Kuwait’s al-Manakh stock market crash in August 1982, which resulted in an outstanding debt of US $94 billion, subjected banks to high risks and precipitated an economic recession, business failures, and bankruptcies. Courts could not settle traders’ debts one at a time because of their entanglement. We constructed linear programming models to identify insolvent traders, to determine the fraction of debt insolvent traders could pay their creditors, and to apportion an insolvent trader’s payment to his creditors by asset type. The models provided the basis for the final court decisions in resolving the crisis. They proved to be effective, equitable, and robust. Without this work, courts would have been occupied for years with the criminal, commercial, and bankruptcy cases resulting from 29,000 postdated checks; it avoided more than $10 billion in court costs and attorney fees.

Kuwait is a small country whose economy is heavily dependent on its considerable oil wealth. In addition, its harsh climatic conditions, absence of natural water resources, and the lack of mineral and ferrous deposits limit the opportunities for productive investment. With the government owning almost half the country’s
share-holding companies, small and medium size Kuwaiti investors are left with few alternatives. They can invest their surplus funds abroad, in real estate projects at home, or in the local stock exchange. Whenever local liquidity increased and investment abroad became less attractive, funds flowed home toward land and stocks, both of which could readily become speculative in the absence of institutional regulations and government control.

From 1952 to 1960, only three share-holding companies were established. As the number of shareholding companies increased, stock trading began to take place even before the government regulated the official exchange. In 1970, a national committee was set up to oversee stock-trading activities in the official stock exchange, known as the Kuwait Stock Exchange (KSE).

While the '60s witnessed slow and limited stock trading, by the mid-'70s trading became heavy and often speculative. An increase in liquidity coupled with low returns on capital abroad due to the instability of foreign exchange and lower interest rates produced more traders with sizable funds who were ready to play the Kuwaiti market. The number of traded shares climbed from 37.3 million in 1974 to 172.2 million in 1975 and to 176.3 million in 1976. This increase, however, could not continue because it was fueled by the use of postdated checks, used as a means of payment but not necessarily backed by available funds. The bottom fell out in 1977. The volume of traded shares dropped to 60 million [Al-Bablawi and Fahmy 1980]. Share prices also fell by 38 percent, causing a widespread panic among traders and engulfing this small country in crisis.

This was Kuwait's first stock market crash. It was attributed to the dominance of speculative trading, aided by the emergence of more and more new companies and by the use of postdated checks. In response, the government temporarily banned the establishment of new shareholding companies and severely restricted the use of postdated checks. To resolve the crisis, the government compensated traders for their losses by buying their shares at the lowest price realized during the market's 2.5-month peak period prior to the crash. The cost of the bailout exceeded 150 million Kuwaiti Dinars (KD) or about $525 million.

Evolution of al-Manakh Stock Market

With the third major oil price hike in 1979, government oil revenues increased from KD 2.3 billion in 1977/1978 to KD 5.8 billion in 1979/1980 (one Kuwaiti Dinar (KD) = US $3.50). This caused public spending to increase from KD 1.753 billion to KD 2.295 billion during the same period. Once again, the limited availability of investment opportunities coupled with increased liquidity created the environment leading to another speculative bubble. This time, however, it was carried out in a parallel, unofficial stock market that existed side by side with the then government regulated KSE. This unofficial market became known as Souk al-Manakh, or "The Manakh Market."

Because of the ban on new Kuwaiti companies, traders registered companies in neighboring Gulf countries, notably Bahrain and the United Arab Emirates, using Kuwaiti funds. Shares of these Gulf companies in addition to those of newly established Kuwaiti closed joint stock companies provided the al-Manakh traders with
their own stocks. Because of the absence of institutional regulations in Souk al-Manakh, the presence of excess liquidity, and the heavy use of postdated checks, stock prices soared. This in turn lured funds to the market and created a strong demand for additional shares of new companies. The Central Bank of Kuwait (CBK) reports [CBK 1983] that between 1979 and 1982, 45 new Gulf companies and 120 closed Kuwaiti companies were established. As it turned out, quite a few were established for speculative purposes only. In 1982, the year of the crash, traded shares of al-Manakh Gulf companies amounted to 3.5 billion compared to only 837 million in the KSE. In

A 100-percent price increase in a few weeks was considered the norm.

the three months from June to August 1982, two billion shares were traded [CBK 1982]. The share market value of the Gulf companies reached KD 2 billion in 1982 compared to an initial face value of only KD 648 million [IBK 1985].

