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"Big Bang" Versus Gradualism in Economic Reforms: An Intertemporal Analysis with an Application to China

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This paper analyzes issues concerning the speed of adjustment and sequencing of reforms in a transition economy. It presents a dynamic general equilibrium model parameterized with Chinese data. The model is used to generate different policy simulations that highlight the importance of the policy instruments used during the transition period. The simulations consider privatization, tariff reform, and devaluation, as well as alternative speeds of introducing these policies. They show that different speeds of adjustment, as well as sequencing of reforms, will have very different implications for macroeconomic aggregates. [JEL D58, 21]

This paper analyzes the implications of alternative paths of economic reform in the context of an economy with a large public sector that is being transformed to become more market oriented. Two alternative paths to reform can be envisaged. First, the country can move gradually by selectively introducing reforms and spacing them over time. Second, the country can pursue a "big-bang" approach, under which all reforms are immediately and simultaneously introduced.

No general consensus has emerged on whether the "big-bang" approach to reform is superior or inferior to a gradualist approach. Further, the order in which reforms should be undertaken has remained a matter of debate.[1] This paper examines the economic setting in China, the country to which the analysis is applied. We develop a dynamic general equilibrium model that is used to analyze the effects of different speeds and sequencing of reforms. The model is solved numerically, permitting us to carry out simulations for different policies. Finally, we conclude by drawing some policy conclusions from the simulations.

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[1]For a detailed discussion of the issues and an overview of the literature, see Nsouli, Rached, and Funke (2002).

The paper focuses on only three types of policies that might be used to implement reforms. These are the privatization of publicly owned capital, the devaluation of a currency, and reductions in tariff rates. We do not address the general issue of just how general reform should be, nor do we consider many possible policies and reforms.

I. The Reform Setting and Model Intent

The model we use is applied to China. China is quite possibly the best example among formerly planned economies of the use of gradualism in introducing economic reforms. In this section, we provide some background information on the Chinese reform process. There is a general theme that connects most of the elements in this process, namely that there has been a move toward the decentralization of economic decision making and toward the opening of the economy.

In the early 1950s, the Soviet model of central planning shaped the structure of the Chinese economy. The central authority exercised direct administrative control over local governments through various mechanisms. The central authorities also directly controlled major enterprises, distributed funds, and supervised fixed investment through a centralized budgetary allocation. At the same time, production was carried on entirely through state-owned enterprises and collectives, the exchange rate was maintained at an artificially overvalued level, and the economy was closed, through a system of quantitative restrictions and prohibitive tariffs.

Concentration of power at the center reduced the initiative of local governments and hindered production, leading, in 1957, to the move to reform by decentralizing. A wave of recentralization, however, began in the early 1960s, when almost all large and medium-sized enterprises were returned to the central authority. A new decentralization movement started in 1964 and continued throughout the Cultural Revolution period. In the 1970s, most central authority over enterprises was transferred to local governments, which were allowed to retain enterprise depreciation funds. At the same time, the gradual movement toward privatization began, as did the slow opening of the economy to foreign trade and the corresponding devaluation of the exchange rate.

Before 1979, China's budgetary policy essentially consisted of generalized tax collection and profit remittances controlled by the central government and then redistributed as needed to the provinces. This system was changed in the 1980 intergovernmental reform, under which different jurisdictions were assigned different expenditure responsibilities and were also made responsible for collecting necessary revenues and managing their own budgets. Regions that raised more revenues than were necessary were permitted to retain the excess, giving them an incentive to increase revenue collection. This ability to retain revenues was especially attractive to newly privatized state-owned enterprises, which now were able to take advantage of locally provided public infrastructure. At the same time, decentralization was supported by the gradual opening of foreign markets and sequenced devaluations of the exchange rate. All of these changes tended to permit newly privatized firms to operate in a

more market-oriented economy than had existed at the beginning of the decentralization process.[2]

Economic decentralization in the postreform period has explicitly aimed at introducing a free market economy by gradually removing price controls. Decentralized resource allocation allowed an increase in investment in efficient non-state firms, leading to a rise in aggregate economic growth. On the other hand, productivity in the inefficient state sector lagged behind that in the non-state sector.[3] In order to sustain public welfare, the central government found it necessary to support the ailing state-owned enterprises. The relative inefficiency of state-owned firms implies that they tend to be hurt by tariff relaxation more than do the privatized, or non-state, enterprises. At the same time, they tend to benefit less from devaluations.

Against this background, we will consider three types of policy reforms in our simulation analysis. Although there are many other reforms that can be examined, these three should give some sense of the lessons to be drawn from our model. The focus will be on reform policies relating to state enterprises, exchange rate policy, and external sector liberalization. More specifically, in terms of the model we use, the reforms are introduced as follows:

- *Privatization of capital:* Initially, the government owns capital, which is sector specific. We assume that the private sector is more efficient than the public sector. We allow privatization to be either gradually or immediately introduced.
- *Devaluation:* We start with an overvalued exchange rate. We then explore two devaluation paths. At one extreme, there is an up-front devaluation, while at the other, the devaluation is effected gradually through several discrete steps.
- *Tariff reduction:* We suppose that the economy has operated under a system of high overall rates on import duties. We examine the effects of both gradual and immediate tariff reductions.

We should view our exercises as essentially forward looking for China. That is, the reforms of the past 25 years have been quite different from those that we will simulate. In particular, China has not made active use of exchange rate policy in the past. Nor has there been a significant movement toward trade reform. In addition, despite the privatization that has been carried out so far, most capital still remains in the public sector. Hence, our exercises should be viewed as a quantitative examination of certain possible policies rather than as a description of the past. The main objective is to get a sense of the effects of different speeds and sequences of reforms.

[2]It is beyond the scope of this paper to fully analyze Chinese decentralization. For a review of Chinese fiscal decentralization, see Bell, Khor, and Kochhar (1993), Blejer (1993), Lardy (1998), Tseng and others (1994), Hofman (1993), World Bank (1994, 1996, 1997), and G. Ma (1995). A broad historical, as well as analytical, survey of Chinese fiscal and macroeconomic policies is given in J. Ma (1997), as well as in Broadman (1995) and Yusuf (1994).

[3]See Groves and others (1994), Dollar (1990), and Jefferson and Rawski (1994) for further discussion of changes in Chinese productivity. The general relationship between fiscal policy and growth is examined in Easterly and Rebelo (1993).

