically interconnected by the law of motion $C_t = C_{t-1} + I_t - F_t$; where C, I, and F denote, capital, income, and cash flow, respectively. Second, the BS, IS, and CFS satisfy a law of conservation, according to which the capital in one period must be equal to the financial obligations of the firm towards some capital providers (equityholders and debtholders); the income generated by the investments is equal to the income accrued to the capital providers; the cash flow extracted from (or injected into) some assets is equal to the cash flow distributed to (or raised from) the capital providers. Blending these two laws, the BS, IS, and CFS may be graphically interlinked by a Split-Screen Matrix (SSM) as in Table 1.

Table 1. The Split-Screen Matrix (SSM).

+ BALANCE SHEET$_t$	+ BALANCE SHEET$_{t-1}$	+ INCOME STATEMENT$_t$	+ CASH FLOW STATEMENT$_t$
+ Net Operating Assets$_t$	+ Net Operating Assets$_{t-1}$	+ Operating income$_t$	− Cash flow from operations$_t$
+ Liquid Assets$_t$	+ Liquid Assets$_{t-1}$	+ Interest income$_t$	− Cash flow from liquid assets$_t$
+ Debt$_t$	+ Debt$_{t-1}$	+ Interest expense$_t$	− Cash flow to debt$_t$
+ Equity$_t$	+ Equity$_{t-1}$	+ Net income$_t$	− Cash flow to equity$_t$

where the red (horizontal and vertical) bars represent equality (see Magni 2023). This tabular format enables reading the three financial statements jointly, both horizontally and vertically. Reading it horizontally (dynamic dimension), each component of the BS as of time t is obtained from the same component of the BS as of time $t − 1$ by adding the corresponding component of the IS and subtracting the corresponding component of the CFS (e.g., net operating assets at time t are equal to net operating asset at time $t − 1$ plus the operating income less the cash flow from operations). Reading it vertically (static dimension), the investment components equate the financing components for each financial statement: assets equate financings (BS), income from investments equates income to capital providers (IS), cash flow from investments equates cash flow to capital providers (CFS) (e.g., the sum of operating income and interest income is equal to the interest expense and the net income). The tabular format may be enriched by decomposing each one of the four areas in its constituent assets. For example, breaking down the net operating assets, the SSM is expanded as in Table 2.

Table 2. The Full-Scale Split-Screen Matrix.

+ BALANCE SHEET$_t$	+ BALANCE SHEET$_{t-1}$	+ INCOME STATEMENT$_t$	+ CASH FLOW STATEMENT$_t$
+ Accounts receivable$_t$	+ Accounts receivable$_{t-1}$	+ Sales$_t$	− Cash receipts from customers$_t$
+ Inventory$_t$	+ Inventory$_{t-1}$	+ ΔInventory$_t$	− 0
− Accounts payable$_t$	− Accounts payable$_{t-1}$	− Cost of purchases$_t$	+ Payments to suppliers$_t$
− Salaries and wages$_t$	− Salaries and wages$_{t-1}$	− Labor cost$_t$	+ Payments to employees$_t$
+ Net fixed assets$_t$	+ Net fixed assets$_{t-1}$	− Depreciation$_t$	+ Net asset disposals$_t$
− Taxes payable$_t$	− Taxes payable$_{t-1}$	− Taxes$_t$	+ Payments for income taxes$_t$
+ Liquid Assets$_t$	+Liquid Assets$_{t-1}$	+ Interest income$_t$	− Cash flow from liquid assets$_t$
+ Debt$_t$	+ Debt$_{t-1}$	+ Interest expense$_t$	− Cash flow to debt$_t$
+ Equity$_t$	+ Equity$_{t-1}$	+ Net income$_t$	− Cash flow to equity$_t$

The first six rows represent the net operating assets (i.e., operating assets less operating liabilities). Given an n-year project project, there exists a sequence of n such SSMs, which give rise to a strip of SSMs. This strip must be built by the modelers on the basis of the assumptions on the input parameters.

As shown in Part I, this very framework may be used for financial evaluation as well. To this end, one builds the strip of SSMs related to the benchmark portfolio. Opposing the two strips (the project's and benchmark portfolio's), the relevant financial metrics are directly computed: economic residual income, net present value, and project's rate of return.

This approach is highly innovative and, while consistent with the traditional capital budgeting theory described in the traditional finance and engineering texts (e.g., Hartman 2007; Newnan et al. 2009; Brealey et al. 2011; Ross et al. 2019; Berk and DeMarzo 2019; Park 2019), it integrates the static and dynamic dimension of a project overturning the traditional models from three main points of view:

- the creation of isolated pro forma financial statements derived from the model's assumptions is replaced by the so-called Split-Screen Matrix (SSM) and split-screen film (displayed in different formats);
- the new notion of cash flow from (or to) liquid assets is employed (in addition to the classical operating cash flow, cash flow to debt, and cash flow to equity);

- the role of the payout and financing decisions is made explicit;
- the project's economic profitability, usually based on cash flows and measured by net present value and internal rate of return, is replaced by a set of new, reciprocally consistent measures, which provide deeper information about the project's economic profitability; and
- the model is designed to act as a diagnostic tool for spotting internal inconsistencies.

These features make the AFES radically different from the approaches to project appraisal currently available in applied corporate finance or engineering economics. For this reason, the new approach requires that the association among accounting and financial magnitudes are remodeled; in other words, the AFES asks for a different-from-usual spreadsheet modeling. This paper aims at filling this gap. We provide a complete translation of the theory into spreadsheet modeling for practical applications and offer a detailed step-by-step guide to the AFES construction in spreadsheets, aiming at helping practitioners to employ it in real-life applications. Using a mockup project and following Part I's concepts, notions, formalizations, and algebraic relationships, we build the whole spreadsheet model for the project, starting from the verbal description of it and explaining it in full, cell by cell.[2]

Several organizations propose guidelines in financial modeling with spreadsheets (especially with Microsoft Excel). Two of the most popular guidelines are the *FAST Standard* (FAST Standard Organization 2022), a set of rules on the building spreadsheet-based financial models, developed by a non-profit organization, and *SSRB Best Practice Spreadsheet Modeling Standards* (Spreadsheet Standards Review Board 2016). These standards contain some similar principles and rules, which we have implemented in the methodology used in our workbook (described in this paper); in particular, we use separate worksheets for inputs, calculations, and outputs, avoid circular references and use concise and simple formula. The result is a spreadsheet model that fulfils the requisite for clear and concise communication and transparency. Indeed, using the rigorous-yet-simple structure of the AFES and implementing the worksheet according to the best practices, we establish a "spreadsheet engineering" discipline that, put it in Thorne's (2009) words, mitigates the problem of spreadsheet errors. Several criteria for spreadsheet accuracy are also applied (some suggestions are, for example, in Powell et al. 2008) and, more specifically, the AFES articulation is based on the law of motion and law of conservation, which enables the analyst to spot modeling errors (e.g., if numbers in rows and columns do not match according to the law of motion and law of conservation, there is some inconsistencies in the calculation). This zeroes out possible internal inconsistencies.

