



## SJMMA 2022 E 题

### 18CE：中欧班列

Francis Tresham 在 20 世纪 70 年代设计了重现 19 世纪铁路公司竞争与建设的 1829，其核心模型被其他桌面游戏设计师广泛采纳、修正并衍生出了 18xx 系列。典型的 18xx 游戏以六边形网格划分特定区域，模拟从该地区出现铁路至约 100 年后的铁路网建设。铁路由各公司建设、运营并产生收益；火车的续航能力表现为可以通过收益点的数量上限，其范围通常由开始时的 2 至结束时的 8 至 10；通常，公司仅能购入当前数字最低的火车，从而购买每个等级的第一辆车代表了新时期的开始，数字为 3、5 和 6 或 7 的火车将模拟周期划分为四大时代；区域内具有代表性的收益点被分为城镇、城市、大城市、大都会，区域附近的典型收益点则为远方，收益点的收益随时代变化。

公司的运营需要资金的支持，故 18xx 系列引入了简化的股票机制。该机制将大公司股票分为 1 张 20% 的总裁股与 8 张 10% 的普通股，资金由玩家注入或在公司上市时由银行注入或部分注入，买卖股票可能导致股价发生变动，公司在运营后选择分红比例（通常为 0、50% 或 100%），根据分红金额决定股价的变动；私人公司在开始时由玩家竞标，提供固定收入，公司可以选择将其并购；一些 18xx 游戏中还引入了小公司，其初始资金由玩家在购买其总裁凭证时注入，固定进行 50% 的分红，小公司可以在特定时期选择扩股或与其他小公司合并为大公司。玩家在游戏的目标是在游戏结束时拥有最多的股票面值与现金总和。2011 年，拥有“新东方快车”之称的中欧班列首班列车成功开行。近年，中欧班列货运量激增，从而促进了新路线的建设。

#### 任务

中欧班列未来的路线将会是如何的？目前的线路又是如何形成的？你的团队受邀研究上述问题，重现中欧班列的建设过程并作出预测。为此，你的团队需要：

1. 根据附件中给出的规则与地图，分析玩家在该 18xx 游戏中的策略，并展示该地图上最终的铁路网。
2. 为中欧班列涉及及可能涉及的区域设计合理的网格系统与时代划分，并展示在该网格系统下，区域内目前的铁路网络是如何的。指出如何修正公司的运营规则以适配所得的系统。
3. 建立模型分析收益点产生的客运与货运收益，在先前的网格系统中选择典型的收益点应用该模型。指出如何修正或新增列车的种类或挂件以及运行规则以适配该模型。
4. 在修正的规则下重现区域内 1825 年起的铁路建设过程，分析重现后的铁路网络与目前铁路网的区别。考虑其他可能影响公司决策的因素，如收益点的动态收益等以修正该规则。

