Natural Resource Abundance and Privatization: Comparative Statics with a Three-Sector General Equilibrium Model of Uzbekistan

by

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ABSTRACT

Using a political-economic paradigm, this study examines the role of natural resources in countries moving from a former Soviet planned economy to a market economy. Specifically, the study examines the effect of natural resource abundance in the privatization process through a computable general equilibrium model of the 1991 Uzbekistan economy.

The model establishes a social objective and structural features characteristic of a reforming economy. Society's objective is to maximize the welfare of two voting classes—traditional workers and entrepreneurs. The welfare of each voting class is affected by an exogenously initiated privatization process, modeled as the free movement of productive factors away from state enterprise to entrepreneurial agents. Through these welfare effects, the voting classes determine preferential government policies. In particular, traditional workers endowed with labor services support politicians, and entrepreneurs owning capital support reformers. The relative strength of these two voting classes is compared based on nature's endowment of natural resources—a country with few resources vs. a country with plentiful resources. I model two decision problems faced by the political agents (reformers and politicians). The decision problems involve the rate of reform (privatization) and the choice between government-sponsored investment or welfare.

The results indicate that in a resource-abundant country such as Uzbekistan, the strength of the reformers' position is greatly reduced due to the natural, Dutch disease driven, reduction of the tradable sector because their constituents, the entrepreneurs, experience severe losses in the value of their endowments. This reduction will more likely result in policies of absorption and slow rates of privatization. On the other hand, traditional households' (workers) welfare improves because of the resource windfall as income rises and inefficiencies and price distortions are naturally mitigated through increased imports. Conversely, countries with fewer resource windfalls are more likely to choose investment and rapid reform owing to the relative strength of the reformers vs. politicians.

By examining the sensitivity of the results to changes in structural variables, capacity to transform is identified as perhaps the single most important characteristic of a transitional economy in determining the success or failure of reform policies as measured by overall change in welfare. Capacity to transform measures an economy's ability to respond to market-driven price signals in allocating its factors of production to their marginally most productive employment. In my study, the entrepreneurs, who are highly price responsive, are characterized by a high capacity to transform. The strength of the entrepreneurial class, therefore, is shown to be instrumental in directing a successful reform effort.

Additionally, because they are motivated by profit maximization rather than political control, entrepreneurial agents, rather than governments, are best suited to

identify society's next low-cost product when comparative advantage changes from resource-based to export-based. This study therefore suggests that resource-boom governments should maximize the potential of entrepreneurs to identify comparative advantage by maximizing the social dividends of resource endowments and encouraging an economy characterized by a high capacity to transform.

Finally, consistent with capacity to transform, resource-boom economies experiencing the natural structural shifts attributed to Dutch disease are shown to be specializing according to comparative advantage. Traditional recommendations designed to protect the tradable sector from shrinking are seen as socially detrimental, as these recommendations require factors of production to be artificially removed from their most productive employment.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

Table Page

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Chapter 1

INTRODUCTION

For most of the twentieth century, economists have debated the role of government in managing the productive sectors of an economy. Recently the focus has shifted away from the direct control of state ownership to more free-market principles and "laissez faire" policies. Much of this renewed emphasis in the free-market system is due to the failure of the Soviet Union's centrally planned economy. Among neoclassical economists, there is little debate about the corrective actions necessary for the former Soviet states to move to a free-market system. Five areas have been identified as crucial for reform. These are macroeconomic stabilization; price liberalization and market reform; enterprise reform; trade liberalization and current account convertibility; and creation of the legal framework for a market economy (Lipton and Sachs, 1990; Fisher and Gelb, 1991; Akyuz, 1993).

Although there is a general consensus among neoclassical economists regarding corrective action necessary for reform, the actions and inactions of leaders enacting reform remains a less understood phenomenon as these leaders have frequently failed to follow neoclassical economic advice. The profit motive remains a cornerstone of free-market economics, yet other motives must be included when trying to understand the incentives of politicians. Rather than traditional profit motives, reflecting the actions of

firms minimizing costs, or consumers maximizing utility, actions of politicians are better understood as the need to maximize political control (Downs, 1957). In a democracy, politicians will act to appease their constituents. A dictator will often use more coercive tactics, yet the motive—political stability (control)—is consistent in both.

Using a political-economic paradigm, this study examines the role of natural resources in countries moving from a former Soviet planned economy to a market economy. Specifically, the study examines the effect of natural resource abundance in the privatization process through a computable general equilibrium model of the 1991 Uzbekistan economy. Political agents will seek those policies that maximize the welfare of their constituents. However, when political parties are in disagreement as to the rate or methods of reform, the dominant political party will establish policy. In this case, the level of resource abundance provides insight into which party will ultimately establish policy.