II. Model Structure

This section develops the analytical structure of our model.[4] Much of this structure is designed in order to permit a numerical implementation. It is also aimed at reflecting certain stylized elements of the Chinese economy. Although we would not claim that this model lends itself to goodness of fit estimations, we will calibrate the model's endogenous macroeconomic outcomes to corresponding Chinese historical data. The comparison of the simulated and historical data should then serve to offer some confidence in both the structure and the parameterization of the model.

Intuitive Background

Let us give a brief intuitive description of our model. This should help clarify the technical description that we will present next. The model has n discrete time periods. All agents optimize in each period over a two-period time horizon. That is, in period t they optimize given prices for periods t and $t+1$ and expectations for prices for the future after $t+1$. When period $t+2$ arrives, agents re-optimize for period $t+2$ and $t+3$, based on new information about period $t+2$. For example, there may have been a change in fiscal parameters, such as tax or tariff rates, or an exchange rate change. Thus the savings decision made in period $t+1$ may not give an optimal allocation when period $t+2$ arrives. We should note that this does not mean that expectations are incorrect. If there are no exogenous parameter changes, then solving the two-period problem will be equivalent to solving the infinite horizon problem.

We wish to avoid having a perfect foresight model since it would tend to underestimate the costs of gradual reform. The reason for this bias comes from the fact that agents today would know about policy changes that might happen far in the future, as would be the case under gradualism. Hence they would adjust today, rather than have a set of imperfect adjustments over time. Thus there would never be any "wrong" decisions, as might occur under a system of gradualism with unknown future policies. In our framework the agents in the model correctly predict prices and quantities for the next period, but do not know what will happen after that. Hence they optimize with perfect foresight for one period into the future, but they base their expectations for the periods thereafter on the past. That is, they use an adaptive expectations formulation.[5]

The model will have certain features that distinguish it from a standard representation of a market economy. In particular, it has production by both the state and private sectors. In general, we will suppose that the private sector profit maximizes, while the public sector has other goals, such as output or employment targets. A key feature of the transition period will be the privatization of public production, via the transfer of capital to private firms.

[4]The dynamic structure of the model is derived from Blejer, Feldman, and Feltenstein (2002).

[5]Thus our structure would tend to generate less favorable outcomes for gradualism than would a perfect foresight model. It is our view, however, that this is a more realistic outcome than would be the case with the perfect foresight results.

Suppose, for simplicity, that there are two firms at the beginning of the transition period. One firm is publicly owned while the other is privately held. Both firms produce current output via identical neoclassical production functions. Hence the two firms differ only in the ownership of their initial capital stocks. We also do not permit loss-making behavior by the publicly owned firm in its current production. Rather, it faces a "hard" budget constraint.

The firms do differ, however, in their investment behavior. The privately held firm invests so as to equate the present value of the anticipated future stream of earnings on new capital to the cost of borrowing needed to finance the investment. This is thus normal market-determined investment that assumes free entry and hence exhaustion of profit. The public firm, on the other hand, invests according to instructions from the government. That is, it invests a nominal amount that is not based on any economic reason but in reality would be based on a governmental decision that could be politically determined. Since there is normally pressure on the public firm to invest, it does so beyond the optimal level, perhaps to support employment. Hence the public firm may find that the returns to its investments may not cover its interest obligations at some time in the future and it may need to be financed by budget transfers from the government.

The government in our model is quite simple. It makes current expenditures on pure public goods, buying inputs of capital and labor from the private sector. It also invests in public capital, such as electricity generation or transportation. This public infrastructure may augment the efficiency of private production. Our government also carries out privatization policies. Although, in reality, privatization of state enterprises may be carried out by the sale of equity, here we make a simplification. We suppose that the government privatizes state enterprises by simply giving publicly owned capital to the private sector. This reflects the notion that there are no developed capital markets in which it would be possible to sell off public enterprises. Finally, the government finances itself by issuing bonds. These bonds are the same as those issued by the private sector, so public and private sectors compete for private savings.[6] Part of the issuance of debt may be monetized by the central bank.

Let us suppose, again for simplicity, that there are two consumer types, one urban and one rural. Rural labor is used in agricultural production, while urban labor is used in all other types of production. Both consumers maximize intertemporal utility functions with transaction demands for money. They save by holding bonds, either domestic or foreign currency–denominated. The rest of the world is represented by a single export equation.

Finally, equilibrium in the model is determined as market clearing for goods and financial markets in each period. Thus our model differs from that of a dynamic market economy in only a few key ways. Capital is both publicly and privately owned, and public investment is determined by political rather than market parameters. Hence the public sector may find itself financing investment by state enterprises. Privatization may be carried out, and is done so by giving the publicly owned capital to the private sector, rather than by carrying out sales of new equity.

[6]The government may also carry out foreign borrowing to finance the deficit. The size of the foreign loan is exogenously determined by the lender.

Let us now turn to a formal description of our model. We will do so while attempting to highlight the elements of the model that are meant to capture the transition economy.

Production

Private sector

There are eight factors of production and three types of financial assets:

1–5. Capital types
6. Urban labor
7. Domestic currency
8. Bank deposits
9. Foreign currency
10. Rural labor
11. Land

The five types of capital correspond to the major nonagricultural productive sectors from the national accounts. We wish to avoid using a single, perfectly mobile, capital type since it would generate overly rapid sectoral adjustments. The initial ownership of each capital type is divided between the public and private sector. Each of these factors and financial assets is replicated in each period and, accordingly, has a price in each period.

An input-output matrix, A_t, is used to determine intermediate and final production in the private sector in period t. Corresponding to each sector in the input-output matrix, sector-specific value added is produced using capital and urban labor for the nonagricultural sectors, and land and rural labor in agriculture. Agriculture uses land and rural labor, and all other sectors use one of the five capital types plus urban labor.

The specific formulation of the private sector firm's problem is as follows. Let y^j_{Ki}, y^j_{Li} be the inputs of capital and urban labor to the jth nonagricultural sector in period i. Let Y_{Gi} be the outstanding stock of government infrastructure in period i. The production of value added in sector j in period i is then given by

$$va_{ji} = va_{ji}\left(y^j_{Ki}, y^j_{Li}, Y_{Gi}\right). \tag{1}$$

We suppose that public infrastructure may act as a productivity increment to private production. Sector j pays income taxes on inputs of capital and labor, given by t_{Kij}, t_{Lij}, respectively, in period i.