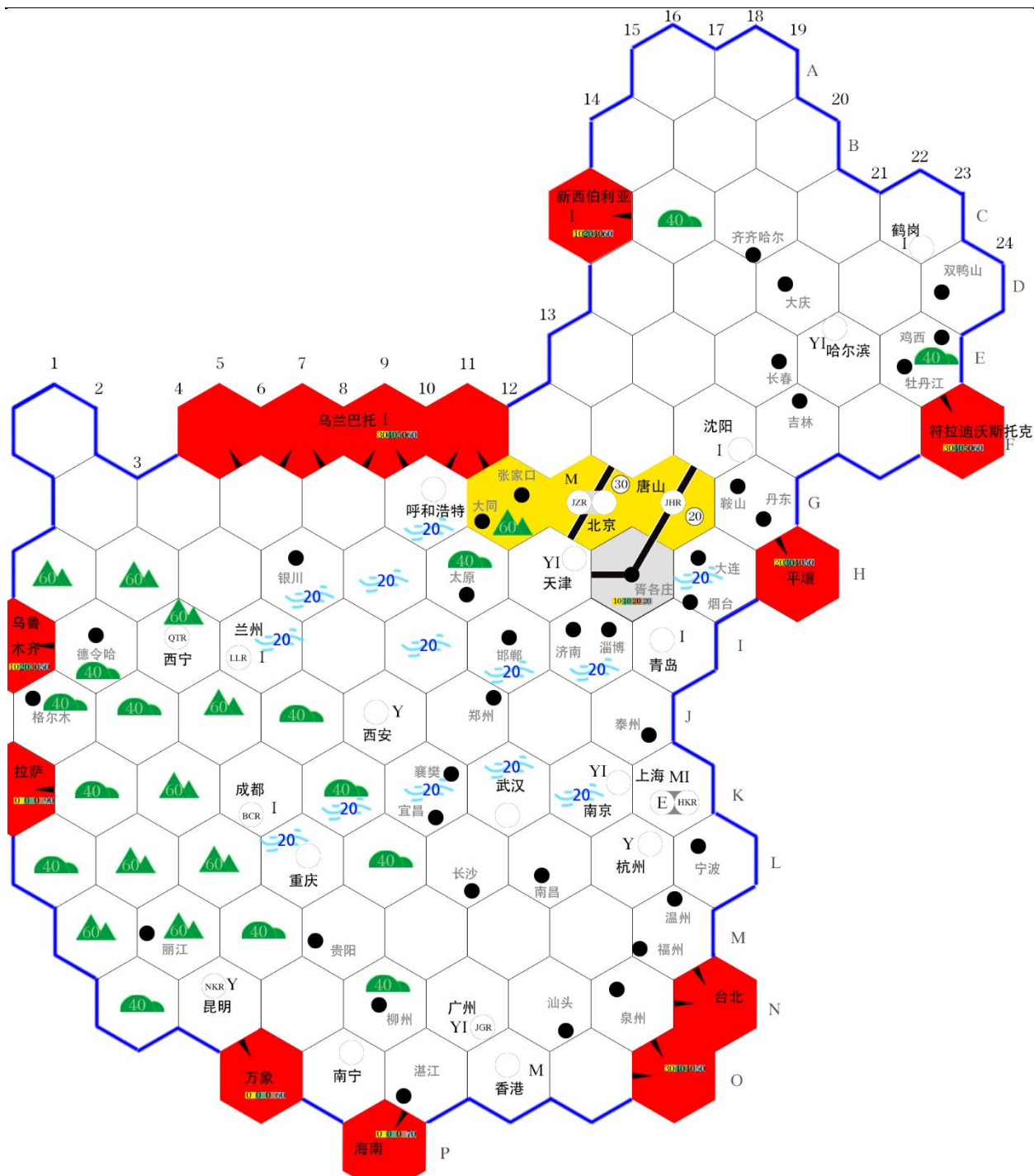


5. 预测中欧班列未来的线路。并给中国铁路总公司写一份不超过 2 页的非技术性报告。

**提交** 你的团队所提交的报告应包含 1 页“总结摘要”，2 页的非技术性报告，其正文不可超过 20 页（总页数限于 23 页）。附录和参考文献应置于正文之后，不计入 23 页之限。



上海地区数学建模联校活动  
Shanghai Joint Secondary School Mathematical Modeling Activity





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## SJMMMA2022 Problem E

### 18CE:On The Tracks of The China-Europe Railway Express

In the 1970s, *Francis Tresham* designed *1829*, which recreates the building of railroad corporations during the 19<sup>th</sup> century. Its model was then diffusely adopted, corrected and optimized by other designers, forming the *18xx* series. Typical *18xx* games divide specific region with a hexagonal grid system and simulates construction of the track network in the region. Railroads are laid and operated by companies, generating revenues. Cruising abilities of trains are represented by a figure, indicating the maximum number of revenue centers their routes may contain, which ranged from 2 at the beginning to 8 through 10 at the end of the game. In normal circumstances, companies are only allowed to purchase from the locomotive works trains with the smallest available number, the purchase of the first train of each number thus represents the start of a new phase of development. Trains with the number of 3,5 and 6 or 7 divides the simulation period into 4 eras. Typical revenue centers in the region are classified into towns, cities, major cities and metropolises, while those outside the boarder are defined as off-board locations, the revenue of which changes as the phase develops.

Operating companies requires the support of fund. *18xx* games thus introduces a simplified stock mechanism. The mechanism divides major company stocks into a 20% director share and eight 10% shares. Capitals that supports companies are injected by players by purchasing shares or fully or partly injected by the bank. Purchasing and selling stocks may lead to a change in the share price. After a company operates, its director decides whether the revenue is paid out or retained(in some *18xx* games, the director may choose to retain half of the revenue, and pay out the other half), share price of the company changes according to the amount of cash paid out. Private companies are bid by players at the beginning, and provides fixed income for their owners. Major companies may merge private companies. Some *18xx* games introduce minor companies, the initial capital of which is injected by players when they purchase the director certificate. Minor companies pays out half of its revenue, and may expand its shares or merge into major companies. When the game ends, the player with the greatest wealth(cash + market value of shares) wins. In the year of 2011, the first train of the China-Europe railway express, which was referred to as the "New Orient Express", launched successfully. In Recent years, the volume of freight delivered by the China-Europe railway express increased dramatically, stimulating the construction of new routes.



## Requirements

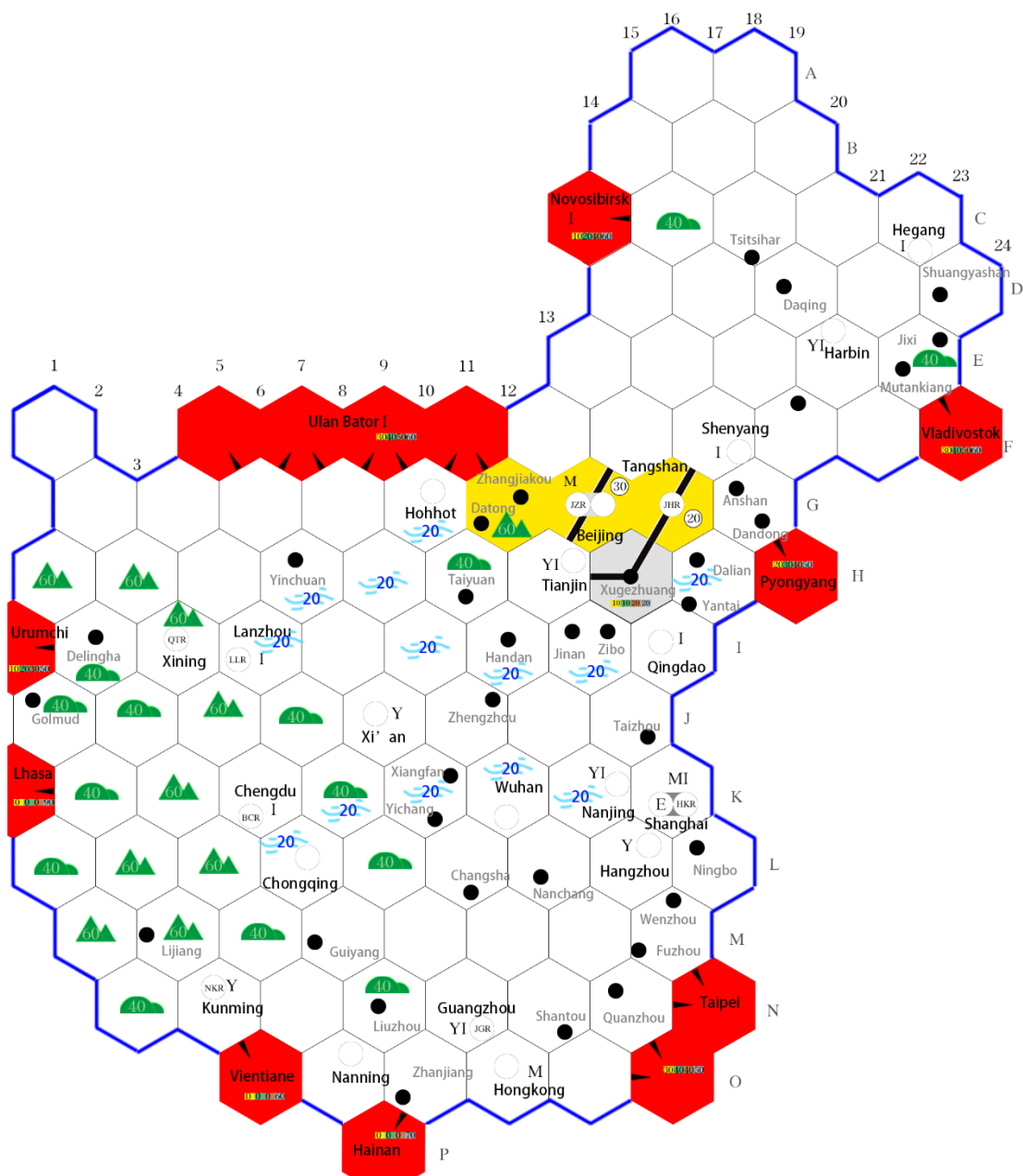
What will the future routes of the China-Europe railway express be like? How is its current route formed? Your team is invited to study on aforesaid questions, recreate the construction of the China-Europe railway express. For this purpose, your team should:

1. Analyze the player's strategy in the 18xx game, the rules and map of which are given in the attachment, and demonstrate the railway network on the map at the game's end.
2. Design a reasonable grid system for the areas involved and likely to be involved in the China-Europe railway express, and demonstrate what the current railway network in the region looks like under your system. Figure out how to modify the company's operating rules to fit the system.
3. Construct a mathematical model or models to analyze the revenue for both passenger transport and freight offered by a revenue center. Apply your model to typical revenue centers in your grid system. Point out how to modify or add train types or accessories and operating rules to fit the model.
4. Under the modified rules, recreate the railway construction process in the region since 1825, and analyze the differences between the recreated railway network and the current railway network. Modify the rules by considering other factors that may influence a company's decision, such as dynamic revenue offered by revenue centers.
5. Predict future routes of the China-Europe railway express and write a non-technical report of no more than 2 pages for China Railway.

**Submission** Your solution paper should include a 1-page Summary Sheet, a 2-pages non-technical. The body cannot exceed 20 pages for a maximum of 23 pages with the Summary Sheet inclusive. The appendices and references should appear at the end of the paper and do not count towards the 23 pages limit.



上海地区数学建模联校活动  
Shanghai Joint Secondary School Mathematical Modeling Activity



# 18CE:Chapter0

## 1 总体信息

18CE:Chapter0 是一款 3-6 位玩家的铁路建设与股票模拟游戏，主要规则基于 *Francis Tre-sham* 的 1829。游戏过程中，玩家通过购入股票、运营铁路公司：在六边形网格地图中铺设铁路、设置站点、经营线路、购入火车以产生收益。股票与运营的过程划分为股票轮与运营轮，在前者中玩家进行股票交易，在后者中铁路公司的总裁运营公司。随着时代的推进，每个股票轮后可能有不同数量的运营轮。游戏结束时拥有最高现金 + 股票市值的玩家获得胜利。

## 2 公司分类

在 18CE:Chapter0 中，公司分为私人公司与上市公司。

### 2.1 私人公司

私人公司仅有一张标识总裁的凭证，表示了玩家对该公司的完全控制。在运营轮中，私人公司为其拥有者产生固定收益。此外，多数私人公司都具有一定的效果，其拥有者可以在其上记述的时刻使用该效果，上市公司并购私人公司后视为其拥有者。本游戏中共有 6 家私人公司，概况如下表。

公司代号	面值	固定收益	效果
A	20G	5G	无特殊效果
B	40G	10G	拥有“张家口”板块
C	75G	15G	铁路桥梁技术
D	110G	20G	可交换为股票
E	180G	25G	拥有可兑换的“上海”站
F	260G	35G	获得“JHR”总裁股

其中公司能力描述如下：

- A: 无特殊能力。
- B: 由上市公司并购后，该私人公司运营轮时仅 1 次可发动，在张家口 (G12) 铺设绿色板块，不支付费用，但需要符合其他规则。
- C: 拥有该私人公司的玩家在运营上市公司时地形改造费用均减少 20G(有多种地形的格点可多次适用)。
- D: 拥有该私人公司的玩家在股票轮中可以选择以此凭据交易任意公司 IPO 或公开市场中 10% 的股票作为购买行动的代替。

- *E*: 该私人公司在上海格 (K16) 设有站点 (以“E” 标记), 由上市公司并购时公司可选择以其财产中的站标替换之, 并购后视为一辆 2 级火车, 不产生固定收益。
- *F*: 玩家购入该私人公司时, 立刻获取 JHR 总裁股并为其确定 IPO 定价, 不支付其价格, JGR 公司公开上市时该私人公司立刻作为一组货运车厢加入公司财产, 该车厢在此公司第一个运营轮可以作为一辆 1 级火车使用, 此后不产生固定收益。

## 2.2 上市公司

上市公司的股票分为 1 张 20% 的总裁股与 8 张 10% 的普通股。购买某家上市公司的股票时必须优先购入总裁股, 即确定其首次公开募股 (IPO) 定价 (67G,71G,76G,82G,90G 或 100G 每 10%) 后向银行支付两倍于该价格的现金。拥有总裁股的玩家 (下称总裁) 在运营轮中对铁路公司进行运营。然而, 当其他玩家对该公司持股量大于当前持有总裁股的玩家时, 总裁将其总裁股与该玩家的两张 10% 股票交换。上市公司运营线路后总裁选择线路产生的收益按股票持有情况分红或保留收益。

## 3 股价板

上市公司都具有股价, 在股价板上标注。玩家与公司的行为均可能导致铁路公司的股价发生变化, 具体而言:

- 股票轮结束时铁路公司的股票完全由玩家拥有: 右移 1 格。
- 玩家卖出铁路公司股票: 左移 1 格。
- 运营轮铁路公司选择分红且分红金额不为 0: 右移 1 格。
- 运营轮铁路公司选择保留收益或分红金额为 0: 左移 1 格。

## 4 游戏准备

### 4.1 设置版图

将所有股票凭证按所属公司分堆, 将 20% 的总裁股置于所在堆顶。将所有火车按数字等级分开依次放置。

### 4.2 起始资金

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3 人游戏	800G
4 人游戏	600G
5 人游戏	480G
6 人游戏	400G

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### 4.3 确定玩家顺序

随机确定拥有优先交易权的玩家。股票轮将从优先交易权玩家开始，将按顺时针方向不断进行，该顺序称玩家顺序。

### 4.4 玩家协议与规定

- 玩家在游戏开始前规定何种协议是有效的，何种协议是无效的，这些协议不能违反基础规则。
- 游戏内的所有信息，即玩家现金与股票持有情况，公司账面上的资产以及火车持有情况，均为公开的。
- 玩家间的协议需要公开。

### 4.5 竞标私人公司

将所有私人公司按面值从小到大排列。按玩家顺序，每位玩家可以选择：

- 跳过自己当前回合。
- 按面值价格购买当前面值最低的私人公司。
- 竞标非当前面值最低的私人公司，即将现金盖于该公司凭证下。若当前没有玩家对该公司竞标，最低竞标价格为面值，否则为当前最高竞标价 +5G，加价幅度为 5G。