Traditional financial modeling is based on a vast number of functions (see Avon 2021, Ch. 11 for a list of the most used ones; see also Benninga 2014, Benninga and Mofkadi 2018). Owing to the AFES design, we propose a more frugal and user-friendly model, based as it is on very few spreadsheet functions, which are most common tools for modelers. Specifically, we use only four functions: the numeric function SUM(. . .), the reference functions INDEX(. . .) and MATCH(. . .), and the logical function IF(. . .); these functions are available in most spreadsheets (with small syntactic differences). We will also use the text string operator &[3] (and, last but not least, the analyst will not need any of the usual financial functions).

We accompany this paper with its associated Microsoft Excel file, which is available at the following link: https://morespace.economia.unimore.it/carloalbertomagni/spreadsheet-modeling (accessed 18 February 2023). The spreadsheet file, according to best practices described in handbooks (e.g., Swan 2016) and in standard guidelines, has a structure based on separated sheets for inputs and assumptions (inputs), calculations (working sheets), and presentation of the results (outputs).

The analyst must be equipped with a spreadsheet software such as Microsoft Excel, Apple Numbers, Google Sheets, LibreOffice, OpenOffice Calc, or equivalents (tools that any financial analyst knows and daily employs in its work).

To present the model, we assume the role of a financial analyst who oversees the economic analysis of a given capital asset investment. We follow the entire process of the

analyst, starting from the collection of the pieces of information from the various experts (CFO, CEO, CTO, etc.).

The analyst makes explicit all the assumptions obtained from interviews to the firm's experts (CEO, CFO, CTO, marketing experts, etc.). For illustrative purposes, we model the project in Box 1, which has been inspired by an example presented in Magni (2020, Example 4.1).

Box 1. Description of CAD Inc. project.

CAD Inc. project

CAD Inc. faces the opportunity of undertaking a five-year project consisting in the production of a manufactured good. The initial investment in fixed assets is equal to USD 20,000, to be fully paid in year 0. The investment in fixed assets is depreciated with straight-line depreciation.

The sales projection for the first period (year 1) is 6,000 units of product and the sales growth is equal to 10% yearly. The sale price of each unit of the product is USD 10 for each year.

The unit manufacturing costs incurred are

- material used for production: USD 2.5,
- direct and indirect labor: USD 4.

The production department requires that materials inventory at the end of each period should be 25% of the consumption estimated for the next period.

Selling, General & Administrative Expenses (SGA) are composed of

- purchases of non-manufacturing materials, estimated at 15% of sales
- incremental salaries for non-manufacturing activities, estimated at USD 6,000 each year.

Finished goods inventory will be zero (i.e., production will equal sales).

The average number of days to fully collect the payment after a sale is 90. All the purchases of materials (both manufacturing and non-manufacturing) will be cashed out in the year after the one in which they are incurred (except for the last period, when they will be cashed out in that year); salaries and wages will be paid monthly.

The tax rate is $\tau = 30\%$ and taxes are paid within the year in which they are incurred.

The capital expenditure of USD 20,000 in $t = 0$ is sustained by

(i) an equity injection of USD 6,000,

(ii) a loan of USD 10,000 at an interest rate of $i^d = 2.00\%$; the loan is reimbursed with 4 principal repayments of equal amount,

(iii) a withdrawal from liquid assets for the residual amount of USD 4,000.

The interest rate i^l on liquid asset is forecasted to be 3.80%.

CAD Inc. will pay out $\alpha = 20\%$ of the net income to its shareholders in each period from 1 to 4.

The required returns on operating assets, on liquid assets, and on debt are respectively:

$r^o = 15.00\%$ (pre-tax WACC),

$r^l = 1.00\%$,

r^d 3.00%.

We describe the development of the project model step by step, the creation of the benchmark obtained from the market input data, and the fabrication of the (absolute and relative) measures of economic profitability, which will lead to an accept or reject decision.

The model is divided into seven modules (see Figure 1 and Table 3):

Module 1: Extracting the data of the project

Module 2: Building the project split-screen strip

Module 3: Building the strips of other matrix representations

Module 4: Building the benchmark split-screen strip

Module 5: Performing the single-period analysis

Module 6: Reshaping the project split-screen strip

Module 7: Assessing value creation and financial efficiency

Starting from the verbal description of the project presented above (see also "Description" worksheet), Module 1 translates it into formal inputs and assumptions ("Assumptions" worksheet) and carries out the preliminary calculations ("PreCalc" worksheet) that are

necessary for Module 2 ("SplitScreenStrip" worksheet). The latter shows how to build the full-scale project film (split-screen strip). It first carves out the accounting magnitudes for period 0. The formulas for filling the cells in period 0 are in turn divided into: (i) cells whose values are provided by the preliminary calculations, (ii) cells whose values are calculated via the law of motion, (iii) cells whose values are calculated with suitable accounting formulas, and (iv) cells whose values are calculated with the law of conservation. Cells of periods 1 through n are obtained by simply dragging the fill handle right. Module 3 starts from the full-scale strip and, in a top-down approach, builds other lower-scale Matrix representations which show different pieces of information and different classification of costs and cash flows, up to the germ strip, which condenses the capital invested in the project, C_t; the project's return, I_t; and the project's cash flow, F_t. Module 4 creates the benchmark split-screen strip ("SplitScreenStrip" worksheet), which is necessary for valuation and decision-making. In Module 5, we build a menu of SSMs for every period ("SinglePeriod" worksheet) which favors a period analysis. Module 6 shows how to pass from the split-screen film to the project Transposed Matrix and benchmark Transposed Matrix ("TransMatrix" worksheet). In the same module, we show how to pass from the project split-screen film to the standard pro forma financial statements ("ConventionalFinStat" worksheet). The object of Module 7 is to measure value creation ("ValueCreation" worksheet); in it, we derive the set of absolute measures (quantifying the economic value created by the project) and relative measures (quantifying the financial efficiency of the project) that are described in Magni (2023). Some conclusions follow, and a legend of symbols and abbreviations used in this paper is located at the end of the paper, for the benefit of the reader.
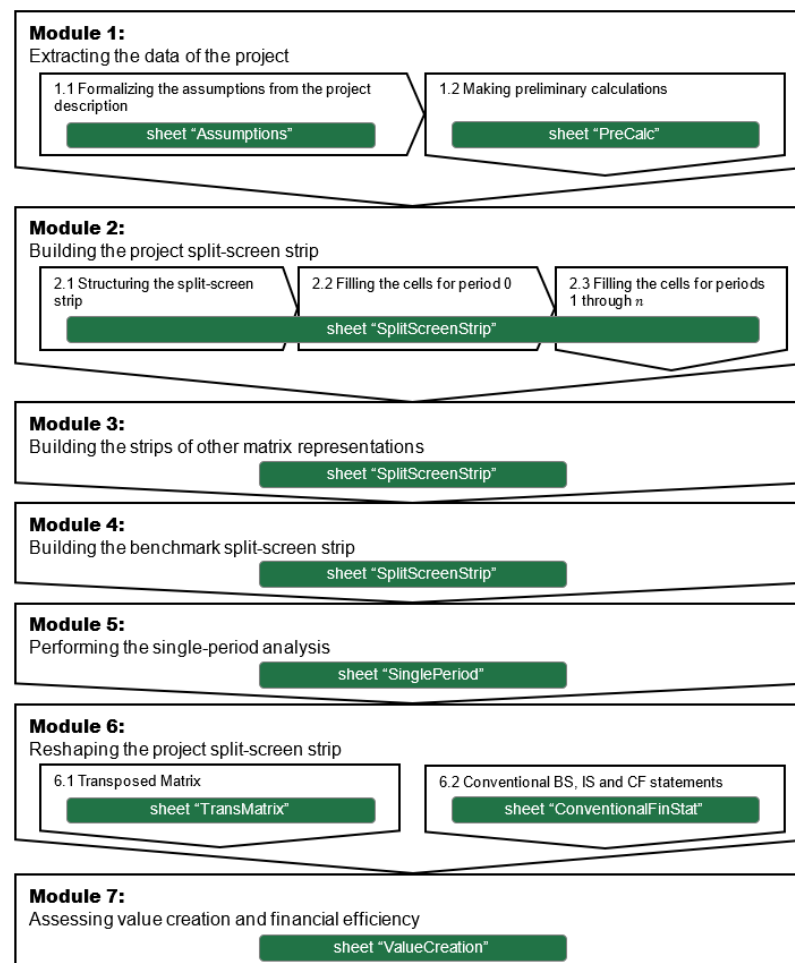
Figure 1. Structure of the paper and of the spreadsheet file.