By the summer of 1982, about 6,000 individuals and legitimate corporations were trading feverishly in this market. It was not unusual to realize a 100-fold spread between the par value of a new issue and its al-Manakh price within the first few weeks of its initial public offering. And it seems that once a price was set, it seldom looked back. A 100-percent price increase in a few weeks was considered more the norm than the exception. A trader usually sells a stock at its current market price if it is paid for immediately in cash. This price represents the current spot price. However, if the buyer pays for the stock using postdated checks, the seller receives a premium over the spot price. This premium compensates the seller for the delay in getting paid until the postdated check become due. With the use of postdated checks, some traders received an average premium of 60 percent per annum over current spot prices. This premium climbed to 200 or 300 percent among the few large traders who dominated the market. Trading in the al-Manakh stock exchange thus began to take on the characteristics of another speculative bubble. Even in the relatively docile KSE, the CBK [1982] reports that the turnover ratio (traded shares/tradable shares) reached 70 percent in 1981 compared to only 48 percent in 1980.

Clearly al-Manakh stock market was an anarchic stock exchange. Uncertified and untrained brokers traded many worthless securities often at astronomical P/E ratios using crude and sometimes illegal (postdated checks) settlement methods. It was operating with no supervision by any regulatory body.

al-Manakh Market Collapse

In August 1982, the bubble burst when one large trader defaulted. Total shares traded during this month fell to 72 million from 602 million shares in the preceding month. By then, the Souk had been operating for about three years. The subsequent meltdown left its impact on the rest of the economy where other assets lost much of their precrash values. The all-share price index of the official KSE, for example, fell 53 percent (from 509.4 at the end of 1982 to 238.6 two years later). Securities traded in al-Manakh lost 60 to 98 percent of their
peak values. Likewise, commercial and investment real estate, whose values had increased annually by 63.9 and 21.5 percent, respectively, between 1979 and 1982, dropped by 26.6 and 18.2 percent per annum between 1983 and 1985 [CBK 1985].

Moreover, neither the government nor the central bank had any knowledge of the magnitude of the outstanding transactions on the day of the crash—the number of traders, the size of trades, debt balances, the financial positions of brokers and traders, and so forth. Traders were left with handwritten IOU notes, postdated checks, stocks of different companies, including defunct Gulf companies, some real estate, and cash balances. They were entangled in a web of two-way IOU notes and postdated checks. The following staggering facts about the al-Manakh stock market emerged:

—The crisis involved individual speculators, legitimate banks, industrial firms, and commercial companies.

—The outstanding debt amounted to US $94 billion or about 4.3 times the nation's gross domestic product. This was equal to the face value of al-Manakh's 29,000 postdated checks. In comparison, postdated checks in KSE over the period 1978-1982 totaled only $30 billion.

—Ninety-five percent of the total outstanding debts involved only 18 traders.

—The number of declared bankruptcies during the early days of the crisis reached 350.

—The banking sector was heavily involved in that it expanded its local credit facilities in 1982 at double the rate of the previous year. It allowed personal loans to increase by 92.4 percent and loans for financial purposes, some of which found their way to speculative stock trading, to grow by 123.4 percent.

Because the collapse of the souk affected a large segment of the population, directly as well as indirectly, it precipitated a crisis of national proportions with wide regional and international effects. World press coverage of the event appeared in the Wall Street Journal [1983 and 1984], the Washington Post [Ottaway 1982], and Atlantic magazine [Epstein 1983], among others. The last stated: "In Washington the US State Department began to focus on the distant crisis. The Near East division sent back to the Embassy in Kuwait a series of questions that, if nothing else, illuminated the concerns of the Reagan administration" [Epstein 1983].

**Damage Control Measures**

To contain the damage, the government established late in 1982 (1) a clearinghouse company with the objectives of collecting, matching, verifying, and systematizing the financial accounts of individuals and brokers, (2) a $1.7 billion trust fund to compensate small investors (those with losses less than $1.7 million), and (3) an arbitration panel to effect settlements and to finalize those reached voluntarily between traders. The government also set up a special organization, the Corporation for the Settlement of Company Forward Share Transactions, in April 1983 with the objectives of designing and implementing the policies required to bring the crisis to an end. It is similar to the US S&L Resolution Trust Corporation (RTC). The government established a task force in the spring of 1983, headed by the minister of finance, to oversee the overall national effort directed to-
al-Manakh Stock Market Events

al-Manakh market begins trading.  
al-Manakh stock market collapses.  
Law (57/82) passed, establishing  
— The clearinghouse company,  
— The arbitration panel,  
— The small investors fund, and  
— September 20, 1982 [CBK 1983] as a due date for all postdated checks with profits prorated accordingly and the original rate of return retained.