每次购买结算后，若当前面值最低的私人公司已有玩家竞标，

- 若仅有 1 位玩家竞标，则该玩家立刻以竞标价格，即盖于凭证下的金额购入该私人公司。
- 若有多位玩家竞标，则他们收回竞标资金，以最高竞标价格升序为顺序，玩家依次进行叫价，从当前最高竞标价开始，加价幅度为 1G，放弃者不加入下一轮叫价，最后未放弃的玩家以所出价格购入。

当所有玩家不间断地选择跳过自己的回合且私人公司尚未全部被购买，

- 若私人公司 A 尚未被购买，其面值下降 5G，降至 0 时下一位玩家必须选择购买之。
- 若私人公司 A 已被购买，所有已被购买的私人公司立刻为拥有者产出一固定收益。

当所有私人公司均被玩家购买时，将优先交易权交给最近一次进行交易玩家的下家，随后进行第一次股票轮。

## 5 游戏过程

游戏按股票轮-运营轮组的顺序不断进行，直至满足游戏结束条件，此时拥有最高现金 + 股票市值的玩家获得胜利。

## 5.1 股票轮

### 5.1.1 总体规则

在股票轮中，按玩家顺序，每位玩家可以选择：

- 跳过自己的回合。
- 依次选择进行：
  - 向公开市场卖出任意张股票。
  - 从 IPO 或公开市场买入一张股票。
  - 向公开市场卖出任意张股票。

当所有玩家不间断地选择跳过自己的回合时，将优先交易权交给最近一次交易玩家的下家，当前股票轮结束，所有股票均被玩家持有的公司股价右移 1 格。

### 5.1.2 股票数量限制

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玩家能够持有的凭证张数，即股票张数与私人公司凭证数量之和有所限制，具体而言：

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3 人游戏 20 张

4 人游戏 16 张

5 人游戏 13 张

6 人游戏 11 张

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凭证张数达到上限的玩家不能选择购入股票。此外，玩家对单个公司的股票持有数量不能超过 5 张。

### 5.1.3 卖出股票

玩家在卖出股票时可以向公开市场以任意顺序一次性卖出相同或不同公司的任意张股票，从银行拿取等于这些股票卖出前市场价总和的现金，随后卖出股票对应的所有公司股价左移 1 格。然而，玩家不能直接卖出总裁股，作为替代，该玩家首先需要将总裁股与当前持股次高的玩家（若存在平局则从该玩家下家开始，按玩家顺序第一个持股次高的玩家）的两张 10% 股票（若没有其他玩家拥有两张 10% 股票则不可出售）交换，随后将股票出售到至多低于新总裁持股。此外，

- 卖出动作不能使任何公司在公开市场中的股票量超过 50%。
- 不能卖出未上市公司的股票。
- 第一次股票轮中不能卖出股票。
- 一旦卖出某公司的股票，在同一股票轮内不能买入该公司的股票。

#### 5.1.4 购买一张股票

持股未达到上限的玩家可以从 IPO 或公开市场中购入任意一张股票，

- 若从公开市场购入，玩家向银行支付该股票对应公司在股价板上标注的市场价格购入该股票。
- 若从 IPO 购入，
  - 若总裁股尚未被购买，玩家立刻为该公司确定 IPO 定价 (67G,71G,76G,82G,90G 或 100G 每 10%)，向银行支付两倍于该数值的现金并拿取该总裁股。
  - 若总裁股已被购买，玩家向银行支付该股票的 IPO 定价，并拿取该股票。

#### 5.1.5 总裁更替

在一位玩家卖出或买入后，若某公司总裁的持股小于另一位玩家，则现任总裁将总裁股与该玩家的两张 10% 股票交换。

#### 5.1.6 公司公开上市

一旦上市公司 60% 的股票都被玩家购买，该公司立刻上市，总裁拿取公司板，从银行为公司账面拿取 10 倍于其 IPO 定价的现金，并拿取该公司所有的站标。

### 5.2 运营轮组

#### 5.2.1 运营顺序

在一个运营轮中，私人公司先运营，即产生固定收益，随后所有已经公开上市的上市公司按股价降序 (若多个公司股价相同，后到达该股价的公司优先) 运营。轮到一家上市公司运营时，其总裁按顺序进行：

- 放置起始车站 (公司第一个运营轮必须执行)
- 铺设或升级一块铁路。(非必需)
- 设置车站。(非必需)
- 为每辆火车运营线路。(必须)
- 选择分红或保留收益。(必须)
- 购买火车。(非必需)

#### 5.2.2 放置起始车站

从公司财产中将第一个车站标放置在地图标明该公司代号的位置 (下称预留位) 上。

### 5.2.3 铺设或升级铁路

在 18CE:Chapter0 中, 带有铁轨的六边形板块按颜色分类共 4 种, 称为黄色板块, 绿色板块, 棕色板块和灰色板块, 其升级顺序为黄色 => 绿色 => 棕色 => 灰色。此外, 在板块上通过黑色的点与白色的圆分别表示了城镇与城市, 带有字母的城市板块则表示该城市具有某种性质, 具体而言:

- I: 工业城市。
- Y: 大城市。
- M: 大都会。

板块上没有城镇或城市的板块称普通板块, 不具有特殊性质的城市板块称小城市板块。黄色普通板块特点为六边形中心分别连接了两条边的中点 (下称有 2 条铁轨), 普通绿色板块有 3 条铁轨, 普通棕色板块有 4 条铁轨。小城市与工业城市板块铁轨数量与普通板块一致, 按升级顺序分别可容纳 1,2,2 个站点, 收益分别为 20,30,40。大城市按升级顺序分别有 2,4,4-6,4-6 条铁轨, 可容纳 1,2,2,2 个站点, 收益分别为 30,40,50,60。大都会铁轨数量与大城市一致, 按升级顺序分别可容纳 2,2,3,3 个站点, 收益分别为 30,60,80,100。城镇板块按升级顺序分别有 2,4,4-6 条铁轨, 每个城镇收益为 10,10,20, 两个城镇在路线上被视为连续的两点, 路线可以停止于其间。铺设与升级的基本规则为:

- 对于地图上没有特殊颜色的格点, 仅能铺设黄色板块, 且城市与城镇数量与原图保持一致。
- 对于地图上的黄色格点与黄色板块, 仅能升级为绿色板块, 原有的铁轨必须保留。
- 对于绿色板块, 仅能升级为棕色板块, 原有的铁轨与城市属性、城镇数量必须保留。
- 对于棕色板块, 仅能升级为灰色板块, 原有的铁轨与城市属性、城镇数量必须保留。
- 对于地图上的灰色格点或灰色板块, 不能在其上铺设或升级。