We suppose that each type of capital is produced via a sector-specific investment technology that uses inputs of capital and labor to produce new capital. Both the public and private sector invest and produce capital. Investment that is carried out by the private sector is entirely financed by domestic borrowing.[7] Let us define the following notation.

Let C_{Hi} be the cost of producing the quantity of capital H_i in period i. Let r_i denote the interest rate in period i. The return to capital in period i is denoted by P_{Ki}. The price of money in period i is given by P_{Mi}, and δ represents the rate of depreciation of capital.

[7]We assume that all foreign borrowing is carried out by the government, so that, implicitly, the government is borrowing for the private investor but the debt thereby incurred is publicly guaranteed.

The cost of borrowing must equal the present value of the return on new capital. Hence,

$$C_{H1} = \sum_{i=2}^{N} \frac{\left(1-t_{Ki}\right)P_{K_i}\left(1-\delta\right)^{i-2}H_l}{\prod_{j=1}^{i-1}\left(1+r_j\right)}, \tag{2}$$

where r_j is the interest rate in period j.

Public sector

We take a very simple view of public sector production. We will suppose that state-owned enterprises have the same production technology for intermediate and final goods as do those firms in the private sector. Hence there are no efficiency gains in current production if production is transferred from the public to the private sector. We make this assumption for essentially data-based reasons. It will not be possible, using Chinese data, to estimate separate production functions for public and private sector firms.

We do, however, assume that public sector investment is different than private sector investment. In particular, public sector firms do not invest in an optimal fashion, as in equation (3). Rather, the government allocates an arbitrary amount of revenues to investment in each sector. Suppose then that the government decides to spend $GINV_i$ on public enterprise capital formation in period i. Let public enterprise firm j have a Cobb-Douglas investment function with coefficients γ_j, $1-\gamma_j$.

We suppose that the government allocates $GINV_i$ to the different public enterprises according to an arbitrary set of policy weights η_{ij} in period i. Thus the government spends $\eta_{ij}GINV_i$ on sector j's investment in period i. Accordingly, sector j uses $\gamma_j\eta_{ij}GINV_i/P_{Kij}$ units of capital as inputs to investment in period i, and $(1-\gamma_j)\eta_{ij}GINV_i/P_{L_{ij}}$ units of labor. The capital thus produced is then available in period $i+1$.

Thus, public investment in public enterprises is determined purely by policy considerations, rather than intertemporal profit maximization. In addition, this capital formation may be financed by taxes or by borrowing, unlike private investment, and it may, in fact, be loss-making over time, even in the absence of shocks. That is, the public sector may overinvest for noneconomic reasons. In addition, the public sector's investment is not forward looking in the sense of maximizing a stream of profits.

Privatization

We will implement a simple form of privatization of public enterprises. We will assume that, when the government privatizes a state enterprise, it simply gives the capital of the state enterprise to the corresponding private firm. This privatization can be partial. In other words, the government gives a portion of the publicly owned capital to the corresponding private firm and retains a fraction for itself. We thus avoid any issue of the marketing and pricing of public capital. As public capital is

allocated to the private sector, there is a corresponding reduction in public capital expenditure on state-owned enterprises.

Consumption

There are two types of consumers, representing rural and urban labor. We suppose that the two consumer classes have differing Cobb-Douglas demands. The consumers also differ in their initial allocations of factors and financial assets. The consumers maximize intertemporal utility functions, which have as arguments the levels of consumption and leisure in each of the two periods. We permit rural-urban migration, which depends upon the relative rural and urban wage rate. The consumers maximize these utility functions subject to intertemporal budget constraints. The consumer saves by holding money, domestic bank deposits, and foreign currency. He requires money for transactions purposes, but his demand for money is sensitive to changes in the inflation rate.

The specification of the consumers' maximization problem is given in the Appendix.

The Government

The government collects personal income, corporate profit, and value-added taxes, as well as import duties. It pays for the production of public goods, as well as for subsidies. Unlike the government of a market economy, it also pays for investment in state enterprises and collects revenue from the returns to the capital of those enterprises. If the state enterprises have losses, the government subsidizes them. In addition, the government must cover both domestic and foreign interest obligations on public debt. The deficit of the central government in period 1, D_1, is then given by

$$D_1 = G_1 + S_1 + r_1 B_0 + r_{F1} e_1 B_{F0} - T_1 - \sum_{j=1}^{5} P_{Kj1} K_{Gj1} \left(1 - PRIV_{j1}\right), \tag{3}$$

where S_1 represents subsidies given in period 1, G_1 is spending on goods and services, while the next two terms reflect domestic and foreign interest obligations of the government, based on its initial stocks of debt. T_1 represents tax revenues, while the final term represents the income from publicly owned capital that accrues to the government. The term $PRIV_{j1}$ represents the degree to which public capital in sector j is privatized in period 1. Thus if the sector were fully privatized we would have $PRIV_{j1} = 1$. Any partial privatization would be reflected by a value less than 1.

The resulting deficit is financed by a combination of monetary expansion, as well as domestic and foreign borrowing. If Δy_{BG1} represents the face value of domestic bonds sold by the government in period 1, and C_{F1} represents the dollar value of its foreign borrowing, then its budget deficit in period 2 is given by

$$D_2 = G_2 + S_2 + r_2 \left(\Delta y_{BG1} + B_0\right) + r_{F1} e_2 \left(C_{F1} + B_{F0}\right) - T_2 - \sum_{j=1}^{5} P_{Kj2} K_{Gj2} \left(1 - PRIV_{j2}\right), \tag{4}$$

where $r_2(\Delta y_{BG1} + B_0)$ represents the interest obligations on its initial domestic debt plus borrowing from period 1, and $e_2 r_{F2}(C_{F1} + B_0)$ is the interest payment on the initial stock of foreign debt plus period 1 foreign borrowing. As before, the final term is the revenue from state enterprises after privatization.

The government finances its budget deficit by a combination of monetization, domestic borrowing, and foreign borrowing. We assume that foreign borrowing in period i, C_{Fi}, is exogenously determined by the lender. The government then determines the face value of its bond sales in period i, Δy_{BGi}, and finances the remainder of the budget deficit by monetization. Hence,

$$D_i = P_{Bi}\Delta y_{BGi} + P_{Mi}\Delta y_{Mi} + e_i C_{Fi}.$$

The Foreign Sector

The foreign sector is represented by a simple export equation in which aggregate demand for exports is determined by domestic and foreign price indices, as well as world income. The specific form of the export equation is

$$\Delta X_{no} = \sigma_1 \left[\frac{\pi_i}{\Delta e_i + \pi_{Fi}} \right] + \sigma_2 \Delta y_{wi}.$$

The left-hand side of the equation represents the change in the dollar value of exports in period i, π_i is inflation in the domestic price index, Δe_i is the percentage change in the exchange rate, and π_{Fi} is the foreign rate of inflation. Also, Δy_{wi} represents the percentage change in world income, denominated in dollars. Finally, σ_1 and σ_2 are corresponding elasticities.