When characterizing a transitional economy it is helpful to distinguish between those government agents who are pro-reform and those who are pro-status quo. Boycko et al. (1996), for example, divide policy makers in transitional economies into different classes. In building on Boycko my study divides policymakers into two categories—reformers and politicians. Both seek to maintain political control through appeasing their respective constituents. Reformers seek to appease entrepreneurs (shareholders), and politicians seek to appease traditional workers. This study examines the interplay

between these two groups to arrive at an explanation for the actions and inactions of policy makers in transitional economies observed over the last few years.

While much can be learned by examining the interplay between reform-minded and politically-motivated policy makers using an agent incentive paradigm, this study is specific in examining how a country's natural resource endowment affects the final outcome between reformers vs. politicians in the privatization process.

Previous studies related to this research broadly fall into three categories—literature related to privatization and reform, political-economic studies, and studies related to natural resources and growth. The literature on privatization and reform primarily focuses on the rate of reform, the role of the entrepreneurial agents in reform, or stylized facts used to model reform. Political-economic literature focuses on capturing the incentives of agents operating within the economy. Much of this literature seeks to better understand the incentives of politicians so as to model policy choice. Finally, literature related to natural resources and growth primarily seeks to demonstrate the negative value of leading sector resource production. However, a few authors take the opposing view—that resource abundance is beneficial to an economy.

My contribution lies in combining these three areas of study. Using a structuralist computable general equilibrium model my approach adopts a *political-economic paradigm*, identifies the various agents' incentives, and demonstrates that given these incentives, *the (Pareto optimal) rate of reform* will likely vary depending on *the amount*

of resource endowment. The political-economic paradigm provides a more realistic scenario of reform than studies that have simply recommended normative corrective action in disregard of positive political realities. By understanding the political implications of free-market recommendations, the methods, timing, and sequence of reform can be better managed. Additionally, by understanding the effect of a country's resource endowment on the reform process, an optimism exists that regardless of the methods, timing, or sequences attempted, the many constraints facing policymakers are eased.

Given this framework, I argue that a country endowed with resources will more likely choose a "gradualist" approach to reform. A country without abundant resources will more likely choose a quicker "shock therapy" approach to reform. However, I demonstrate that both of these actions reflect the optimal actions of policymakers given the strength of constituent classes and the strength of the respective resource endowment. This finding contradicts studies that assume a slower rate of reform is less than optimal and therefore imply a resource driven inefficiency.[1]

[1] The bias is particularly prevalent among those who espouse the "shock therapy" approach to reform. See Sachs (1994) for example. However, the argument is prevalent in "resource curse" literature as well. See Gelb (1988) and Auty (1993).

Motivation

The collapse of the Soviet Union in the late 1980s and early 1990s set a course of economic and political reform for the former Eastern Block countries, including the 15 nations now comprising the Commonwealth of Independent States (CIS). Although these countries have unanimously sought to attain the prosperity of Western economies, the means and ways of achieving this goal seem to have evaded policy makers. Functioning legal systems capable of protecting private property, macroeconomic stabilization and trade policies, privatization policies, and social safety nets protecting the unemployed are only beginning to emerge.

There has been sufficient time since the collapse of the Soviet Union to assess how and why these economies have responded as they have. Additionally, the current political and economic reality has important implications for future prospects of the various agents within the economy. From the standpoint of the multinational or national entrepreneurial investor, it is important to understand the forces driving the rate of reform. Can the risk of appropriation be better understood from observing the events of the last few years? In choosing where to invest, what factors can be observed to minimize risk? The results of this study may help the multinational or national investor choose not only the country, but also the industry sector (service vs. industrial), best suited for development. From the standpoint of reformers, it is important to understand the social and economic forces working to maintain the status-quo. From the standpoint

of the politicians, it is helpful to recognize and adopt those policies that have proven most effective in raising society's welfare.

The interaction between reformers and politicians is examined in this study, and a predictable outcome is presented relative to a given level of resource endowment. The results of this study can be applied directly to the former Soviet transition economies in predicting the likely rate of reform, the relative strength of the tradable and nontradable sectors of their respective economies, and the potential welfare benefits resulting from natural resource exploitation. Furthermore, the information may be useful for those developing countries rich in natural resource endowments. The results indicate that society is best served by policies that promote comparative advantage in the country's low-cost industry. For countries with comparative advantage in primary products, any policies that would divert factors of production away from these industries are welfare reducing, including policies designed to protect or develop value-added tradable sectors.

Methodology

This study assumes that a society's welfare can be measured in terms of utility maximization and the implementation of a computable general equilibrium framework. Specifically, the study examines the potential benefit of natural resource endowments in the privatization process through a computable general equilibrium model (GEM) of the 1991 Uzbekistan economy.