Table 3. Structure of the paper and of the spreadsheet file.

Module	Worksheet	Section Number	Section Title
1	Assumptions PrelCalc	1	Extracting the data of the project
2	SplitScreenStrip	2	Building the project split-screen strip
3	SplitScreenStrip	3	Building the strips of other matrix representations
4	SplitScreenStrip	4	Building the benchmark split-screen strip
5	SinglePeriod	5	Performing the single-period analysis
6	TransMatrix ConventionalFinStat	6	Reshaping the project split-screen strip
7	Value Creation	7	Assessing value creation and financial efficiency

1. Module 1: Extracting the Data of the Project

1.1. Formalizing the Assumptions from the Project Description

In Module 1, the analyst identifies and formalizes the assumptions and, hence, makes some preliminary calculations, which are necessary for carrying out Module 2. The analyst retrieves all pieces of information regarding the project by the firm's CEO, CFO, CTO, and the marketing experts, and then needs convert them from natural language to figures in order to use them in a financial model that fully describes the project and the relevant relationships. More precisely, the analyst must carve out the figures and the relationships among all the inputs and the resulting accounting and financial magnitudes. As testified by the description above (and explained in detail in Magni 2023),[4] all pieces of information can be classified as capital, income, and cash flow. Furthermore, some of the inputs involve estimation regarding the project (costs, prices, quantities sold, etc.) or the market (required returns on assets, on debt, etc.), some other involve embedded decisions (e.g., the payout policy, the financing policy). The objective of the modeler is to derive, for each magnitude, the capital component, income component, and cash-flow component. Hence, the modeler must derive all the formal links among these basic variables for each area, build the project's SSM for every period, and, therefore, the corresponding split-screen strip.

As a first step of Module 1, the analyst extracts the input variables of the model and the corresponding assumptions from the description conveyed in the natural language. We classify them in project inputs and market inputs:

Project inputs	(verbatim)
Assumption 01	a five-year project
Assumption 02	investment in fixed assets is equal to USD 20,000, to be fully paid in year 0
Assumption 03	the investment in fixed assets is depreciated with straight-line depreciation
Assumption 04	the sales projection for the first period (year 1) is 6,000 units of product
Assumption 05	the sales growth is equal to 10% yearly
Assumption 06	The sale price of each unit of the product is USD 10 for each year
Assumption 07	the unit manufacturing costs incurred are—material used for production: USD 2.5
Assumption 08	the unit manufacturing costs incurred are—direct and indirect labor: USD 4
Assumption 09	the production department requires that materials inventory at the end of each period should be 25% of the consumption estimated for the next period
Assumption 10	purchases of non-manufacturing materials, estimated at 15% of sales
Assumption 11	incremental salaries for non-manufacturing activities, estimated at USD 6,000 each year
Assumption 12	the average number of days to fully collect the payment after a sale is 90
Assumption 13	all the purchases of materials (both manufacturing and non-manufacturing) will be cashed out in the year after the one in which they are incurred (except for the last period, when they will be cashed out in that year)
Assumption 14	salaries and wages will be paid monthly
Assumption 15	the tax rate is $\tau = 30\%$
Assumption 16	taxes are paid within the year in which they are incurred
Assumption 17	the capital expenditure in $t = 0$ is sustained by an equity injection of USD 6,000
Assumption 18	The capital expenditure in $t = 0$ is sustained by a loan of USD 10,000
Assumption 19	at an interest rate of $i^d = 2.00\%$
Assumption 20	the loan is reimbursed with 4 principal repayments of equal amount
Assumption 21	the interest rate i^l on liquid asset is forecasted to be 3.80%

Assumption 22	CAD Inc. will pay out $\alpha = 20\%$ of the net income to its shareholders in each period from 1 to 4 and in the last period it will distribute the total amount of the equity
Market inputs	
Assumption 23	$r^o = 15.00\%$ (pre-tax WACC)
Assumption 24	$r^l = 1.00\%$
Assumption 25	$r^d = 3.00\%$

The project inputs are in turn divided into estimation variables (assumptions 1–11, 13–16, and 19) and decision variables (assumptions 12, 17, 18, 20, and 22).

The assumptions reported above provide the pieces of information needed for populating the SSM.

CODE INSTRUCTIONS: FORMALIZING ASSUMPTIONS

In a spreadsheet program, the analyst creates a workbook and adds a first sheet in it called "Assumptions", where he collects the assumptions. The analyst can fill the cells of the Assumptions table with the figures extracted from the description of the project. Column G contain the inputs, column H (yellow background) contain the assumptions (Figure 2). In this sheet, each input value is contained only in one single cell: this means that every time an input is used in the calculations ("PreCalc" sheet), the formula captures the content of the input cell. Therefore, the analyst can simulate different scenarios by changing only the contents of the Assumptions sheet.