Equilibrium

An equilibrium in our model is defined as market clearing in the markets for factors and financial assets, replicated in each time period. Factor markets are capital (five types), urban and rural labor, and land. Financial assets are domestic currency, domestic bank deposits, and foreign currency. We use a solution method that is based on an approximating fixed-point algorithm to solve for the equilibrium.

III. Data Sources for China

A variety of data sources for China are used to parameterize the model. The technology for intermediate and final production is given by the 1995 Chinese input-output matrix. This is taken from the 1998 *China Statistical Yearbook*, and represents 1995 technology. The matrix has 17 sectors, which are as follows:

1. Agriculture
2. Mining
3. Foodstuff
4. Textiles

5. Other Manufacturing
6. Production of Electricity
7. Gas, Coal, and Petroleum
8. Chemicals
9. Building Materials and Nonmetallic Minerals
10. Metal Products
11. Machinery and Equipment
12. Construction
13. Transport and Telecommunications
14. Commerce
15. Public Utilities
16. Banking and Insurance
17. Other Services

In order to correspond to our different capital types, we have assumed that these 17 sectors are grouped into 5 aggregate groups. These are as follows:

Sectors	Capital type
2	1
3–5	2
6–11	3
12–13	4
14–17	5

We derive indirect taxes from the input-output matrix, using the coefficient for Net Taxes on Production. In order to derive import coefficients for the input-output matrix, as well as import tariff rates, we take a somewhat involved approach. This approach is necessary since the Chinese input-output matrix does not include import coefficients. Here, as with all other derived data, we take our figures from 1995 in order to correspond to the input-output matrix. We assume that all inputs are used as intermediate and primary inputs to production, since we lack the information to derive imports used for final consumption. We use Table 16.5 from the 1998 *China Statistical Yearbook* to obtain sectoral imports for five sectors. These are (1) Agriculture, (2) Mining, (3) Foodstuff, (4) Textiles, and (5) Other Manufacturing. These are given in U.S. dollars, and we use an exchange rate of 8.35 yuan/$ to calculate domestic currency figures. Corresponding input-output (IO) coefficients are then derived by dividing sectoral imports by the total inputs to sectoral production from the IO matrix.

We need to derive the effective rates of direct taxation for enterprises. Table 7.8 of the *China Statistical Yearbook* gives total revenues transferred to the government by state-owned enterprises (SOE) and collectively owned enterprises (COE). Table 2.10 gives total income from industry, and from this we derive a tax rate of 4.8 percent that is levied on inputs of capital and labor to all nonagricultural sectors. We also need government current and capital expenditures, as percentages of GDP. Nominal expenditure is taken from Table 7.4, while nominal GDP comes from Table 2.13. From these we obtain a figure for capital expenditures of 2.9 percent of GDP, and for current expenditures on goods and services of

8.6 percent of GDP. We should note that this does not include interest payments, which are generated endogenously by the model.

In order to parameterize the consumer's problem, we need several types of data. We need utility weights for the different consumer demand functions, as well as initial allocations of factors and financial assets. In order to derive utility weights, we use Table 3.18, the final use part of the IO matrix. This gives expenditures on each of the 17 sectors by agricultural and non-agricultural households. From these, we obtain utility weights for the two consumer categories.

Initial allocations of capital are given by the sectoral operation surpluses, that is, returns to capital, from the IO matrix. Similarly, allocations of labor are given by compensation of laborers across sectors. Thus we define a physical unit of capital and labor as that which earned one yuan in 1995. Initial allocations of money are taken from *International Financial Statistics* (IFS) as M1 for 1994. Initial allocations of bank deposits are also derived from IFS as 1994 holdings of quasi-money. Finally, we assume that there are no holdings by the two domestic consumer types of foreign currency. The initial holding of foreign currency by the rest of the world, that is, the foreign consumer, is taken to be the 1994 value of exports. This, in turn, is taken from Table 16.3 of the *China Statistical Yearbook*.

IV. Simulations

In this section we will derive certain conclusions about the effect of alternative paths for the economy, corresponding to different assumptions regarding policy changes and reforms.

Baseline Scenario

The baseline scenario assumes no reform actions are taken. We use the period 1990–95 for the simulation in order to make a comparison with theoretical outcomes. Table 1 gives the macroeconomic outcomes over a six-year simulation period.

Under the baseline scenario, real GDP grows at an average annual rate of 7.0 percent over the period of the simulation. At the same time there is a 12.2 percent average inflation rate over the time period. If we compare the baseline scenario for the period 1990–95 with historical Chinese data, the simulated real growth rate is lower than the historical rate of 12.0 percent, while the simulated inflation rate is slightly lower than the historical rate of 12.9 percent. At the same time, the budget over the first four years of the simulation is reasonably close to Chinese historical outcomes. After four years, the simulated budget deficit is higher than historical levels, largely because of our assumption of a fixed real spending by the government. Finally, the simulated interest rate, after the first two years, is broadly in line with historical values. Until the final two periods, our simulated trade balance is higher than the actual levels.

We do not attempt to claim any statistical "goodness of fit" properties for our simulation exercises. That is, there is no econometric comparison between the historical outcomes and the corresponding endogenous outcomes generated by the general equilibrium model. Rather, we wish only to show general similarities

Table 1. China: Baseline Scenario[1]

Period	1	2	3	4	5	6
Price level	100	111.6	123.7	137.5	147.4	177.6
	(100)	(103.5)	(110.0)	(126.1)	(156.6)	(183.1)
Real GDP	100	107.6	114.5	123.1	131.1	140.3
	(100)	(109.2)	(124.7)	(141.5)	(159.4)	(176.2)
Budget (in percent of GDP)	0.7	–0.2	–3.1	–3.3	–6.3	–6.0
	(–0.2)	(–1.1)	(–1.0)	(–0.8)	(–1.2)	(–1.0)
Interest rate	1.8	3.4	4.7	11.3	9.9	14.8
	(7.9)	(7.2)	(7.2)	(10.1)	(10.1)	(10.4)
Trade balance (in percent of GDP)	11.1	11.7	7.3	8.2	4.9	3.8
	(2.8)	(2.9)	(1.1)	(–2.0)	(1.3)	(1.7)
Utility of consumer 1 = 100, utility of consumer 2 = 100						

Source: Authors' simulation results.