Facts about the size of the al-Manakh debt became known.  
— The clearinghouse company receives 29,000 postdated checks worth about $94 billion.

The government establishes the Corporation for the Settlement of Company Forward Share Transactions.

Two experts of al-Manakh special task force ask the second author, Girgis, informally to look into ways of clearing up entangled debts.

The government takes a new approach to resolve the crisis.  
— A new finance minister seeks our participation.  
— We propose the use of LP to determine the debt settlement ratios (DSRs) to clear up debt.  
— The minister becomes convinced that entanglements involving two or more traders cannot be resolved without the use of LP.  

We determine DSRs for the largest 18 traders, which are published in the local paper.  

DSRs for the largest 254 insolvents without apportionment by asset type are made public.  

DSRs for the largest 254 insolvents with apportionment by asset type are made public.  

We determine DSRs for the last batch of 100 traders.  

Payments to creditors begin.  

Table 1: The chronology of events in al-Manakh stock market crisis shows that our involvement started in the summer of 1983, about one year after the crash. We determined the debt settlement ratios in batches with the last batch completed in 1985. Economic indicators started to improve by 1986, when all parts of the solution were in place.

ward resolving the al-Manakh debacle.

Initially, it was natural for the government to resort to legal means to resolve the crisis. Legally, all traders must fulfill their promises and pay their debt in full to all creditors. This, however, proved to be impossible in light of the fact that many traders became insolvent. One year passed and very few voluntary settlements took place.

Insolvents were unable to redeem their postdated checks. The arbitration panel prosecuted several of those traders and declared their bankruptcy. The legal approach did not help in restoring confidence in the economy and the business climate of the country at large. The economy continued to be paralyzed and banks continued to be threatened. Accordingly, the government

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decided to alter its course in dealing with the problem. Its major concern was to un-
tangle traders and settle debts in the short-
est possible time. Our involvement began as part of the overall national effort to re-
solve the crisis. Table 1 summarizes the chronology of events in al-Manakh stock market crisis.

The Traders’ Entanglement

Disentangling traders was difficult. Financial records did not exist at the time of the crash. Even if this obstacle was re-
moved, it would have been impossible still to solve the entanglements one at a time because of the insolvents’ simultaneous de-
pendencies on each other.

For example, Trader A expected to re-
ceive payments from Traders B and D (Figure 1). He was also expected to pay his debts to Traders B, C, and D; and so on for Traders B, C, and D. Insolvent
Trader A is unable to ascertain how much he can pay his creditors B, C, and D for each dollar he owes them because he does not know how much insolvent trader B can pay him when B’s receivables are partly dependent on C’s ability to pay. C’s ability to pay, however, depends on A’s ability to pay C.

Evolution of the Solution Approach

After the crash, the government called on many experts for advice. In April 1983, two experts explored the possibility of using a simultaneous equation system with M. Girgis, the second author, and provided him with approximate data on the largest anonymous 18 traders. During this project, all three authors were members of the Techno-Economics Division of the Kuwait Institute for Scientific Research (KISR), which had the expertise and tools to work out a solution. The main objective was to

![Figure 1: A typical four-trader A, B, C, D entanglement. Each square represents a trader. The top section of each circle identifies a trader while the lower part represents the trader’s assets. The top half of the square represents receivables while the lower section represents payables. Assets, receivables, and payables are in millions of dollars.](image-url)
compute the equilibrium debt settlement ratio (DSR) for each trader, that is, how each trader would divide his assets fairly to all his debtors. We defined the DSR of a trader as follows:

\[
DSR = \text{Minimum} \left[ \frac{\text{Assets} + \text{Actual Receivables}}{\text{Payables}}, 1 \right].
\]

We defined a system of linear equations to solve the problem. We encountered some pitfalls at the outset. To obtain a solution, we solved a linear set of 18 equations using matrix inversion. Each equation represented the financial position of a trader. The diagonal element represented his total payables to all creditors, while off diagonal elements were the negative of his receivable from each of the 18 traders. The right hand side of the equation was the total assets of the trader. The solution was straightforward, and we did not encounter any numerical difficulty.

Meanwhile we looked at different ways to calculate DSRs. We also observed that if a trader was solvent despite defaults by his creditors, then the system of linear equations would provide a DSR greater than one; that is, a trader could wind up paying more than he owed. We had to find tools that would derive DSR while restricting its value to a maximum of one.