	A	B C D	E	F	G	H	I
2	assumption				**INPUTS**	**assumptions**	**UoM**
5	01			n	Project length	5	y
6	02		**Fixed Assets**	NFA_0	Investment	20,000	$
7	03				Depreciation	straight-line	
8	04		**Sales**	S_0	Sales projection of the first period	6,000	u
9	05				Growth rate (%/year)	10%	% / y
10	06				Unit Price	10	$ / u
11	07		**Manufacturing Costs (COGS)**	COP^m	Unit Cost of Purchases	2.5	$ / u
12	08			LC^m	Unit Cost of Labor	4.0	$ / u
13	09				Raw Materials Inventory (% of next-period consumption)	25%	%
14	10		**NonManufacturing Costs (SGA)**		Cost of purchases (SGA) (% of Sales)	15%	%
15	11			LC^{nm}	Labor costs (SGA)	6,000	$ / y
16	12		**Operating cycle**		DSO (Days Sales Outstanding)	90	dd
17	13				DPO (Days Payable Outstanding)	365	dd
18	14		**Pay period**		Salaries and Wages will be paid	monthly	
19	15		**Taxes**	τ	Tax Rate	30%	%
20	16				Taxes are paid	yearly	
21	17		**Equity financing**	C_0^e	Capital Payment (period 0)	6,000	$
22	18		**Debt financing**	C_0^l	Loan amount	10,000	$
23	19			i^d	Loan Interest Rate	2.00%	%
24	20				Loan reimbursement periods	4	y
25	21		**Liquid Assets**	i^l	Interest rate on liquid assets	3.80%	%
26	22		**Payout policy**	α	Payout ratio (% Net Income)	20%	%
27	23		**Market data**	r^o	pre-tax WACC	15.00%	%
28	24			r^l	required return on liquid assets	1.00%	%
29	25			r^d	required return on debt	3.00%	%

Figure 2. Inputs and Assumptions ("Assumptions" sheet).

1.2. Making Preliminary Calculations

The objective of the analyst is to feed the Full-scale Matrix (Part I, Equation (33), right matrix) and build the whole strip of SSMs (see Part I, Equation (68)). However, to fill in the cells of each Matrix, preliminary calculations are needed, which make explicit, period by period, the figures already implicit in the assumptions.

More precisely, we highlight in yellow the cells in the full-scale matrix whose values may be obtained from the assumptions via some simple calculations (see Figure 3). We

describe these calculations in this section. The remaining (not highlighted) cells contain amounts that will be calculated in Module 2, as we will see, by making use of the law of motion or the law of conservation or specific accounting formulas.

Full-scale Matrix (compact)

C_t	C_{t-1}	I_t	$-F_t$
$+AR_t$	$+AR_{t-1}$	$+S_t$	$-F_t^{ar}$
$+Inv_t$	$+Inv_{t-1}$	$+\Delta Inv_t$	-0
$-AP_t^m$	$-AP_{t-1}^m$	$-COP_t^m$	$+F_t^{ap,m}$
$-AP_t^{nm}$	$-AP_{t-1}^{nm}$	$-COP_t^{nm}$	$+F_t^{ap,nm}$
$-SWP_t^m$	$-SWP_{t-1}^m$	$-LC_t^m$	$+F_t^{swp,m}$
$-SWP_t^{nm}$	$-SWP_{t-1}^{nm}$	$-LC_t^{nm}$	$+F_t^{swp,nm}$
$+NFA_t$	$+NFA_{t-1}$	$-Dep_t$	$-F_t^{nfa}$
$-TP_t$	$-TP_{t-1}$	$-T_t$	$+F_t^{tp}$
$+C_t^l$	$+C_{t-1}^l$	$+I_t^l$	$-F_t^l$
$+C_t^d$	$+C_{t-1}^d$	$+I_t^d$	$-F_t^d$
$+C_t^e$	$+C_{t-1}^e$	$+I_t^e$	$-F_t^e$

Figure 3. Full-scale matrix (compact form. See also Part I, Equation (33), right matrix). The yellow cells contain values that may be obtained from the assumptions via some simple calculations.

FIXED ASSETS. Assumption 02 regarding the NFA provides the following figures:

Period	0	1	2	3	4	5
$-F_t^{nfa}$	20,000	0	0	0	0	0

Assumption 03 enables calculating the (straight-line) depreciation:

$$Dep_t = \frac{NFA_0}{n} = \frac{20,000}{5} = 4000$$

Period	0	1	2	3	4	5
$-Dep_t$	0	–4,000	–4,000	–4,000	–4,000	–4,000

SALES. Assumptions 04, 05, and 06 enable the analyst to calculate the sales for each period:

$$\text{Units sold in } t = (1.1) \cdot \text{Units sold in } t-1$$
$$S_t = \text{Units sold in } t \cdot \text{unit sale price}$$

Units (produced and) sold in the first year = 6,000.
Annual sales growth = 10%.
Unit sale price = USD 10.

Period	0	1	2	3	4	5
Units solid in t	0	6,000	6,600	7,260	7,986	8,785
$+S_t$	0	60,000	66,000	72,600	79,860	87,850

MANUFACTURING COSTS. Assumption 07 enables calculating the material (direct material and overhead) used for production:

$$\text{Material used in } t = \text{units sold in } t \cdot \text{unit cost}$$

Unit cost = USD 2.5

Period	0	1	2	3	4	5
Units sold in t	0	6,000	6,600	7,260	7,986	8,785
−Material used in t	0	−15,000	−16,500	−18,150	−19,965	−21,963

Assumption 09 enables calculating the raw materials inventory:

$$\text{Inv}_t = (\text{Material used in } t+1) \cdot 25\%$$

Period	0	1	2	3	4	5
Material used in t	0	15,000	16,500	18,150	19,965	21,963
$+\text{Inv}_t$	3,750	4,125	4,538	4,991	5,491	0

The Cost of Purchases for the manufacturing activities (COP^m) is the sum of the Material used for the production and the change in the raw materials inventory:[5]

$$COP^m_t = \text{Material used in } t + \Delta\text{Inv}_t$$

Period	0	1	2	3	4	5
−Material used in t	0	−15,000	−16,500	−18,150	−19,965	−21,963
$-\Delta\text{Inv}_t$	−3,750	−375	−413	−454	−499	5,491
$-COP^m_t$	−3,750	−15,375	−16,913	−18,604	−20,464	−16,472

Assumption 08 enables calculating the labor costs for manufacturing activities (LC^m):

$$LC^m = \text{units sold} \cdot \text{unit labor cost}$$

Unit labor cost = USD 4.