此外公司铺设铁路必须提高某条路线的收益或延伸该公司原有的线路, 且不能将铁轨连接至蓝色边界。通常, 铺设或升级一块铁路不需要费用, 但初次在标有河流形状标记的格点上铺设时, 公司需要额外支付 20G 的改造地形费用, 对于丘陵标记与山脉标记的地区则分别为 40G 与 60G, 这些费用可以叠加。

### 5.2.4 设置车站

对于一个城市中的站点空位, 以公司的某站为起点, 经过一条任意长的路线若能到达该城市则该公司可以在此空位设置站点。另外, 不可在其他公司的预留位上设置车站。每个公司的起始站点放置没有费用, 此后第一个站点放置费用为 40G, 第二个及以后的站点费用为 100G。

### 5.2.5 运营线路

定义收益点为城镇, 城市或远方 (地图上带有黑色箭头的红色板块, 仅能从该板块的黑色箭头出入, 远方的当前可用最高级铁路颜色对应的收益记录在版图上)。则该公司长度为  $n$  的线路

定义为从一个收益点出发，通过铁路共经过  $n$  个城市 (含起点与终点) 并以一个收益点为终点，其间任何铁路不能重复使用，即六边形网格中任一格点同一条边不能被穿过两次，且不能穿过远方与同时不存在站点空位与该公司车站的城市 (仅能做起点或终点)，一个收益点仅能经过一次。一辆等级为  $n$  的火车不挂载车厢时被视为客运车，仅能被用于运用长度至多  $n$  的线路。挂载货运车厢时视为货运车，等级视为减少 1，线路需要以工业城市作为起点。此外，公司的线路之间也不能有铁路的复用，但一个收益点可以被多条线路经过。公司运营时必须选择总体收益最高的线路。

### 5.2.6 计算并分配收益

对于每辆火车，若其为

- 客运车，则选择其线路中其等级数量个收益点计算收益。
- 货运车，则其线路所有收益点均产生收益。

计算收益的收益点收益加和得到该火车的收益。该公司所有火车的收益加和得到该公司的收益。公司可以选择 100% 分红或保留收益，若

- 选择分红，则玩家收益等于公司收益乘以玩家持股量，位于公开市场的股票分红则会回到公司财产，IPO 中的股票为银行产生分红。若分红不为 0，则公司股价右移 1 格，否则左移 1 格。
- 选择保留收益，产生的所有收益进入公司财产，公司股价左移 1 格。

### 5.2.7 购买火车

火车可以从银行或其他公司购买，若

- 从银行购买，必须优先购买当前可用等级最低的火车，即公司向支付火车的面值，拿取火车至公司财产。
- 从其他公司购买，若双方总裁为同一玩家，则价格为 1G 至原价，否则必须在双方总裁同意下以原价购买，并从对方公司财产将火车转移至公司财产。

公司可以选择购入多辆火车，但必须在每一次购入产生的效果结束后购买下一辆。持车数量达到上限的公司不能购买火车，该步骤中不能主动出售火车。因各种原因持车数量超过持车上限的公司必须选择多余的火车舍弃。除火车外，公司可以购入货运车厢，其价格为 80G 每组，每一辆火车仅能挂载 1 组货运车厢。

## 强制购买

当公司存在线路而财产中没有火车时，需要强制购买火车，若公司财产中现金不足，需要尽可能使用该现金支付部分价格，总裁使用现金或出售股票补足剩余部分 (此时不触能发总裁更替，但影响股价)，或选择总裁仅支付部分不足量，其余欠款，每个运营轮开始时产生 50% 的利息，产生利息后可以进行还款。

### 5.2.8 并购私人公司

自第三阶段起公司可以在自身运营轮的任意时刻在双方同意下以 0.5 至 1.5 倍面值的价格购入私人公司凭证，此后该私人公司为此公司产生固定收益。

### 5.2.9 火车出口

第二阶段至第四阶段每个运营轮组结束时，银行将出口一辆当前等级最低的火车 (即移除)，这可能会触发阶段的更替。

## 5.3 游戏阶段

### 5.3.1 第一阶段

即第一次股票轮前的阶段，玩家在此阶段竞标私人公司。

### 5.3.2 第二阶段

第二阶段开始于第一次股票轮时，此时

- 黄色板块从此可用。
- 上市公司持车上限为 4 辆。
- 每个运营轮组仅有一个运营轮。
- 火车从此开始出口。

### 5.3.3 第三阶段

第三阶段开始于第一辆 3 级火车被购买时，此时

- 上市公司从此可以并购私人公司。
- 绿色板块从此可用。
- 上市公司持车上限为 4 辆。
- 此后每个运营轮组由两个运营轮组成。

### 5.3.4 第四阶段

第四阶段开始于第一辆 4 级火车被购买时，此时

- 所有 2 级火车立刻淘汰，即移除游戏并不再可用。
- 公司持车上限为 3 辆。
- 每个运营轮组由两个运营轮组成。

### 5.3.5 第五阶段

第五阶段开始于第一辆 5 级火车被购买时，此时

- 公司持车上限为 3 辆。
- 此后每个运营轮组由两个运营轮组成。
- 火车从此不再出口。
- 棕色板块从此可用。

### 5.3.6 第六阶段

第六阶段开始于第一辆 6 级火车被购买时，此时

- 公司持车上限为 2 辆。
- 每个运营轮组由两个运营轮组成。
- 所有 3 级火车立刻淘汰。
- 所有私人公司关闭并移除游戏。

### 5.3.7 第七阶段

第七阶段开始于第一辆 7 级火车被购买时，此时

- 公司持车上限为 2 辆。
- 每个运营轮组由两个运营轮组成。
- 灰色板块从此可用。

### 5.3.8 第八阶段

第八阶段开始于第一辆 8 级火车被购买时，此时

- 公司持车上限为 2 辆。
- 此后每个运营轮组由三个运营轮组成。
- 所有 4 级火车立刻淘汰。

## 5.4 游戏结束条件

当银行中现金首次耗尽 (银行中初始现金共 9000G) 的运营轮组结束 (玩家记录应获得分红, 并在游戏结束时计入现金) 或使第八阶段开始的运营轮组结束后经过一个股票轮与一个运营轮组后游戏结束。