[1]The figures in parentheses are historical values taken from the IMF's *International Financial Statistics.*

between the simulated and historical time series. There are several reasons for this approach. We lack enough observations to derive meaningful statistical properties. Additionally, Chinese macro data reflect a variety of price and interest rate controls that we do not include (see Feltenstein and Ha, 1991).[8] Also, we do not attempt to incorporate all historical changes in exogenous parameters that actually occurred in China during the period in question. Finally, we are not trying to use the model for predictive purposes. Rather, we wish to be able to make qualitative judgments about the possible effects of counterfactual policies.

The last line in the table represents the utility levels of the two consumers, which are normalized to 100 for the baseline scenario. The utilities are calculated as the present value of the stream of consumption over the time periods of the simulation. The calculation is made ex post: that is, it is made by calculating the value of a utility function of the following form:

$$U = x_1 x_2^{1/(1+\delta)} \ldots x_T^{\left[1/(1+\delta)\right]^{(T-1)}}$$

where δ is the rate of time preference. The values of $\{x_i\}$, representing vectors of consumption in each period, are given by the solutions to the intertemporal maximization problem over T periods. The utility function, which is thus time separable, is Cobb-Douglas in each period. That is,

$$x_i = x_{i1}^{\alpha_1} x_{i2}^{\alpha_2} \ldots x_{iN}^{\alpha_N}, \text{ where } \sum_i \alpha_i = 1.$$

Thus, the consumer maximizes his utility with a two-period time horizon and expectations about the future thereafter. Because unexpected policies may be

[8]See also Qian and Xu (1998) for a discussion of some of the results of regimes with price controls as well as soft budget constraints.

introduced over time, his realized consumption may be different from his intended consumption. Hence the value of his utility function, calculated using realized consumption, may also be different than would have been the case had he achieved his planned consumption levels. Accordingly, our utility levels, if this were a single representative agent model, could be thought of as the present value of a real income index.

While we would not claim that our parameterized model offers a statistically significant rendition of Chinese reality, it provides a basis for carrying out the policy simulations for purposes of illustrating the different effects of alternative speeds and sequencing of reforms.

Privatization

Two initial simulations are carried out in which privatization is introduced at different speeds. In the first, there is a gradual process of privatization, while in the second there is complete privatization in the first period. In carrying out privatization, it is assumed that public state-owned enterprise capital is simply given to the private sector, and that privatization is carried out uniformly across sectors.

To simulate gradual privatization, it is assumed that 30 percent of state-owned enterprise capital is given to the private sector in period 1, 30 percent more in period 3, and the final 40 percent in period 5. Thus, in the last two periods of the simulation there is full privatization. The outcomes are given in Table 2.

There are a number of differences compared with the baseline scenario. First, there is a small but uniform increase in the price level in all periods. As the public capital stock is privatized, there is a corresponding decline in the rate of public investment, which is not fully picked up by the private sector. The resulting lower capital stocks cause the general price level to rise. There is an initial decline in real GDP, due to the decline in aggregate investment. Over time, however, there is a more efficient distribution of sectoral investment by the private sector, leading to an eventual rise in real GDP to 1.4 percent above the baseline scenario in period 6. There is also an improvement in the budget position, relative to the baseline scenario, as the loss in public revenue from privatization is more than made up by the reduction in public investment spending.

Table 2. China: Gradual Privatization

Period	1	2	3	4	5	6
Price level	101.9	114.1	124.5	153.1	153.8	187.6
Real GDP	98.8	106.4	113.7	121.9	133.3	142.2
Budget deficit (in percent of GDP)	1.7	0.7	–1.5	–2.0	–4.2	–3.9
Interest rate	4.0	6.8	10.7	14.0	12.4	20.9
Trade balance (in percent of GDP)	10.9	11.7	7.3	5.5	3.3	2.0

Utility of consumer 1 = 102.3, utility of consumer 2 = 90.5

Source: Authors' simulation results.

Table 3. China: Immediate Full Privatization

Period	1	2	3	4	5	6
Price level	112.6	136.2	132.5	161.6	155.2	188.6
Real GDP	95.2	102.3	116.6	124.3	138.0	146.7
Budget deficit (in percent of GDP)	3.9	2.5	–1.7	–1.9	–6.1	–5.3
Interest rate	11.5	14.5	13.5	21.7	15.0	27.7
Trade balance (in percent of GDP)	9.4	7.8	5.0	3.6	2.1	1.1

Utility of consumer 1 = 108.5, utility of consumer 2 = 137.3

Source: Authors' simulation results.

The current account deteriorates slightly, compared with the baseline scenario, in line with the increased appreciation of the exchange rate, and the nominal interest rate is higher, as private investment eventually increases in the new environment. The resulting borrowing requirements of the private sector bring about the increase in the interest rate. Finally, the urban consumer is relatively better off than before, while the rural consumer is worse off. This is because the increase in interest rates has created a positive wealth effect for the urban consumer, who owns relatively more financial assets than does the rural consumer. Accordingly, the urban consumer increases his demand, thereby driving up prices. The rural consumer suffers from these higher prices, and hence realizes a lower utility level.

Suppose that, instead of gradual privatization, an immediate full privatization takes place in period 1. Thus, all the capital of the state-owned enterprises is given to the private sector at the beginning of period 1. Table 3 gives the outcome of simulating a full privatization.