Period	0	1	2	3	4	5
Units sold in t	0	6,000	6,600	7,260	7,986	8,785
$-LC^m_t$	0	−24,000	−26,400	−29,040	−31,944	−35,140

NON-MANUFACTURING COSTS (SGA). Assumption 10 enables calculating the cost of purchases for the nonmanufacturing activities.

$$COP^{nm}_t = S_t \cdot 15\%$$

Period	0	1	2	3	4	5
S_t	0	60,000	66,000	72,600	79,860	87,850
$-COP^{nm}_t$	0	−9,000	−9,900	−10,890	−11,979	−13,178

Assumption 11 enables calculating the cost of labor for the nonmanufacturing activities:

Period	0	1	2	3	4	5
$-LC^{nm}_t$	0	−6,000	−6,000	−6,000	−6,000	−6,000

OPERATING CYCLE. The next set of information extracted from the interviews to the various firm's experts provides information about the operating cycle of the project. Assumption 12 enables computing the Account Receivables:

$$AR_t = S_t \cdot \frac{90}{365}$$

Period	0	1	2	3	4	5
$+S_t$	0	60,000	66,000	72,600	79,860	87,850
$+AR_t$	0	14,795	16,274	17,901	19,692	0

Assumption 13 enables calculating the Account Payables:

$$AP_t^m = COP_t^m \text{ and } AP_t^{nm} = COP_t^{nm}$$

Period	0	1	2	3	4	5
$-COP_t^m$	–3,750	–15,375	–16,913	–18,604	–20,464	–16,472
$-AP_t^m$	–3,750	–15,375	–16,913	–18,604	–20,464	0

Period	0	1	2	3	4	5
$-COP_t^{nm}$	0	–9,000	–9,900	–10,890	–11,979	–13,178
$-AP_t^{nm}$	0	–9,000	–9,900	–10,890	–11,979	0

PAYROLL PERIOD. Assumption 14 enables calculating the payments to employees:

$$LC_t^m = F_t^{swp,m} \text{ and } LC_t^{nm} = F_t^{swp,nm}$$

Period	0	1	2	3	4	5
$-LC_t^m$	0	–24,000	–26,400	–29,040	–31,944	–35,140
$+F_t^{swp,m}$	0	24,000	26,400	29,040	31,944	35,140

Period	0	1	2	3	4	5
$-LC_t^{nm}$	0	–6,000	–6,000	–6,000	–6,000	–6,000
$+F_t^{swp,nm}$	0	6,000	6,000	6,000	6,000	6,000

TAXES. Assumption 16 enables calculating the Taxes Payable, which will be 0 in each period:

$$T_t = F_t^{tp} \implies TP_t = 0$$

Period	0	1	2	3	4	5
$-TP_t$	0	0	0	0	0	0

DEBT FINANCING. Assumptions 18 enables calculating the debt's principal repayment and the principal outstanding:

$$\text{principal repayment} = C_{t-1}^d - C_t^d = \frac{C_0^d}{4} = \frac{10,000}{4} = 2500$$

whence

$$C_t^d = C_{t-1}^d - 2500$$

Period	0	1	2	3	4	5
−Principal repayments	0	−2,500	−2,500	−2,500	−2,500	0
$+C_t^d$	10,000	7,500	5,000	2,500	0	0

CODE INSTRUCTIONS: PRELIMINARY CALCULATIONS

The analyst adds, in his workbook, a new sheet, named "PreCalc", where he calculates the figures obtained from the assumptions (see Figure 4).

Figure 4. Examples of preliminary calculations ("PreCalc" sheet).

Each column represents one period, and the rows contain the values taken on by the various variables. Columns A:G contain descriptions regarding the variables; column H contains the constant values (i.e., the values that are independent of the period); column I contains the unit of measurement of the variables; columns K to P contain the amounts of periods 0 through $n = 5$ (last period of the project).

Column G contains the labels that describe the variables. Columns D, E, and F report the variables that are expected to be recorded (with proper sign) in the SSM, classified, respectively, as:

capital (AR, Inv, $-AP^m$, $-AP^{nm}$, $-TP$, C^d),
income (S, $-COP^m$, $-COP^{nm}$, $-LC^m$, $-LC^{nm}$, $-Dep$),
cash flow ($F^{swp,m}$, $F^{swp,nm}$, $-F^{nfa}$).

The amounts in the rows with a label in columns D, E, or F, are the ones that will be linked in the SSM in the next steps.

We use different font colors for the cells that are linked to other cells:

- blue for the rows that are linked to rows in the previous sheet, "Assumptions";
- grey for the rows that are linked to other rows in the same sheet;
- red for the cells that will be used for building the SSM and will be linked to cells in the "SplitScreenStrip" sheet.

2. Module 2: Building the Project Split-Screen Strip

2.1. Structuring the Split-Screen Strip

As seen in Part I, four main areas are involved in a project: operating assets, non-operating (i.e., liquid) asset, debt capital, and equity capital. The law of motion holds for each of the four classes and may be represented with the four-area Matrix for each one of the n periods, giving rise to a split-screen film or split-screen strip.

In Figure 5, the project film is displayed in a discrete format (sequence of matrices). Merging the last and first column of any two consecutive matrices, the project film may be reframed in a continuous format (Figure 6):[6]

Figure 5. The split-screen film or strip (discrete format) (reprinted from Part I, Equation (66)).

Figure 6. The split-screen film or strip (continuous format) (reprinted from Part I, Equation (67)).

This compact representation of the film of split-screen matrices in a continuous format is particularly convenient for spreadsheet modeling. The assumptions and the preliminary calculations enable building the project film in full scale—that is, the strip of the n full-scale split-screen matrices (Figure 7).

Figure 7. The full-scale strip (reprinted from Part I, Equation (68)).

CODE INSTRUCTIONS: STRUCTURE OF THE SPLIT-SCREEN STRIP

The analyst adds, in his workbook, a new sheet—named "SplitScreenStrip"—where he lays out a range of cells with the structure of the previous table (see Figure 8).

Figure 8. Structure of the full-scale strip in the spreadsheet ("SplitScreenStrip" sheet).

The table has a first group of columns representing a generic full-scale SSM: column D, E, and F report, respectively, the capital amounts, incomes, and cash flows.[7] The following columns (from column G on) will contain the figures of the project, starting from period $t = -1$, before the beginning of the project. The total number of columns containing numerical values is $(3 \cdot (n + 1) + 1)$. Each value is 0 in column G since the project has not started yet ($C_{-1} = 0$).

Row 8 describes the kind of column (C, I or F) and row 9 contains the periods. Row 12 contains the labels of the columns, with specification of the category to which they belong (C, I, or F) and of the period ($-1, 0, \ldots, n$). Each cell is identified by the labels. For example, cell K13 will contain the sales (S) of period 1; cell M13 will contain the Accounts Receivable (AR) of period 1 (see Figure 9).

Figure 9. Cell M13 will contain the Accounts Receivable at $t = 1$ ("SplitScreenStrip" sheet).

To build the whole split-screen film, one must follow two steps:

Step 1. The analyst fills in the cells of array H13:J23, which contain the values of all the 33 accounting and financial magnitudes that refer to period 0. These cells may be divided into four classes:

- Cells whose values are provided in "PreCalc" (step 1a)
- Cells whose values are calculated with the law of motion (step 1b)
- Cells whose values are calculated with suitable formulas (step 1c)
- Cells whose values are calculated with the law of conservation (step 1d)

We describe the calculations for all these cells in Section 2.2.

Step 2. The analyst fills the whole strip by copying the range H13:J23, which refer to the remaining periods (periods 1 to *n*). This is completed in few seconds by copying and

pasting it in the adjacent ranges, or by dragging the fill handle (we show the procedure in Section 2.3).