## 附录

### 火车价格与数量表

火车等级	价格	数量
2	80	7
3	180	6
4	300	5
5	500	3
6	630	2
7	780	2
8	1000	无限供应

### 公司信息

公司代号	起始站位置	站标数
JZR	北京 (G14)	3
JHR	唐山 (G16)	3
HKR	上海 (K16)	3
BCR	成都 (L6)	4
LLR	兰州 (I6)	4
JGR	广州 (N10)	4
QTR	西宁 (I4)	3
NKR	昆明 (N4)	3

### 股票板

股票板股价从左至右依次为: 10,18,25,32,38,46,53,60,67,71,76,82,90,100,112,126,142,160,180,200,225,250,275,300,325,350,375,400  
当股价达到 400 而仍需右移时不移动。



# 18CE: Chapter 0

## 1 GENERAL INFORMATION

18CE: Chapter 0 is a 3-6 player railway construction and stock simulation game based on *Francis Tresham's 1829*. During the game, players purchase stocks, operate railroad companies: construct railway networks on a hexagonal grid map, set up stations, operate routes, and purchase trains, to generate revenue. The stock and operation process is divided into stock rounds, in which players trade stocks, and operating rounds, in which the director of a railroad company runs the company. As the train phase develops, there may be a different number of operating rounds after each stock round. The player with the highest cash + stock market value at the end of the game wins.

## 2 CORPORATIONS

In 18CE:Chapter0, companies are classified into private companies and share companies.

### 2.1 PRIVATE COMPANIES

Private companies are represented by their director certificate, which shows complete administration authority over the company. During operating rounds, private companies generate fixed revenue for their owners. Besides, most private companies have unique abilities, which their owners are able to activate on the occasion described in the director certificate. A share company is regarded as the owner of a private company after the private company is merged. There are 6 private companies in 18CE: Chapter 0, the general situation of which is described in the following table.

CODE	NAME	PAR VALUE	FIXED INCOME	EFFECT
A		20G	5G	No special effects.
B		40G	10G	Comes with the green "Zhangjiakou" tile.
C		75G	15G	Comes with railroad bridge technique.
D		110G	20G	Can be traded into a share.
E		180G	25G	Comes with the tradable "Shanghai" station.
F		260G	35G	Comes with the director share of JHR.

their effects are described specifically as follows.

- A: No special effects.

- *B*: A share company owning this private company may activate only once during the private company's operating round: lay a green tile on Zhangjiakou Hex(Hex G12) for free, in compliance with other rules.
- *C*: When a player owning this private company operates a share company, the terrain cost is reduced by 20G(applies for all types of terrain when there are multiple terrain features in a single hex)
- *D*: A player owning this private company may choose to trade this certificate for a 10% share of any company from its IPO or open market as the substitution of their purchasing shares action.
- *E*: This private company owns a station on Shanghai Hex(Hex K16). When merged by a share company, its director may choose to replace the station with one of the station marker in its treasury, and, mandatorily, the certificate is flipped to become a level 2 train, and no longer generates fixed revenue.
- *F*: When a player purchases this certificate, the player immediately gets the director share of JGR for free, and decide the starting share price(67G, 71G, 76G, 82G, 90G or 100G per 10%). When JHR floats, this certificate is immediately transferred to its treasury and flipped to become a wagon, which may be treated as a level 1 train during the first operating round of the company, and no longer generates fixed revenue.

## 2.2 SHARE COMPANIES

The stock of share companies are divided into a 20% director share and eight 10% shares. The first purchasable share of a company is its director share. When a player purchases a director share, the player first decides the starting share price for the company(67G, 71G, 76G, 82G, 90G or 100G per 10%), and then pays twice this price to the bank. The player who possesses the director share(such player is hereinafter referred to as the director) operates the railroad company during the operating round. Yet, when another player's shareholding ratio surpasses that of the director, the director exchanges the director share for two 10% shares which belongs to that player. After share companies operate their routes, their directors choose whether to pay out or retain generated revenue.

## 3 STOCK PRICE BOARD

Share companies have their share prices marked on the stock price board. Both player and company behaviors may result in changes in the stock price of a company, specifically speaking, when:

- stock round ends with the company's share fully owned by players: share price moves 1 space right.

- any amount of share sold by a player simultaneously: share price move 1 space left.
- a dividend greater than 0G is paid to shareholders: shareprice move 1 space right.
- the company has a dividend of 0G or retains generated revenue: shareprice move 1 space left.

## 4 GAME PREPERATIONS

### 4.1 SETUP

Divide all stock certificates into piles according to the company they belong to, and place each director share at the top of the pile. Place all trains in a numerical order.

### 4.2 INITIAL CAPITAL

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3 players	800G
4 players	600G
5 players	480G
6 players	400G

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### 4.3 PLAYER ORDER

Randomly determine the player with the priority deal. The stock round will begin with the player who possesses the priority deal, and will continue clockwise, such order is called the player order.

### 4.4 ETIQUETTE

- Players specify which agreements are valid and which are not before the game starts, and these agreements cannot violate the underlying rules.
- All in-game information: a player's cash and stock holdings, a company's treasury and trains, is public.
- Agreements between players need to be made public.

### 4.5 BIDDING FOR PRIVATE COMPANIES

Lay out the six private companies in ascending order of their values. In player order, each player may choose to:

- skip the turn for the time being.
- pay its face value to purchase the actual cheapest private company.

- bid for a private company which is not the cheapest one by setting the player's cash under the corresponding certificate. If no one has bid for the company, the lowest bidding price is its par value, otherwise it is the highest bidding price +5G, and the minimum raise is 5G.

After each purchase is settled, if the actual cheapest private company is already bid,

- if only one player bids for the company, that player immediately purchases the company at the bidding price, which is the amount set under by the certificate.
- If multiple players are bidding for the company, they recover their bidding funds, and take turns in ascending order of their highest bidding price, to offer their bidding price, starting from the highest bidding price, with the minimum raise of 5G. The players who quits will not join the next round of bidding, and the last player who remains in the auction will purchase at the bidding price that player offered.

When all players consistently choose to skip their turn and not all private companies have been purchased,

- If private company *A* has not yet been purchased, its face value is then reduced by 5G, when it becomes 0G, the next player must choose to purchase it.
- If private company *A* has been purchased, all purchased private companies immediately produce their fixed income for their owners.

When all private companies have been purchased by players, the priority deal is then given to the player next to the one who has made the last deal, in player order, and the first stock round begins.

## 5 GAME PLAY

The game is played in a stock round - operating round set order until the end of the game condition is met, at which point the player with the highest cash + stock market value wins.