In a meeting with KISR’s chief executive officer and the finance minister, we proposed applying linear programming to compute the DSRs. We made the key point that our approach would compute DSRs in a way that protected the rights of all creditors while maintaining the utmost level of fairness in asset distribution. We also noted that the LP approach would provide wide flexibility in the form of applying bounds on the DSR, namely \(0 \leq DSR \leq 1\). We proposed several objective functions:

1. Minimize the number of bankruptcies,
2. Maximize the payoff of solvent creditors,
3. Maximize the minimum DSRs of insolvents,
4. Maximize total payments to all creditors,
5. Maximize the sum of insolvents’ DSRs,
6. Minimize insolvents’ deficits (assets + receivables − payables),
7. Determine DSRs that were least susceptible to further deterioration in asset values, and
8. Determine DSRs while keeping the DSRs of the largest 25 insolvent traders equal.

After careful deliberation, the minister selected the fifth objective function to maximize the sum of all DSRs, which had much in common, mathematically, with the others. Two considerations influenced the selection of this objective function:

—First, if all traders paid their debts in full, the debt settlement problem would disappear, minimizing its negative impact on the economy.
—Second, in the interest of fairness, the objective function should guarantee that all traders were treated equally and in accordance with the strengths and weaknesses of their precrash financial portfolios, al-Manakh stock trading, and their choice of trade cohorts.

A few weeks later, we were handed the actual financial positions for the first 18 traders. We entered these data and obtained the outcome of the model. The min-
Figure 2: This four-group classification of traders was based on the relationship among their assets, receivables, and payables. Only traders in the second and the third groups need to be in the LP model.

ister quickly spotted our few data-entry mistakes. The results of our calculations appeared in next morning’s daily newspapers [AlQabas 1983], the DSRs for the largest 18 traders. Publishing this information in the paper was important to progressing towards a resolution of the crisis.

Classification of Traders

At the outset, we classified the al-Manakh stock market traders into the following four groups (Figure 2):

1. Definitely solvent traders have assets exceeding their payables and can therefore pay all their debts in full even if they are not paid their receivables.

2. Seemingly solvent traders have assets and receivables that together exceed their payables; however, some of their debtors may default on a portion of their debts, rendering the sum of assets and actual receivables less than payables.

3. Definitely insolvent traders with positive receivables have payables that exceed the sum of their assets plus receivables.

4. Definitely insolvent traders with zero receivables have payables that exceed their assets and no receivables.

In contrast to the market-induced insolencies of the first two groups, traders in the last two groups overextended themselves in the market by issuing postdated checks to cover stocks at high future share prices compared to the current spot prices in the expectation that the stock market would turn around in their favor.

Determination of the Debt Settlement Ratios (DSR)

We developed a linear programming
model (appendix) to identify which, among the set of seemingly insolvent traders, had become definitely insolvent because of worsened market conditions. In addition, the model was to simultaneously determine the DSRs for all traders. We included in the model only traders in groups 2 and 3. During the conceptualization stage, we abided by the legal requirement that each insolvent trader must treat his creditors equally by paying each of them the same percentage on each Kuwaiti Dinar worth of his debts.

When legally binding claims should have been deducted from an insolvent's assets prior to distributing them to his creditors, we entered only the balance in the model. We also assumed for the time being that all assets were homogenous, perfectly substitutable and of identical risks.

We noticed, however, that the vast majority of al-Manakh traders were small definitely solvent traders. We therefore excluded them at the outset since they were able to pay all their debts in full. We computed the payments made by traders in the first and the fourth groups in a separate operation outside the LP model and used these payments to augment the assets of their creditors. We thus reduced the problem formulation to identifying solvent from insolvent traders within the relatively small number of seemingly solvent traders, in addition to estimating the DSRs for traders in groups 2 and 3 (the seemingly solvent traders and definitely insolvent traders with positive receivables), whose assets would be used to settle their debts.

We also identified a special structure of the LP model. This structure indicated that the optimum LP solution stays the same as long as the values of objective function coefficients remain positive [Elimam, Girgis, and Kotob 1996].

We used the IBM Mathematical Programming Software Package MPSX 370 [IBM 1980] on the IBM 4341 computer to determine the DSRs.

**Distribution of Payment by Asset Type**

The government classified each trader's assets into the following four categories, from the least to the most risky: (1) cash and equities of Kuwaiti KSE-listed companies, (2) real estate, (3) receivables from solvent traders, and (4) equities of Gulf and Kuwaiti closed joint stock companies (Figure 3). The minister posed the question, "In which combination of assets should debts be paid to creditors?" Deciding this was very complicated, because some assets would accrue to traders from other traders, without knowing their quality or form a priori.