2.2. Filling the Cells for Period 0 (Step 1)

2.2.1. Cells Whose Values Are Provided in "PreCalc" (Step 1a)

Preliminary calculations feed into the split-screen strip. To fill the cells of array H13:J23, the analyst should use nested functions INDEX and MATCH.[8] This function is necessary because it makes the formulas parameterized and dependent on the cell where they are (using the references to the row and column labels): it will enable the analyst to drag and fill the whole strip, thereby completing the project film in few seconds (see Section 3.3).

In the code instructions below, we first provide the code for the general formula and then show how to use it for each one of the three economic elements: capital, income, and cash flow. For those who are not familiar with spreadsheet formulas, we suggest reading the online support pages of the software employed.

There are 15 cells to be filled (highlighted with yellow background in Figure 3): six of them are capital amounts, six are incomes, and three are cash flows (see Table 4).

Table 4. Cells whose values are provided in "PreCalc" (yellow cells).

Cell	Symbol	Magnitude	Type
H13	$+ S_0$	Sales	Income
J13	$+ AR_0$	Accounts Receivable	Capital
J14	$+ Inv_0$	Inventory	Capital
H15	$- COP_0^m$	$-$ Cost of Purchases (manufacturing)	Income
J15	$- AP_0^m$	$-$ Accounts Payable (manufacturing)	Capital
H16	$- COP_0^{nm}$	$-$ Cost of Purchases (nonmanufacturing)	Income
J16	$- AP_0^{mn}$	$-$ Accounts Payable (nonmanufacturing)	Capital
H17	$- LC_0^m$	$-$ Labor costs (manufacturing)	Income
I17	$+ F_0^{swp,m}$	Payments to employees (manufacturing)	Cash flow
H18	$- LC_0^{nm}$	Labor costs (nonmanufacturing)	Income
I18	$+ F_0^{swp,nm}$	Payments to employees (nonmanufacturing)	Cash flow
H19	$- Dep_0$	$-$ Depreciation	Income
I19	$- F_0^{nfa}$	$-$ Asset disposals (net of capital expenditures)	Cash flow
J20	$- TP_0$	$-$ Taxes Payable	Capital
J22	$+ C_0^d$	Debt	Capital

CODE INSTRUCTIONS: CELLS WHOSE VALUES ARE PROVIDED IN "PreCalc"
The analyst must pick the figures from the "PreCalc" sheet and insert them into the split-screen strip. For this operation, the analyst must use the nested formulas INDEX-MATCH.
The INDEX function

$$INDEX(\,array, row\_num, column\_num)$$

returns the value in the cell of the array at the intersection of row_num and column_num.
The MATCH function

$$MATCH(\,lookup\_value, lookup\_array, match\_type)$$

returns the position of the matched value within lookup_array, finding the first value that is exactly equal to lookup_value, if the optional argument is 0.
Hence, the combined formula

$$INDEX(\,PreCalc!\$K : \$P, MATCH(lookup\_value, lookup\_array, 0), column\_num)$$

returns a value within the range PreCalc!K:P, that is, the columns which contain the amounts preliminarily calculated in "PreCalc" sheet. The row of this value must be the one where the label in columns D, E, or F matches with the corresponding label in the split-screen strip. The column must be the $(t+1)$-th column, where t is the period (i.e., first column for $t = 0$, second column for $t = 1$, etc.). The formulas are similar for three types of components: capital, income, and cash flow. Following are some examples of spreadsheets codes.

For an income component: lookup_value is the label in column SplitScreenStrip!E and lookup_array is the column PreCalc!E. For example, the code for cell H13 is

$$\text{H13} = \text{INDEX}(\underbrace{\text{PreCalc!\$K : \$P}}_{\substack{\text{array :} \\ \text{columns group of the} \\ \text{amounts calculated} \\ \text{in worksheet "PreCalc"}}} , \underbrace{\text{MATCH}(\$E13, \text{PreCalc!\$E : \$E}, 0)}_{\substack{\text{the result of this formula is the number} \\ \text{of the row in the worksheet "PreCalc" with} \\ \text{the same label of cell E13}}} , \underbrace{\text{H\$9} + 1}_{\substack{\text{the } (t+1) - \text{th column,} \\ \text{where } t \text{ is the period} \\ \text{(first column for period 0)} \\ \text{in the columns group of the} \\ \text{worksheet "PreCalc"}}})$$

(see Figures 10 and 11).

For a cash-flow component: lookup_value is the label in column SplitScreenStrip!F, and lookup_array is the column PreCalc!F. For example, the code for cell I17 is

$$\text{I17} = \text{INDEX}(\text{PreCalc!\$K : \$P}, \text{MATCH}(\$F17, \text{PreCalc!\$F : \$F}, 0), \text{I\$9} + 1)$$
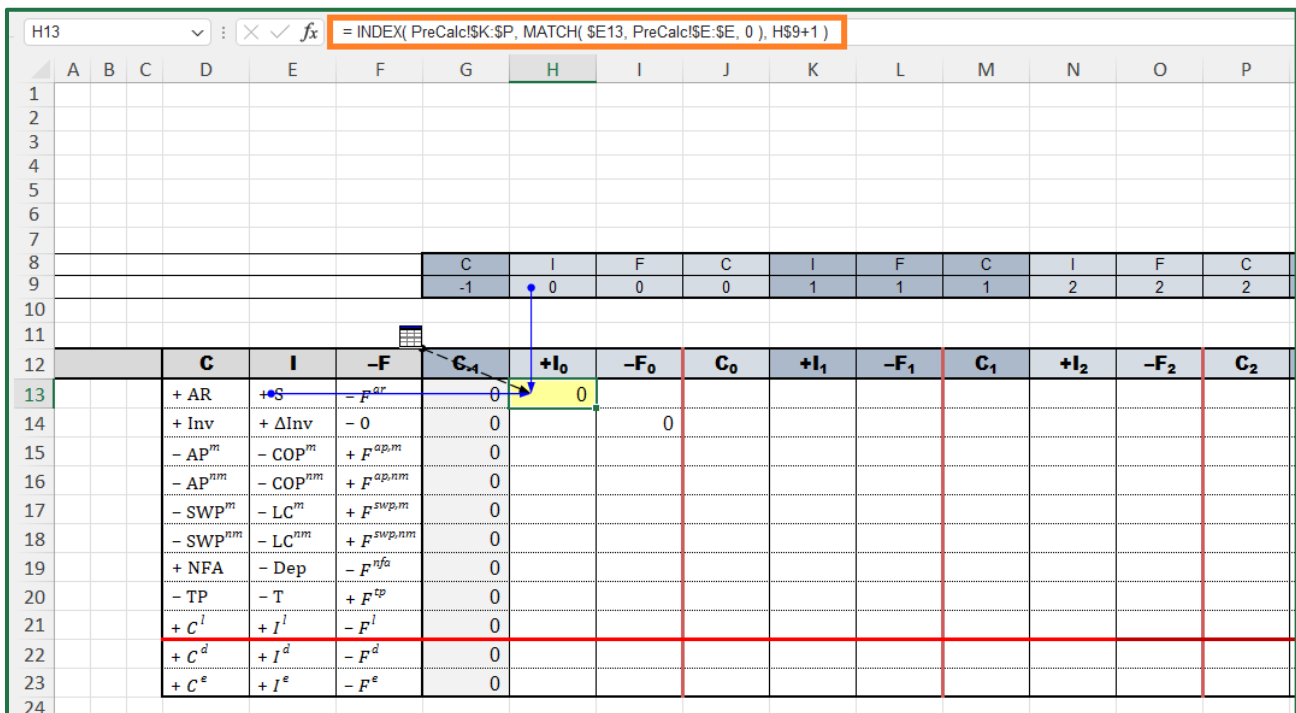

Figure 10. Cell H13 contains the formula for calculating the income component of AR (i.e., sales). Cell I14 is zero, by definition ("SplitScreenStrip" sheet).