A number of interesting observations, compared with a process of gradual privatization, can be made. First, inflation is significantly higher in the initial periods, with the price levels gradually converging under the two scenarios over the six periods. The higher inflation rates, particularly in the earlier periods, reflect the initial drop in capital and real GDP as the government's cutback on public investment is not picked up initially by the private sector. Second, there is a further decline in real GDP in the initial two periods, because the elimination of public sector investment is not immediately made up for by a corresponding increase in private output. However, by period 3, the more efficient allocation of private, as compared to public, investment leads real GDP to rise beyond the level achieved under the gradual privatization scenario. Indeed, by period 6, real GDP is 3.2 percent higher than under gradual privatization. The budget deficit deteriorates, reflecting the higher interest rates in this case, as compared to the previous case. These higher rates are themselves caused by the fact that all investment is now carried out by the private sector, starting in period 1. Since private investment is entirely financed by borrowing, unlike public investment, which may be partially financed by monetization, the increased borrowing drives interest rates up. There is a further deterioration in the current account balance, as the higher inflation rates lead to a greater overvaluation of the currency under the fixed exchange rate. Both consumers realize higher levels of utility, as the overvaluation of the currency

Table 4. China: Gradual Privatization and 5 Percent Annual Devaluation

Period	1	2	3	4	5	6
Price level	104.3	119.9	135.0	165.0	174.3	215.5
Real GDP	99.0	106.8	115.0	122.9	134.3	143.6
Budget deficit (in percent of GDP)	1.6	0.5	–1.5	–2.2	–4.1	–4.0
Interest rate	5.2	7.2	11.2	13.6	12.6	18.9
Trade balance (in percent of GDP)	11.7	13.7	8.7	7.9	5.5	4.8

Utility of consumer 1 = 101.3, utility of consumer 2 = 99.1

Source: Authors' simulation results.

has a positive effect on consumption of both consumers. We should note that the deterioration of the trade balance indicates that this higher level of consumption may not be sustainable in the long run.[9]

The basic conclusion of these two simulations is that, on balance, an immediate privatization has a more positive impact on consumers than a gradual one. However, in both cases, the increased deterioration of the current account relative to the baseline scenario, because of the increasingly overvalued exchange rate, raises questions of policy sustainability in the absence of exchange rate reduction.

Exchange Rate Policy

In view of the results of the two privatization simulations, this section presents the results of simulations combining an adjustment in the exchange rate with privatization. To examine a "gradual-gradual" approach, assume there is a gradual devaluation along with a gradual privatization. Suppose that there is a 5 percentage point devaluation in each period starting with period 1, and that a gradual privatization is implemented consistent with the process shown in Table 2. The results are given in Table 4.

There are a number of differences compared with Table 2. There is a significant increase in the price level, reflecting the effect of the devaluation, as well as a marginal increase in real GDP, due to the expenditure-switching effect of the devaluation. The budget deficit does not change much, as the increased costs in foreign debt are balanced by increased revenues from import duties. As expected, the current account balance improves, as the overvaluation is progressively corrected. Interest rates do not change much in nominal terms and there are no significant changes in the utility levels of the urban and rural consumers. Finally, we should note that the main reason for the relatively small changes in real output in this simulation, as compared to Table 2, comes from the fact that the inputs of imports into domestic production in the Chinese input-output matrix are quite low. Hence there is only a slight impact on domestic output caused by the devaluation.

Would gradual privatization with up-front devaluation be more appropriate? Thus, instead of a 5 percent annual devaluation, assume there is an initial 30 percent devaluation. Table 5 gives the results of the simulation.

[9]One might analyze the long-run sustainability of the current account by checking running simulations over a considerably longer time period than the six periods in this study.

Table 5. China: Gradual Privatization Plus 30 Percent Up-Front Devaluation

Period	1	2	3	4	5	6
Price level	114.6	133.0	144.1	175.7	181.5	222.7
Real GDP	100.0	107.2	115.4	123.1	134.0	142.7
Budget deficit (in percent of GDP)	1.1	–0.1	–1.7	–2.4	–4.2	–4.0
Interest rate	6.1	5.1	10.8	18.6	11.9	17.8
Trade balance (in percent of GDP)	15.1	14.8	10.0	8.4	5.3	3.8

Utility of consumer 1 = 100.0, utility of consumer 2 = 89.6

Source: Authors' simulation results.

Table 6. China: Immediate Privatization Plus 5 Percent Annual Devaluation

Period	1	2	3	4	5	6
Price level	117.3	143.7	143.6	177.9	175.1	216.6
Real GDP	95.3	102.5	117.2	125.0	139.3	148.2
Budget deficit (in percent of GDP)	3.8	2.2	–1.8	–2.1	–5.9	–5.3
Interest rate	12.0	15.3	14.1	20.9	15.3	25.0
Trade balance (in percent of GDP)	9.6	9.0	6.4	5.7	4.3	3.7

Utility of consumer 1 = 106.9, utility of consumer 2 = 123.1

Source: Authors' simulation results.

Compared with Table 4, there is a small boost to real GDP, but, as expected, inflation is initially higher, but tapers off with the price levels under the two scenarios gradually converging. The budget deficits and interest rates do not change much. However, the current account position, at least in the initial periods, improves significantly, but worsens in the last period. Because of the higher price level and the unchanged real GDP, both rural and urban consumers end up being worse off than under the gradual devaluation scenario.

Let us now examine two possible combinations of immediate privatization—with a gradual devaluation and with an up-front devaluation. Table 6 gives the results of a gradual devaluation with immediate privatization.

It is useful to compare Table 6 with Table 4. There is a relative increase in inflation but a relative fall in real GDP in the first two periods, reflecting the fall in public investment. In the last four periods private productivity catches up, reflected in a higher real GDP level, and a dampening in inflation. The budget improves initially, but starts deteriorating, due to the increase in the nominal interest rate. The real interest rate rises as private investment increases, and the current account deteriorates as private consumption also rises. Both rural and urban consumers are better off than under the gradual privatization scenario.

Let us turn to an alternative policy path. Consider a one-step devaluation at the beginning, together with an immediate privatization. The outcomes are given in

Table 7. China: Immediate Privatization Plus 30 Percent Initial Devaluation

Period	1	2	3	4	5	6
Price level	129.8	156.7	155.6	190.6	184.9	226.0
Real GDP	96.2	103.0	117.4	124.9	138.9	147.5
Budget deficit (in percent of GDP)	3.1	1.7	–2.2	–2.4	–6.1	–5.5
Interest rate	12.5	14.3	13.3	19.2	14.2	24.0
Trade balance (in percent of GDP)	12.6	11.0	7.3	5.8	3.9	2.6

Utility of consumer 1 = 105.9, utility of consumer 2 = 114.2

Source: Authors' simulation results.

Table 8. China: Gradual Tariff Reform

Period	1	2	3	4	5	6
Price level	100	111.6	123.9	137.8	147.6	178.4
Real GDP	100	107.6	114.5	123.8	131.2	140.2
Budget (in percent of GDP)	0.7	–0.2	–3.2	–3.4	–6.6	–6.4
Interest rate	1.7	3.4	4.6	11.2	9.3	15.2
Trade balance (in percent of GDP)	11.1	11.7	7.3	8.3	5.0	3.8

Utility of consumer 1 = 99.1, utility of consumer 2 = 100.6

Source: Authors' simulation results.