It is only fair to distribute traders' assets to their creditors in the same proportion as that of their asset and actual receivables portfolio. We achieved such distribution by resolving entanglements among traders for each asset type through a system of simultaneous linear equations for each type of asset (appendix).

We will illustrate. Suppose a trader's DSR is equal to 0.7, indicating that he will be paying only 70 percent of his debt. To distribute debt payment by asset type, we further determine that this trader will pay 30 percent of his debt in cash, 25 percent in real estate, 10 percent in Gulf stocks, and five percent in receivables from solvent traders. Each creditor of this trader gets paid back in this same mix.

We first implemented this approach to
determine the DSRs and their distribution by asset type for the largest 18 traders (Figure 3), which were announced by the finance minister and published in the local press.

To implement this solution, the government acted as a holding company. It assumed insolvents’ debts, bought their assets, received their payments, and took responsibility for paying their debts to their creditors as per their DSRs. The government used the DSRs determined by our models to compute the actual payables and actual receivables by asset type for each trader. These actual payables and receivables were netted out to determine the amount owed to each creditor by asset type. For all asset types, except for cash, the government issued bonds with future maturity dates to creditors for the amount calculated in each asset type. The arbitration panel put the settlement into effect.

To illustrate the implementation process, we will use the hypothetical four-trader entanglement in Figure 1. Table 2 shows how their assets, classed in the four types, were distributed. By applying the LP model, we determined the DSRs for all traders (Table 3, last row). Only Trader C was solvent. Then, we used the distribution of payment by asset type for the four traders to determine a DSR for each asset type (Table 3).
Table 2: Trader C is solvent since his assets exceed his payables. Trader D is insolvent since his assets plus receivables of $30 million fall short of his $50 million debts.

Next, we determined the actual payables, total and by asset type, and the actual receivables for the four traders. By netting out the actual receivables plus assets minus the actual payables, we determined that Trader C was the only solvent trader.

Subtracting the actual receivables of Trader C from the other three traders minus his actual payables to those traders for each asset type, we determined the amount of cash and KSE equities, real estate, receivables from solvent traders, and Gulf equities that Trader C would receive (Table 4). Trader C would receive $6.63 million in cash, real estate bonds worth $12.236 million,

Table 3: The LP model is used to determine the DSRs for the four traders, given in the last row. Traders A, B, and D are insolvent. Each DSR is divided into four components, one for each asset type.

$6.215 million in receivables from solvent traders entitlements, and $17.989 million in Gulf equities entitlements. Traders A, B, and D were insolvent, and they handed in all their assets and relinquished their receivables to the settlement agency, which assumed responsibility for their actual payables to creditors.

Merits of the Mathematical Models

The actual implementation of the LP and the models to distribute payment by asset type proved to be of merit for the following reasons:

—The government had a robust quantitative tool to determine DSRs, to identify insolvents, and to measure the DSRs’ sensi-

Table 4: This calculation is needed only for solvent traders. All insolvents turn over their assets and claims to their receivables to the clearing company. The last row provides the entitlements of solvent Trader C in millions of dollars.

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tivity to changes in asset values or the addition of new insolvent traders.

—The government had the means to distribute the payments of insolvent traders to their creditors by type of assets in a mathematically exact way that was simple and effective.

—Unlike the arbitration, our approach has precisely and systematically maximized the sum of the DSRs for all traders so that the whole economy is better off; all creditors were treated equally in that they all received the same DSR from any one single debtor; and the financial robustness, or the lack thereof, of each trader’s DSR fairly reflected the weaknesses and strengths of the specific trade cohorts he or she selected.

—Regardless of the number of traders involved in the system and the complexity of the intratrader cash-flow relationships, our approach delivered accurate DSRs. Not only did it settle direct debt interrelationships but it also traced out all the indirect linkages to the nth trader, that is, until it was all exhausted. Such finality and comprehensiveness could not have been accomplished, one trader at a time, through voluntary settlements or through the courts.

—It provided the main tools the government used in computing the bonds established to distribute insolvent trader payments to creditors.

—The LP model’s special structure ensures that the optimum solution is insensitive to changes in the objective function coefficients as long as they stay positive.

—The model is transportable to similar post crash situations, where trader payables, receivables, and assets interact.

Implementation in Sequential Batches

Ideally, one would prefer to disentangle the web of debt for all traders in a single batch. This, however, was not possible because it took time to collect the financial data and to appraise the values of assets. In the meantime, pressure was mounting to provide an outcome, particularly since a year had already passed in attempts to resolve the crisis legally. Therefore, we had to determine the DSRs in batches of traders once we knew their asset values and entanglements.