Figure 11. Cell K43 contains the value that has the same label of SplitScreenStrip!E13 and that is in the (H\$9 + 1)-th column ("PreCalc" sheet).

For a capital component: lookup_value is the label in column SplitScreenStrip!D, and lookup_array is the column PreCalc!D. For example, the code for cell J15 is

$$J15 = \text{INDEX}(\text{PreCalc!}\$K : \$P, \text{MATCH}(\$D15, \text{PreCalc!}\$D : \$D, 0), J\$9 + 1)$$

(see also Figure 12).

Every cell in Table 4 should be filled using the formula INDEX-MATCH. Figure 12 shows the output of this step.

Figure 12. The 15 cells whose values are provided in "PreCalc" are in yellow. Cell J15 calculates the accounts payable for manufacturing activities at $t = 0$ ("SplitScreenStrip" sheet).

2.2.2. Cells Whose Values Are Calculated with the Law of Motion (Step 1b)

The second class of cells in array H13:J23 is the class of those cells which must be filled with the law of motion. To fill in these values, the analyst should use the law of motion for $t = 0$ (see Part I, Equation (2)). Specifically, to find a capital amount, the law of motion is expressed as

$$C_0 = C_{-1} + I_0 - F_0.$$

To find an income amount, the law of motion becomes

$$I_0 = C_0 - C_{-1} + F_0.$$

To find a cash-flow component, the law of motion becomes

$$F_0 = C_0 - C_{-1} + I_0.$$

Applying these laws of motion, the cells of this class are calculated, with their own sign (see Table 5).

Table 5. Cells whose values are calculated with the law of motion (green cells).

Cell	Symbol	Magnitude	Law of Motion	Type
H14	$+\,\Delta\mathrm{Inv}_0$	Income from inventory	$+\,\Delta\mathrm{Inv}_0 = \mathrm{Inv}_0 - \mathrm{Inv}_{-1} + (-0)$	Income
I13	$-\,F_0^{ar}$	$-$ Cash receipts from customers	$-\,F_0^{ar} = \mathrm{AR}_0 - \mathrm{AR}_{-1} - S_0$	Cash flow
I15	$+\,F_0^{ap,m}$	Payments to suppliers (manufacturing)	$+\,F_0^{ap,m} = -\mathrm{AP}_0^m + \mathrm{AP}_{-1}^m + \mathrm{COP}_t^m$	Cash flow
I16	$+\,F_0^{ap,nm}$	Payments to suppliers (nonmanufacturing)	$+\,F_0^{ap,nm} = -\mathrm{AP}_0^{nm} + \mathrm{AP}_{-1}^{nm} + \mathrm{COP}_0^{nm}$	Cash flow
I20	$+\,F_0^{tp}$	Tax payments	$+\,F_0^{tp} = -\mathrm{TP}_0 + \mathrm{TP}_{-1} + \mathrm{T}_0$	Cash flow
I22	$-\,F_0^{d}$	$-$ Cash flow to debt	$-\,F_0^{d} = C_0^d - C_{-1}^d - I_0^d$	Cash flow
J17	$-\,\mathrm{SWP}_0^m$	$-$ Salaries & Wages Payable (manufacturing)	$-\,\mathrm{SWP}_0^m = -\mathrm{SWP}_{-1}^m - \mathrm{LC}_0^m + F_0^{swp,m}$	Capital
J18	$-\,\mathrm{SWP}_0^{nm}$	$-$ Salaries & Wages Payable (nonmanufacturing)	$-\,\mathrm{SWP}_0^{nm} = -\mathrm{SWP}_{-1}^{nm} - \mathrm{LC}_0^{nm} + F_0^{swp,nm}$	Capital
J19	$+\,\mathrm{NFA}_0$	Net Fixed Asset	$+\,\mathrm{NFA}_0 = \mathrm{NFA}_{-1} - \mathrm{Dep}_0 + \left(-F_0^{nfa}\right)$	Capital
J21	$+\,C_0^l$	Liquid assets	$+\,C_0^l = C_{-1}^l + I_0^l - F_0^l$	Capital
J23	$+\,C_0^e$	Equity	$+\,C_0^e = C_{-1}^e + I_0^e - F_0^e$	Capital

Note that the application of the law of motion for J21 supplies a value equal to zero, because I_0^l and F_0^l (respectively, cell H21 and I21) have not been calculated yet. However, the values of J21 will be automatically updated as soon as H21 and I21 will be calculated in the next steps. The same holds for J23, I20, and I22—cells that temporarily can exhibit an incorrect value—because one of the cells linked in the formula is not yet calculated. The output of this step is displayed in Figure 13 (the cells of the class are highlighted in green).

CODE INSTRUCTIONS: CELLS WHOSE VALUES ARE CALCULATED WITH THE LAW OF MOTION
EXAMPLE OF CAPITAL COMPONENT. The (changed-in-sign) salaries and wages payable at $t = 0$ in cell J17 is obtained as follows:

$$\underbrace{\mathrm{J17}}_{-\mathrm{SWP}_0^m} = \underbrace{\mathrm{G17}}_{-\mathrm{SWP}_{-1}^m} + \underbrace{\mathrm{H17}}_{-\mathrm{LC}_0^m} + \underbrace{\mathrm{I17}}_{+F_0^{swp,m}}$$

(see Figure 13).
The analyst can copy cell J17 and paste it in cells J18, J19, J21, and J23 (the equations share the same structure).

EXAMPLE OF INCOME COMPONENT. The income from inventory in cell H14 is just equal to $\Delta\mathrm{Inv}_0$ (because the cash-flow component of inventory is zero):

$$\underbrace{\mathrm{H14}}_{+\Delta\mathrm{Inv}_0} = \underbrace{\mathrm{J14}}_{+\mathrm{Inv}_0} - \underbrace{\mathrm{G14}}_{+\mathrm{Inv}_{-1}} + \underbrace{\mathrm{I14}}_{-F_0^{Inv}}$$

with $F_0^{Inv} = 0$ (see Figure 14).