Table 7. Compared with the previous scenario (Table 6), we see that the price level is generally higher and real GDP and the budget do not change significantly. Real interest rates are lower, as the devaluation has reduced private investment, thereby reducing borrowing requirements. In addition, the current account surplus improves marginally. The higher price levels, however, are reflected in lower welfare for both consumers.

Tariff Reform

Two simulations regarding alternate tariff reform paths are carried out, involving a gradual and an up-front elimination of tariffs. The first simulation (Table 8) supposes that tariff reform is introduced gradually. Assume that, in the first two periods, tariff rates stay at their historical levels. In the remaining four periods, they are reduced by 20, 40, 70, and 100 percent of their initial values. Hence by period 6 they are at 0 percent. Table 8 gives the results of this simulation.

The second simulation assumes the elimination of tariff rates in the first period. The results are given in Table 9.

The outcomes in both simulations are essentially the same as those in Table 1. These suggest that tariff reform, taken alone, appears to have little impact, whether done gradually or in one step. We should, however, qualify our results. The effective

Table 9. China: Immediate Tariff Reform

Period	1	2	3	4	5	6
Price level	100.0	111.3	123.5	139.3	144.9	179.0
Real GDP	100.0	107.8	114.5	122.9	131.6	140.4
Budget (in percent of GDP)	0.4	–0.5	–3.5	–3.7	–6.7	–6.4
Interest rate	2.1	4.0	5.4	11.6	11.0	16.0
Trade balance (in percent of GDP)	11.5	12.3	7.6	8.1	5.4	3.6

Utility of consumer 1 = 101.2, utility of consumer 2 = 101.3

Source: Authors' simulation results.

Table 10. China: The Big-Bang Approach[1]

Period	1	2	3	4	5	6
Price level	130.4	157 .3	156.2	191.4	185.7	227.0
Real GDP	95.9	102.8	117.5	124.9	139.0	147.7
Budget deficit (in percent of GDP)	2.4	1.4	–2.6	–2.8	–6.7	–6.0
Interest rate	12.4	14.6	13.7	20.2	14.9	25.4
Trade balance (in percent of GDP)	12.9	11.2	7.4	5.8	3.9	2.6

Utility of consumer 1 = 107.4, utility of consumer 2 = 116.4

Source: Authors' simulation results.
[1]Immediate privatization, tariff reform, and 30 percent devaluation.

average tariff rate that we have estimated is only 2.7 percent in period 1. Hence the elimination of tariffs would have relatively little impact, at least initially, on prices. At the same time, the coefficients of imports in the Chinese input-output matrix are quite small and, in fact, imports are used as inputs to production in only six sectors. Accordingly, there is little linkage between imports and domestic production.[10]

The Two Extremes

In this section we consider two cases involving several policy instruments. In both, simulations, privatization, tariff reform, and devaluation are undertaken, with the only difference being in the speed with which these actions are taken.

Table 10 gives the results of a "big-bang" approach involving an up-front full elimination of tariffs, full privatization, and a 30 percent devaluation.

These results provide an interesting contrast to the baseline scenario (Table 1) and give an indication of how the addition of tariff reform in a package affects

[10]Trade barriers in China are incorporated as nontariff barriers rather than as high tariff rates. Hence trade liberalization should really be studied as a reduction in quantitative restrictions. Such simulations are, however, beyond the scope of our current study.

Table 11. China: The Gradual Approach[1]

Period	1	2	3	4	5	6
Price level	104.3	119.9	135.2	167.2	174.9	216.3
Real GDP	99.0	106.8	115.0	122.9	134.3	143.1
Budget deficit (in percent of GDP)	1.6	0.5	–1.7	–2.3	–4.5	–4.4
Interest rate	5.2	7.2	11.2	13.9	12.8	19.6
Trade balance (in percent of GDP)	11.7	13.1	8.6	7.9	5.5	4.7

Utility of consumer 1 = 102.1, utility of consumer 2 = 100.0

Source: Authors' simulation results.
[1]Gradual privatization, tariff reform, and devaluation.

welfare (compared to Table 6). First, compared with the baseline scenario, real GDP is lower in the two first periods, but then rises. The price level is higher throughout. After improving, the current account position deteriorates, as the once-and-for-all effect of the devaluation is gradually eroded. Overall, both consumers are better off, benefiting from the reform package. Second, the welfare effect of up-front tariff reform combined with other policies is somewhat greater than the up-front tariff reform alone.

Table 11 gives the results of a gradual approach to a reform package, involving gradual privatization, tariff reform, and devaluation phased in the same manner as in earlier simulations.

Compared with the big-bang approach, this table indicates that gradualism, although resulting in less of a contraction in real GDP in the first two periods, yields lower real GDP levels in the subsequent periods. Partly because of that, both consumers are distinctly less well off in terms of their welfare than under the big-bang approach. In fact, the gradual approach results in minor welfare improvements relative to the baseline scenario only to the urban consumer.

V. Conclusion

The results of the simulations (summarized in Table 12) illustrate the complexities of the issues involved in deciding on the speed of adjustment and sequencing of reforms. Much depends on the objectives being sought, the time frame, and the sustainability of the macroeconomic situation. Nonetheless, certain conclusions can be drawn from the simulations.

In looking at complete policy packages, the big-bang approach is better from a welfare point of view: both consumers are better off under a package where adjustment and reform policies reinforce each other. Although under the big-bang approach the drop in real GDP is initially greater than under the gradual approach, real GDP rises to higher levels in subsequent periods. However, the current account position remains better under the gradual approach partly because the big-bang approach generates worse budgetary outcomes and higher nominal interest rates for most of the period.