Initially, we determined the DSRs for the largest 18 traders. Since the payables of traders in this batch far exceeded the sum of their assets and receivables, we used the IMSL [1980] FORTRAN programs to solve a system of linear equations and determine the DSRs.

The subsequent batches contained some traders who were classified as definitely solvent traders or seemingly solvent traders, some of whom would end up with DSRs greater than one. This triggered the need for developing the LP model, which we first applied to the next 120 traders, including the largest 18. A year later, when enough data had been collected, we processed the second batch, consisting of 254 traders. A year after that, we determined the DSRs for the last batch of traders, containing about 100 new insolvents. Because of the continuing decline in asset values, some traders who were solvent during the first batch had become insolvent by the second. Meanwhile, individual values of DSRs kept falling as total assets and receivables declined. Because of the increasing pressure to wrap up the crisis and announce the DSRs, the settlement agency was forced to assume the same asset values in the second and subsequent runs as in the first batch.
This way the initial DSRs obtained in early runs were no different in later runs. When assets dropped below their initial values, the government had to absorb the resulting losses. The settlement agency charged a one percent processing fee on each insolvent’s total assets (collected prior to determining their DSRs) to offset this additional cost.

Two Legal Controversies

The most controversial legal issue was whether or not to subject insolvent traders to the prevailing commercial law in Kuwait, which imprisons individuals who issue checks against insufficient funds, regardless of their due dates. Since almost all the insolvent traders were guilty of bouncing checks, invoking this law would have meant sending these traders to jail en masse. This outcome would not have been acceptable from a political, social, and especially economic viewpoint, since many of the al-Manakh bankrupt traders were key economic entrepreneurs in Kuwait. In addition, many solvent traders were becoming insolvent through no fault of their own, a phenomenon that added credence to those who questioned the suitability of the country’s commercial laws. The other alternative was to set up a special court to deal with al-Manakh bankruptcies. This alternative prevailed because it also stipulated that traders who had knowingly committed unlawful acts of deceit or fraud would be duly tried under existing laws. The arbitration panel was therefore set up as a special court with powers to issue final edicts.

Another legal issue dealt with postdated checks. Suppose a postdated check, which would become due in a year, is used to pay for a stock sold at a 60 percent premium above its original spot price. And if the market collapsed only two months after the check was issued, should the face value of the check be altered to reflect the two-month duration? And if so, on what basis and how can one choose the date on which all postdated checks caught in the crash should become due? Partly because of concern over these issues and partly to reduce the overall size of the outstanding debt, the government ruled that all postdated checks would become due on September 20, 1982, regardless of the date they bore [CBK 1983]. As for the face value of the check, the government initially decreed that the markup rate agreed upon in the forward contract would be maintained but the value of the check would be figured in proportion to the time that had elapsed from its issuance to the government-set due date. As it became evident that the markups were quite high, the government later added a cap of 25 percent per annum of the spot price.

Benefits of the LP Solution

To gauge the benefits of the LP solution, we can compare it to what would have happened with a no-LP approach. In the absence of our solution, it is very likely that (1) the number of individual and business bankruptcies would have been enormous, (2) the courts would have been overwhelmed for at least five years with criminal, commercial, and bankruptcy cases, (3) at least five of the six banks operating in
Kuwait would have been technically insolvent; in fact, they would have closed down because they could not have written off al-Manakh’s massive bad debts, (4) the nation’s wealth in terms of current market values would have declined further, (5) fears and uncertainty would have stifled any chances for a revival of economic growth, (6) the country would have continued to tear itself apart as strong opposing views, accusations, political posturing, and social discord persisted.

Some of the benefits of the LP modeling solution follow:

(1) The LP-generated DSRs slowed down and in some cases arrested the downslide in asset values that was precipitated by the crash. In 1986, when all parts of the comprehensive solution were in place, both the real estate and the equity markets began to reverse their earlier downward trends. Investment and commercial real estate values, which rose by 22 to 64 percent annually between 1979 and 1982, fell by 18 to 27 percent over the years 1983 to 1985. In 1986, they increased by one to eight percent. In the KSE the volume, value, turnover ratio, and number of transactions increased during 1986 to 123 million shares, KD 354 million, 17.7 percent, and about 23,000 deals compared to 42 million shares, KD 112 million, 6.2 percent, and about 10,000 deals in 1985. In fact, only in the fourth quarter of 1986 did the value of traded shares of Kuwaiti shareholding companies exceed KD 100 million since the fourth quarter of 1983.

(2) When asset values decreased after the crash, many loan holders could not honor their obligations toward the banking sector. This gave rise to the “nonperforming loans” problem. Though bad loans reached more than $7.5 billion at a time when total net equity was only $3.5 billion, the problem was contained because the decline in value of the collateral for the original loans (real estate, cash, business names, and reputations) slowed.