Figure 13. The cells whose values are calculated with the law of motion are in green. Cell J17 contains the law of motion for SWP_0^m ("SplitScreenStrip" sheet). (The cells whose values are provided in "PreCalc" are in yellow and the cells whose values are calculated with the law of motion are in green).

Figure 14. Cell H14 contains the law of motion for ΔInv_0 ("SplitScreenStrip" sheet). (The cells whose values are provided in "PreCalc" are in yellow and the cells whose values are calculated with the law of motion are in green).

EXAMPLE OF CASH-FLOW COMPONENT. The (changed-in-sign) cash receipts from customers $-F_0^{ar}$ in cell I13 are obtained as follows:

$$\underbrace{\text{I13}}_{-F_0^{ar}} = \underbrace{\text{J13}}_{+AR_0} - \underbrace{\text{G13}}_{+AR_{-1}} - \underbrace{\text{H13}}_{+S}$$

(see Figure 15).

Figure 15. Cell I13 contains the law of motion for the cash receipts from customers ("SplitScreenStrip" sheet). (The cells whose values are provided in "PreCalc" are in yellow and the cells whose values are calculated with the law of motion are in green).

The analyst can copy cell I13 and paste it in cells I15, I16, I20, and I22 (the equations share the same structure).

2.2.3. Cells Whose Values Are Calculated with Suitable Formulas (Step 1c)

The third class of cells consists of those cells that can be calculated via suitable, specific formulas. These are the taxes, interest income, interest expenses, and CFE (see Table 6 and description below).

Table 6. Cells whose values are calculated via suitable formulas (blue cells).

Cell	Symbol	Magnitude	Formula	Type
H20	T_t	Taxes	$T_t = EBT_t \cdot \tau$	Income
H21	I_t^l	Interest income	$I_t^l = C_{t-1}^l \cdot i^l$	Income
H22	I_t^d	Interest expenses	$I_t^d = C_{t-1}^d \cdot i^d$	Income
I23	F_t^e	Cash flow to equity	depends on the period	Cash flow

TAXES. The amount of Taxes (T_t) is not known, but the assumptions provide the necessary information for calculating it. The tax amount is computed applying the tax rate to earnings before taxes (EBT):

$$T_t = EBT_t \cdot \tau$$

where τ is the tax rate, equal to 30% (by Assumption 15) and EBT is equal to $\text{EBT}_t = \text{EBIT}_t + I_t^l - I_t^d$, so that

$$T_t = \left(\text{EBIT}_t + I_t^l - I_t^d\right) \cdot \tau$$

where EBIT_t is obtained as $\text{EBIT}_t = S_t - \text{COGS}_t - \text{SGA}_t - \text{Dep}_t$ (Part I, Equation (47)). Hence,

$$T_t = (S_t - \overbrace{(\text{COP}_t^m + \text{LC}_t^m - \Delta\text{Inv}_t)}^{\text{COGS}_t} - \overbrace{(\text{COP}_t^{nm} + \text{LC}_t^{nm})}^{\text{SGA}_t} - \text{Dep}_t + I_t^l - I_t^d)\cdot\tau$$

(see also Part I, footnote 7). All the values in this formula have already been computed or will be computed in the next steps (i.e., I_t^l and I_t^d).

CODE INSTRUCTIONS: TAXES
The tax rate τ is recorded in "Assumption" sheet: the analyst can show it in a cell above the Matrix in the "SplitScreenStrip" sheet (e.g., in cell D3) and then use it in the formulas (see Figure 16).
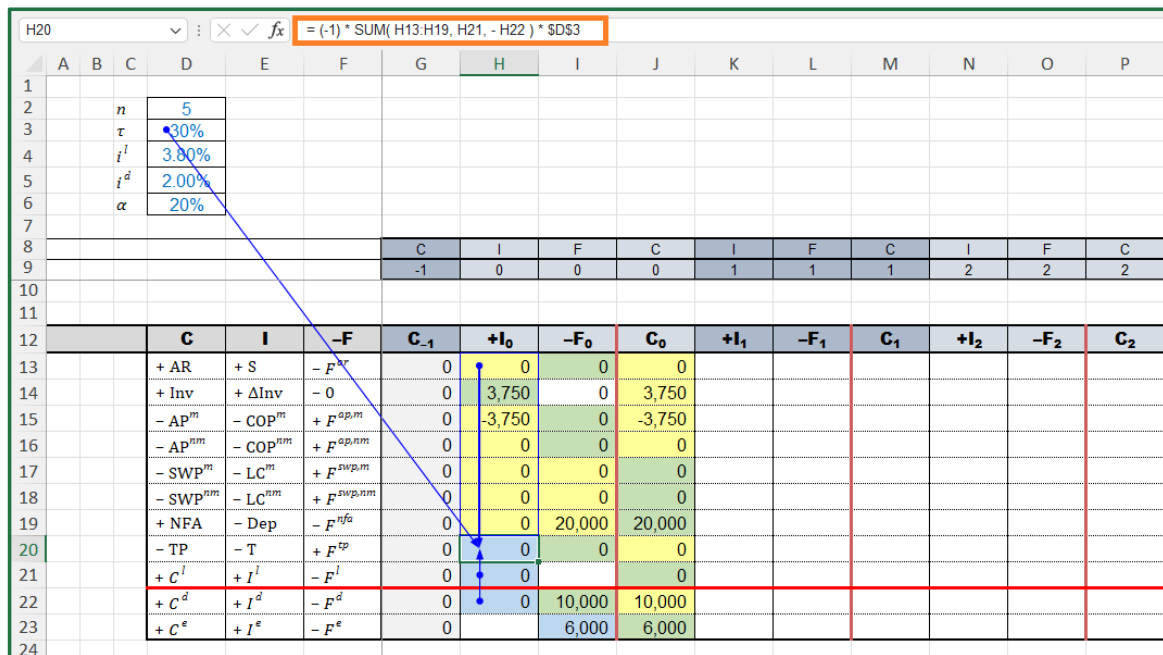
Figure 16. The cells whose values are calculated with suitable formulas are shown in blue. Cell H20 contains the specific formula for calculating the taxes ("SplitScreenStrip" sheet). (The cells whose values are provided in "PreCalc" are in yellow, the cells whose values are calculated with the law of motion are in green, and the cells whose values are calculated via suitable formulas are in blue).

Cell D3 is linked to the cell that contains the value of τ with the formula

$$D3 = \text{Assumptions!\$F\$19}.$$

The (changed-in-sign) taxes, $-T_t$, are calculated in cell H20:

$$H20 = (-1) * \text{SUM}(\underbrace{H13:H19}_{\substack{+S_0 + \Delta\text{Inv}_0 \\ -\text{COP}_0^m - \text{COP}_0^{nm} \\ -\text{LC}_0^m - \text{LC}_0^{nm} \\ -\text{Dep}_0}}, \underbrace{H21}_{+I_0^l}, \underbrace{-H22}_{-(+I_0^d)}) * \underbrace{\$D\$3}_{\tau}.$$