Table 12. China: Summary Table of Simulations[1]

	Baseline	Gradual Privatization	Immediate Privatization	Gradual Privatization and Devaluation	Gradual Privatization and Up-Front Devaluation	Immediate Privatization and Devaluation	Immediate Privatization and Gradual Devaluation	Immediate Tariff Reform	Gradual Tariff Reform	Big Bang	Gradual
U_1	100	102.3	108.5	101.3	100.0	105.9	106.9	101.2	99.1	107.4	102.1
U_2	100	90.5	137.3	99.1	89.6	114.2	123.1	101.3	100.6	116.4	100.0
Real GDP	140.3	142.2	146.7	143.6	142.7	147.5	148.2	140.4	140.2	147.7	143.1
Price level	177.6	187.6	188.6	215.5	222.7	226.0	216.6	179.0	178.4	227.0	216.3
Inflation	20.5	21.9	21.5	23.6	22.7	22.2	23.7	23.5	20.1	22.2	23.7
Budget	–6.0	–3.9	–5.3	–4.0	–4.0	–5.5	–5.3	–6.4	–6.4	–6.0	–4.4
Interest rate											
Nominal	14.8	20.9	27.7	18.9	17.8	24.0	25.0	16.0	15.2	25.4	19.6
Real	–5.7	–1.0	6.5	–4.7	–4.9	1.8	1.3	7.5	–4.9	3.2	4.1
External current account	3.8	2.0	1.1	4.8	3.8	2.6	3.7	3.6	3.8	2.6	4.7

Source: Authors' simulation results.

[1]Last period, except for U_1 and U_2, which refer to the utility of urban and rural consumers, respectively, over the periods simulated.

A piecemeal approach to reform may not only fail to improve overall welfare significantly but may reduce it. A gradual approach to privatization improves marginally the welfare of the urban consumer but leads to a sharp deterioration in the welfare of the rural consumer. Also, a gradual or immediate reduction in tariffs alone may not result in major welfare improvements. Careful sequencing can improve welfare, and improper sequencing can lead to welfare losses. An immediate privatization with a gradual devaluation helps improve welfare more than an immediate privatization and devaluation or a gradual privatization and devaluation.

The objective of improving the current account position over a set number of periods can lead to different results. For example, up-front privatization alone results in a lower current account position in the last period than an overall gradual package, but maximizes the welfare of both sets of consumers. The catch, of course, is that the welfare gains may not be sustainable as the external current account deteriorates further in periods beyond the simulated time frame.

APPENDIX

Consumption

Here, and in what follows, we will use x to denote a demand variable and y to denote a supply variable. In order to avoid unreadable subscripts, let us let 1 refer to period i and 2 refer to period $i+1$. The consumer's maximization problem is thus:

$$\max\ U(x),\ x = (x_1, x_{Lu1}, x_{Lr1}, x_2, x_{Lu2}, x_{Lr2}), \tag{A1}$$

such that:

$$(1+t_i)P_i x_i + P_{Lui}x_{Lui} + P_{Lri}x_{Lri} + P_{Mi}x_{mi} + P_{Bi}x_{Bi} + e_i P_{Bfi}x_{BFi} = C_i \tag{A2}$$

$$P_{K2}(1-\delta)K_0 + P_{A2}A_0 + P_{Lu2}L_{u2} + P_{Lr2}L_{r2} + P_{M2}x_{M1} + r_1 x_{B1} + P_{B2}x_{B1} + e_2 P_{BF2}x_{BF1} + TR_2 = N_2$$

$$P_{K1}K_0 + P_{A1}A_0 + P_{Lu1}L_{u1} + P_{Lr1}L_{r1} + P_{M1}M_0 + r_0 B_0 + P_{B1}B_0 + e_1 P_{BF1}B_{F0} + TR_1 = N_1$$

$$C_i = N_i,$$

$$\log P_{Bi}x_{Bi} - \log e_i P_{BFi}x_{BFi} = \alpha + \beta\left(\log r_i - \log \frac{e_{i+1}}{e_i} r_{Fi}\right), \tag{A3}$$

$$\log P_{Mi}x_{Mi} = a + b\log\left(1+t_i\right)P_i x_i - c\log\pi_i, \tag{A4}$$

$$P_{B2}x_{B2} = d_0 + d_1\left(1+t_2\right)P_2 x_2 + d_2\frac{r_2 - \pi_2}{1+\pi_2}, \tag{A5}$$

where:

P_i = price vector of consumption goods in period i.

x_i = vector of consumption in period i.

C_i = value of aggregate consumption in period i (including purchases of financial assets).

N_i = aggregate income in period i (including potential income from the sale of real and financial assets).

t_i = vector of sales tax rates in period i.

P_{Lui} = price of urban labor in period i.

L_{ui} = allocation of total labor to urban labor in period i.

x_{Lui} = demand for urban leisure in period i.

P_{Lri} = price of rural labor in period i.

L_{ri} = allocation of total labor to rural labor in period i.

x_{Lri} = demand for rural leisure in period i.

a_2 = elasticity of rural/urban migration.

P_{Ki} = price of capital in period i.

K_0 = initial holding of capital.

P_{Ai} = price of land in period i.

A_0 = initial holding of land.

δ = rate of depreciation of capital.

P_{Mi} = price of money in period i. Money in period 1 is the numerator and hence has a price of 1.

x_{Mi} = holdings of money in period i.

P_{Bi} = discount price of a certificate of deposit in period i.

π_i = domestic rate of inflation in period i.

r_i, r_{Fi} = domestic and foreign interest rates in period i.

x_{Bi} = quantity of bank deposits, that is, CDs in period i.

e_i = exchange rate in terms of units of domestic currency per unit of foreign currency in period i.

x_{BFi} = quantity of foreign currency held in period i.

TR_i = transfer payments from the government in period i.

d_i = constants estimated from model simulations.

The left-hand side of equation (A2) represents the value of consumption of goods and leisure, as well as of financial assets. The next two equations contain the value of the consumer's holdings of capital and labor, as well as the principal and interest that he receives from the domestic and foreign financial assets that he held at the end of the previous period. The equation $C_i = N_i$ then imposes a budget constraint in each period.

Equation (A3) says that the proportion of savings made up of domestic and foreign interest-bearing assets depends on relative domestic and foreign interest rates, deflated by the change in the exchange rate. Equation (A4) is a standard money-demand equation in which the demand for cash balances depends on the domestic rate of inflation and the value of intended consumption.

In period 2 we impose a savings rate based on adoptive expectations, as in equation (A5). The constants (d_i) are estimated by a simple regression analysis, based on the previous periods. Thus if we are in period t, where t is the end of a two-period segment, then the closure saving rate for period t is determined by nominal income and the real interest rate. The constants are updated after each two-period segment by running a regression on the previous $t-2$ periods. Thus savings rates are endogenously determined by intertemporal maximization in period t, but are determined by adoptive expectations in period $t+1$.[11] Accordingly, equation (A5) is the terminal condition for the consumer's problem. Combined with the closure rule for investment, described in equation (3), this determines the terminal conditions for our problem.

[11] Since the only information the consumer has about the future is the real interest rate, adoptive expectations is, in this case, equivalent to rational expectations.

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