(3) The government of Kuwait is the largest employer, investor, consumer, and exporter in the country. Moreover, the government’s role in the economy is shaped by its oil revenue, which represents about 90 percent of its total revenue (1982 to 1988). Despite the drastic and unusual drop in the price of Kuwait’s oil from $25.75 in January 1986 to $7.00 per barrel in July of the same year, the ability of our approach to provide a solution to the crisis lessened the uncertainty of consumers and businesses with regard to the future of the economy and cushioned the decline in gross domestic product. The overall decline was slight compared to what it might have been.

(4) The crash produced a rash of conflicting opinions and suggestions from members of the executive branch, the National Assembly, and the press about how best the country should resolve the crisis. Our approach helped tone down these differences. Not only that, it demonstrated that the government was in control of the crisis.

(5) By netting out intertrader debts and credits, the gross debt of al-Manakh crash fell from $94 billion to $20 billion.

(6) Perhaps the most pronounced benefit was saving the legal system from protracted litigation. Each of the initial 29,000 postdated checks, in the absence of our approach, would have become three court cases: a criminal case for issuing checks with insufficient funds, a commercial case...
for violating commercial laws and banking regulations, and a bankruptcy case to verify debts and distribute assets. Each case takes, on average, about five years. Since 4,884 commercial cases were tried in the court system in 1983 [Ministry of Justice 1984], the court’s workload would have increased 18 fold over the next five years. We also estimate that the budget of the ministry of justice would have increased 18 fold over five years by about $380 million. On the other hand, because court costs amount to one percent and the attorneys, to about 10 percent of the disputed amounts, court costs and legal fees would have amounted to $10.34 billion for a debt of about $94 billion. 

(7) Our solution made it unnecessary to proceed with court-ordered bankruptcies, thereby avoiding a massive decline in asset values that would have resulted from auctioning the assets of all the bankrupt traders at nearly the same time.

(8) According to the 1980 census, the Kuwaiti population was 0.565 million, with males over 25 amounting to less than 16 percent or about 86,000 individuals [CSO 1984]. Souk al-Manakh provided this small segment of the population with the opportunity to interact closely and profitably with each other in the course of trading in the al-Manakh and KSE between 1979 and 1982. Very few resisted the lure of al-Manakh. The crash pitted families and members of families against each other. Had disputes between traders been left to the legal system and had assets continued to decline, there would have been more bankruptcies, more traders in jail, and less social harmony. Such a situation would have turned people against each other in prolonged and bitter court contests. Our approach played a positive role in avoiding great social discord in this small society.

Acknowledgment
We acknowledge and thank M. W. Khouja and F. Al-Sultan for first suggesting in private conversation employing a simultaneous equation system to resolve the stock market crash.

APPENDIX
We used the mathematical models to (1) identify solvent from insolvent traders, (2) determine debt settlement ratios for each trader, and (3) apportion the debt settlement ratios by type of asset held by insolvent traders. We accomplished the first two objectives using an \(n\)-trader linear programming model and the third by formulating a system of linear equations.

Decision Variables
\(\lambda_i = \) The fraction of payments made by trader \(i\) to all his debtors, (by definition \(0 \leq \lambda_i \leq 1\)).
\(\lambda_{ik} = \) The portion of asset type \(k\) trader \(i\) uses to settle his debt.

Parameters
\(a_i = \) total assets of trader \(i\), Kuwaiti Dinars (\(KD\)).
\(p_i = \) total payables of trader \(i\), \(KD\).
\(C_i = \) objective function coefficient or weight of trader \(i\) debt settlement ratio.
\(r_{ij} = \) receivables of trader \(i\) due from trader \(j\), \(KD\).
\(A_k = \) a vector of asset type \(k\) for all traders, \(KD (k = 1, 2, \ldots, K)\).
\(A = \) a vector of total assets, \(KD\), where \(A = \sum_{k=1}^{K} A_k\).
\(a_{ik} = \) the amount of asset type \(k\) that belongs to trader \(i\), \(KD\).
\(K = \) number of different types of assets.
\(\bar{\lambda} = \) vector of debt settlement ratios for all traders.
\( \tilde{\lambda}_k = \) vector of asset type \( k \) portion used for debt settlement ratios for all traders.