### 5.1 STOCK ROUNDS

#### 5.1.1 GENERAL RULES

The player who possesses the priority deal becomes the starting player, the stock round then proceeds in player order. During a player's turn, that player may:

- skip the turn for the time begin.
- proceed selectively:
  - sell any amount of shares to the open market.
  - purchase a share from IPO or the open market.

- sell any amount of shares to the open market.

When all players continuously choose to skip their turn, the priority deal is given to the player next to the one who made the last deal, the current stock round then ends, and companies with all their shares purchased by players have their stock price move 1 space to the right.

### 5.1.2 CERTIFICATE LIMIT

There is a limit to the number of certificates a player can hold, i.e. the number of shares(a director share is counted as one certificate) plus the number of private company certificates. The limit is, specifically speaking:

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3 players	20
4 players	16
5 players	13
6 players	11

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Players who has reached the limit cannot purchase shares. In addition, players can hold no more than five shares(which equals 50% without a director share, or 60% with one) of a single company.

### 5.1.3 SALE OF SHARES

When selling stocks, players may sell any shares of the same or different companies in any order to the open market simultaneously: take cash from the bank equal to the sum of the market prices of these stocks, and then corresponding companies have their stock prices moved 1 space to the left. Yet, players can not sell President shares. Instead, the player must first exchange the director share with two 10% share from the second largest shareholder(if there is a tie: starting from the director and in player order, the first player who is the second largest shareholder wins the draw; if no other player has two 10% shares: the director share cannot be sold), and then sell stocks at least enough to not become the director again after the sale, i.e. sell share until the player holds less shares than the new director. In addition,

- No more than 50% shares of a single company are allowed in the open market.
- Shares of those companies which have not floated cannot be sold.
- Shares cannot be sold in the first stock round.
- Once a player sells any amount of shares of a company, that player cannot purchase shares of that company in the same stock round.

### 5.1.4 PURCHASING A STOCK

Players who have not reached the certificate limit can purchase any stock from the IPO or the public market.

- If the player is to purchase from the open market, the player pays to the bank for the stock the price indicated by the stock board.
- If the player is to purchase from IPO, then
  - if the director share has not yet been purchased, the player immediately decides the IPO price for the company(67G, 71G, 76G, 82G, 90G, or 100G), and pays twice the price to the bank to attain the director share.
  - if the director share has been purchased, the player pays to the bank the IPO price, and attain the share.

### **5.1.5 CHANGE OF DIRECTOR**

After a sale or purchase, if the director holds less share than another player, the current director exchanges the director share for two 10% shares from that player.

### **5.1.6 FLOAT**

Once 60% of the share company's shares have been held by players, the company float immediately. The director takes the company board, take 10 times the IPO price from the bank into the company's treasury, and takes all the company's station tokens.

## **5.2 OPERATING ROUND SET**

A stock round is followed by a number of operating rounds, which is called an operating round set.

### **5.2.1 OPERATING ORDER**

In an operating round, private companies operate first, generating fixed income, followed by all floated companies in descending order of share price (if multiple companies share the same share price, the last company to reach that share price takes precedence). When it's a share company's turn to operate, its director executes in order:

- Place the home station(mandatory, but only in the first operating round of a company).
- Lay or upgrade a tile.
- Set up a station.
- Run each train.(mandatory)
- Choose to pay out or retain the revenue.(mandatory)
- Purchase trains.

### 5.2.2 HOME STATION

Place the first station mark from treasury on hex with the company's code name printed on it(hereinafter referred to as the reservated location).

### 5.2.3 LAY OR UPGRADE TILES

In 18CE:Chapter0, there are four color-coded hexagonal tiles with rails, called yellow tiles, green tiles, brown tiles, and gray tiles, the upgrading order of which is yellow => green => brown => gray. Towns and cities are represented by black dots and white circles respectively on the map. A city tile with letters indicates its certain property. Specifically,

- I: Industrial city.
- Y: Major city.
- M: Metropolis.

The tile without towns or cities is called ordinary tile, and the tile with cities on it but without special properties is called ordinary city tile. The tracks on a yellow ordinary tile can be described as 'the hexagonal center connects the midpoints of two sides respectively' (hereinafter referred to as 'has 2 rails'), the ordinary green tile has 3 rails, and the ordinary brown tile has 4 rails. The number of rails in ordinary city tiles and industrial city tiles is the same as that in ordinary tiles, and they can accommodate 1,2,2 stations respectively in the upgrading order, with profits of 20,30,40 respectively. Major city tiles have 2,4,4-6,4-6 rails in upgrade order, and can accommodate 1,2,2,2 stations, with the revenue of 30,40,50,60, respectively. Metropolis tiles has the same number of rails as major cities, and can accommodate 2,2,3,3 stations in the upgrade order, with revenues of 30,60,80,100, respectively. The town tile has 2,4,4-6 rails in upgrade order, with each town generating a revenue of 10,10,20. Two towns are considered as two consecutive revenue centers on the route, and the route can end between them. The basic rules for laying and upgrading are:

- For hexes without special colors on the map, only yellow tiles can be laid, and the number of cities, city properties and towns should be the same as the original map.
- Yellow tiles and hexes on the map can only be upgraded into green tiles, original rails must be retained, and the number of cities and towns should be the same as the original tile or hex.
- Green tiles can only be upgraded to the brown tiles, original rails must be retained, and the number of cities and towns should be the same as the original tile or hex.
- Gray tiles and hexes on the map cannot be upgraded.

In addition, a company must increase the profitability of a route or extend the company's existing lines, and cannot connect tracks to the blue boundary. Normally, it is free to lay or upgrade

a track, but laying tiles for the first time on a hex marked with a river icon, the company will have to pay an additional 20G for the terrain fee, 40G for hilly and 60G for mountain iconed areas, and these costs can be added.

#### **5.2.4 SET UP STATIONS**

For a station vacancy in a city, the company can set up a station in this vacancy if it can reach the city through a route of any length starting from a station of the company. In addition, setting up a station on the reservation of other companies is forbidden. Setting up each company's home station is free, it then costs 40G for the first station and 100G for the second and subsequent stations.

#### **5.2.5 RUNNING TRAINS**

Define revenue centers as towns, cities, or off-board locations (red tiles with black arrow(s) on the map that can only be accessed from the black arrows on that tile, the revenue of which corresponding to the color of the highest available tile currently is recorded on the map) in a hex. Then, the company's line with the length  $N$  can be defined as 'starting from a revenue center, passing through  $N$  cities (including starting point and ending point) by railway and ending at a revenue center. During this period, any railway cannot be reused, that is, the same edge of any unique hex cannot be crossed twice, and can not pass through a city without any station vacancy or the company's station(which can only be the starting point or end point), with a revenue center being passed through only once. A level  $N$  train is considered as a passenger train when it is not carrying a wagon and can only be used to run routes of up to  $N$  length. When trains are equipped with wagons, they are regarded as freight trains, their levels are regarded as being reduced by 1, and their route must start from industrial cities. In addition, the company's routes cannot share rails, but a revenue center can be crossed by more than one route. Companies must operate the routes with the highest overall revenue.