\( D = \) matrix of all traders payables and receivables, where \( D \) is defined as follows:

\[
D = \begin{bmatrix}
p_1 & -r_{12} & -r_{13} & \cdots & -r_{1n} \\
-r_{21} & p_2 & & & -r_{2n} \\
-r_{31} & -r_{32} & p_3 & & \\
& & & \ddots & \\
-r_{n1} & & & & p_n
\end{bmatrix}
\]

Elements of the main diagonal in \( D \) provide the total payables of a trader while the off-diagonal elements in the \( i \)th row represent the negatively of the receivables of trader \( i \). Off-diagonal elements in the \( j \)th column represent the payables of the \( j \)th trader to others in the system.

The Linear Programming Model

This linear programming model identifies solvent from insolvent traders and determines the debt settlement ratio of all traders.

Program (P):

\[
\text{maximize } \sum_{i=1}^{n} C_i \lambda_i
\]

subject to

\[
p_i \lambda_i - \sum_{j=1}^{n} r_{ij} \lambda_j \leq a_i \quad i = 1, \ldots, n,
\]

\[
\lambda_i \leq 1 \quad i = 1, \ldots, n,
\]

\[
\lambda_i \geq 0 \quad i = 1, \ldots, n.
\]

This model consists of \( n \) variables, \( n \) constraints, and \( 2n \) bounds.

System of Linear Equations for Debt Payment by Type of Asset

By setting the inequalities (4) to equalities and using matrix notation, we obtain the following expression:

\[
D \tilde{\lambda} = A.
\] (7)

Substituting for \( A = \Sigma_{k=1}^{K} A_k \) in (7) yields the following relationship:

\[
D \tilde{\lambda} = \sum_{k=1}^{K} A_k.
\] (8)

Multiplying through by \( D^{-1} \) provides the expression:

\[
\tilde{\lambda} = D^{-1} A_1 + D^{-1} A_2 + \cdots + D^{-1} A_K.
\] (9)

By setting

\[
\tilde{\lambda}_k = D^{-1} A_k \quad k = 1, \ldots, K,
\] (10)

then

\[
\tilde{\lambda} = \tilde{\lambda}_1 + \tilde{\lambda}_2 + \cdots + \tilde{\lambda}_K.
\] (11)

Equation (11) shows that the debt settlement ratio of a trader equals the sum of the debt settlement ratios for each type of asset owned by this trader. Clearly \( D^{-1} \) is independent of the asset type, and we need only a single inversion of matrix \( D \).

References


AlQabas (newspaper) 1983, “Minister of oil and finance announces in a press conference the evaluation of the insolvent dinars,” Vol. 4092, Tuesday, October 4, pp. 1.


In a videotape at the prize competition, his Excellency Shaikh Ali Al-KhalIFA Al-Sabah, former Minister of Finance and Oil of Kuwait, said “As the government came to realize the facts of al-Manakh stock market crash, it immediately became apparent that it is not a purely legal problem. We thought that this problem could only be solved if we resorted to mathematical models that would take the raw data and tell us exactly the ratio that each (trader) had to pay (to settle his debt). Therefore we resorted to an academic institution that had the reputation of being neutral which is the Kuwait Institute for Scientific Research (KISR).

“We were lucky at the time to have three distinguished individuals in KISR: Drs. Girgis, Kotob, and Elimam. Immediately after I had a meeting with them, they set a linear programming model to determine the (debt settlement) ratios and they came out with results in a very short time. Results that we could present to the judiciary committee (arbitration panel) with confidence. The results that they have established quickly enabled us to set the figures for all the involved parties. Their work was very important in presenting this framework to the judiciary committee and to finally resolving, or starting to resolve, the crisis by the end of 1983.

“Had we not resorted to this model, the social and economic consequences to Kuwait would have been catastrophic in the sense that the legal system would have been blocked by the claims and counter-claims of about 20,000 claimants. The legal system would have no way of resolving each and every case individually. According to Kuwaiti law, they had to issue a judgment on each and every check. So, it would have been arbitrary, it would have led to results that would have been capricious, benefiting those who were solvent

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against those whose claims came later on.

"The social impact of this on society knowing that the judiciary system did not produce an equitable solution would have been also tremendous since a lot of the people who were involved in these transactions were from the same family.

"The political consequences would have been just as serious. I leave it to your imagination (to consider) the political consequences when members of the society believe that the judiciary system did not give them their due right.

"The economic situation, overall, would have been much slower (which would have caused) asset values to drop tremendously bringing more suffering to the Kuwaiti economy.

"Thank God, as a result of the solution, while not everybody was satisfied, everybody knew that the system was fair. So, I would not be too complimentary to the gentlemen involved in the study in saying that their model was the cornerstone that we have used in solving a very complicated debt crisis that involved so many people in a small society."