#### **5.2.6 CALCULATE AND DISTRIBUTE GENERATED REVENUE**

For each train runned, if it is a:

- passenger train, select  $N$  revenue centers in its route and calculate its revenue, where  $N$  is its level.
- freight train, all revenue centers may produce revenue.

Add up the revenue of revenue centers to get the revenue generated by the train. The revenue of a company is the sum of all its trains' revenue. The director may then choose to pay out fully or retain the company's revenue. And if:

- the director decides to pay out, a shareholder's revenue is then equal to the company's revenue multiplied by the player's shareholding, the shares in the public market pay out to



the company's, while the IPO shares pay out to the bank. If the dividend is not 0G, the company's share price moves 1 space to the right, otherwise it moves 1 space to the left.

- the director decides to retain the revenue, it is then transferred from the bank to the company's treasury. Then its stock price moves 1 space to the left.

### **5.2.7 PURCHASE TRAINS**

Trains may be purchased from the locomotive works or from other companies. If a train is to be purchased from:

- the locomotive works, the company must purchase the train with the lowest available level: the company pays the face value of the train to the bank, and takes the train to its treasury.
- another company's treasury, then if a single player happens to be the director of both companies, the price may range from 1G to the original price; otherwise, the train must be purchased at the original price and by mutual consent, and is then transferred from the treasury of the other company to the treasury of this company.

Companies can choose to purchase more than one train, but they must purchase the next one after the effect of each purchase has been resolved. Companies that have reached the train limit cannot purchase trains and cannot voluntarily sell trains. Companies holding more than the train limit for various reasons must choose to discard the surplus trains. In addition to trains, the company can purchase wagons at a price of 80G each. Each train can only carry one wagon.

## **FORCED PURCHASE**

When a company has a route but own no trains in its treasury, it is forced to purchase a train. If there is not sufficient cash in the treasury and other companies refuse to sell their cheaper trains, the company then pays as much cash as possible (i.e. all of its cash in its treasury), its director then pays for the rest. And if the director does not have sufficient cash, the player may sell stocks to make up for the rest or raise a loan from the bank, with the interest rate of 50% per operating round. The loan may be repaid fully or partly after the interest is paid at the beginning of each operating round.

### **5.2.8 MERGE COMPANIES**

Beginning from Train Phase 3, a share company may, at any time in its own operating round, purchase a private company certificate from a player at a price between 0.5 and 1.5 times its face value, by mutual consent, after which the private company generates a fixed income for the company in future operating rounds.

### **5.2.9 EXPORT TRAINS**

At the end of each operating round set from Train Phase 2 to Train Phase 4, the bank exports the train of the lowest current level (i.e. remove from game without adding more cash to the bank), which may trigger a change in Train Phase.

## **5.3 TRAIN PHASES**

### **5.3.1 TRAIN PHASE 1**

This is the stage before the first stock round, where players bid on private companies.

### **5.3.2 TRAIN PHASE 2**

Train Phase 2 begins with the first stock round. At this point,

- Yellow tiles are available from now on.
- Share companies may own no more than 4 trains.
- Each operating round share includes 1 operating round.
- Trains are exported at the end of each operating round set from now on.

### **5.3.3 TRAIN PHASE 3**

Train Phase 3 begins when the first level 3 train is purchased, and at this point,

- Share companies may merge private companies from now on.
- Green tiles are available from now on.
- Share companies may own no more than 4 trains.
- Future operating round sets(i.e. those after the set when the phase changed) include 2 operating round each.

### **5.3.4 TRAIN PHASE 4**

Train Phase 4 begins when the first level 4 train is purchased, and at this point,

- All level 2 trains rust and are removed from the game.
- Share companies may own no more than 3 trains.
- Operating round sets include 2 operating round each.

### **5.3.5 TRAIN PHASE 5**

Train Phase 5 begins when the first level 5 train is purchased, and at this point,

- Share companies may own no more than 3 trains.
- Operating round sets include 2 operating round each.
- Brown tiles are available from now on.
- Trains are no longer exported.

### **5.3.6 TRAIN PHASE 6**

Train Phase 6 begins when the first level 6 train is purchased, and at this point,

- Share companies may own no more than 2 trains.
- Operating round sets include 2 operating round each.
- All level 3 trains rust and are removed from the game.
- All private companies are closed and removed from the game.

### **5.3.7 TRAIN PHASE 7**

Train Phase 7 begins when the first level 7 train is purchased, and at this point,

- Share companies may own no more than 2 trains.
- Operating round sets include 2 operating round each.
- Gray tiles are available from now on.

### **5.3.8 TRAIN PHASE 8**

Train Phase 8 begins when the first level 8 train is purchased, and at this point,

- Share companies may own no more than 2 trains.
- Operating round sets include 3 operating round each.
- All level 4 trains rust and are removed from the game.

## **5.4 END OF THE GAME**

The game ends after the operating round set when the bank runs out of cash for the first time (the initial amount of cash in the bank is 9000G) ends(players record the dividends they ought to receive, they are counted as cash after the end of the game), or when the second operation round after Train Phase 8 starts(including the one between Train Phase 7 and Train Phase 8) ends. The player with the most cash + share market value wins.

## APPENDIX

### AMOUNTS AND PRICE OF TRAINS

Level	Price	Amount
2	80	7
3	180	6
4	300	5
5	500	3
6	630	2
7	780	2
8	1000	Unlimited

### SHARE COMPANIES

Code Name	Home Station	Staion Markers
JZR	Beijing(G14)	3
JHR	Tangshan(G16)	3
HKR	Shanghai(K16)	3
BCR	Chengdu(L6)	4
LLR	Lanzhou(I6)	4
JGR	Guangzhou(N10)	4
QTR	Xining(I4)	3
NKR	Kunming(N4)	3

### STOCK PRICE BOARD

Stock price on the stock price board from left to right: 10,18,25,32,38,46,53,60,67,71,76,82,90,100,112,126,142,154,166,178,190,202,214,225,250,275,300,325,350,375,400

When the stock price reaches 400 and still needs to move right, its does not move.