The GEM is run in GAMS and coded using the MPS/GE syntax. The general equilibrium model establishes a series of structural features consistent with modeling a transition economy. These features can be used as a baseline for future models of transition economies. These features are: 1) inefficient state production in both inputs and outputs, 2) varying transformation elasticities across productive agents, 3) the introduction of price wedges representing market failure, and 4) the use of natural resource windfall as the source of investment capital.

Society's objective is to maximize the welfare two voting classes. The change in welfare is measured as the change in Hicksian equivalent variation in income. The strength of each voting class, and their political agents, is observed through exogenous privatization modeled as the free movement of productive factors to entrepreneurial agents. In determining the number of sectors to examine, I chose to model a traditional three-sector economy in order to isolate the Dutch disease effects.[2] A three-sector model is consistent with other studies examining Dutch disease in that the interaction between the tradable, non-tradable, and resource sectors are apparent. Because of the high degree of aggregation, a three-sector model cannot be used to identify changes among the various industries comprising a sector.

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[2] The term Dutch disease refers to a historically observed real exchange-rate appreciation and median-term deindustrialization of the economy as a result of foreign exchange windfalls following the discovery and exploitation of natural resources. The term is further described in chapter 2.

The model is calibrated using input/output data for the country of Uzbekistan. The data for Uzbekistan is published by The Central Calculating Center of the Government Committee for statistics of the Republic of Uzbekistan for the year 1991. The data for 1991 represent a former Soviet economy in the very beginning stages of reform. Because the model is based on a single year of data, the model is considered static. A dynamic estimation of investment is required to capture the benefit to future generations. In a dynamic model, the net present value of future gains in welfare from investment may offset the immediate gains from welfare. However, given the principal-agent motivation of politicians, future gains periods would be highly discounted in the dynamic model. Clearly, politicians benefit most from immediate welfare gains, and may not benefit at all from future gains if, for example, they lose power prior to realizing the gains. A dynamic estimation, therefore, should not alter my conclusions. Additionally, the model best characterizes the short run due to the use of specific capital. In the longer run, entrepreneurs theoretically would be able to transfer capital between sectors into the booming resource and services sectors. The long-run effect of a booming resource sector on the entrepreneurial agent welfare, therefore, may differ from the short-run results. I leave the long-run analysis for further study.

Eight counterfactual studies are tested. The counterfactual results are presented as eight payoffs in two decision problems facing reformers and politicians. The relative strength of the two voting classes is compared based on nature's endowment of natural

resources—a country with few resources vs. a country with plentiful resources. The input for the decision problems comes directly from the GEM output. The GEM output represents society's most desirable outcome. However, the best case may not be attainable because of the unique economic and political conditions active in a given transitional economy. Through varying perceptions about the likelihood of attaining a given outcome, the decision analysis is used to capture these economic and political conditions.

Organization

The remainder of the study is organized as follows. Chapter 2 contains the relevant literature specific to transitional economies and Dutch disease. Chapter 3 introduces the methodology used in this study. Specifically, the mixed complementarity problem (MCP) approach and equation set is explained. An example problem is used to derive the cost functions used to calculate the general equilibrium solution. Chapter 4 presents the actual 1991 Uzbekistan Transitional Economy Model. Specific to this model are several structural features characterizing a transitional economy. These are described in chapter 4. Additionally, the counterfactual solutions are mapped onto a decision problem to arrive meaningful results. The decision problem is, therefore, also described in chapter 4. Chapter 5 presents the transitional model results and chapter 6 summarizes the findings and suggests areas for further study.

Chapter 2

THEORETICAL REVIEW AND LITERATURE SURVEY

Chapter 1 indicated that the core issues in this study relate to 1) the incentives of policy makers in transitional economies and 2) how these incentives are influenced by the country's natural resource endowments. This chapter begins, therefore, by defining the agents most relevant to this study—the political agents—and their incentives.

In reviewing cases of recent reform, two paradigms emerge concerning how fast a country should proceed with reform measures. The first would suggest a fast pace is best. Such reform policies have been termed "shock therapy." The second approach suggests that a slower pace is best. These policies are "gradualist" in their approach. While not furthering the debate as to which of these is best, I try to show through a public choice argument the path most likely to be taken—regardless of what is best.

Several CGE models that have captured transition economy stylized facts are reviewed. These stylized facts are then used to construct a prototypical general equilibrium model of transition economies. For example, in addition to political agents, this study distinguishes between privatized agents and entrepreneurial agents. Both are faced with competitive markets, yet the entrepreneurs recognize price incentives while privatized agents, whether firm managers, employee owners, or former communist party leaders, face a learning curve away from the old command system.

The latter portion of this chapter examines the role of natural resources in transition economies. Specifically, this study demonstrates how resources affect the outcome between reformers and politicians in choosing between "shock therapy" or "gradualism." In building up to this theme, the current debate regarding the value of a resource endowment to an economy is reviewed. Central to this argument is an understanding of "Dutch disease" and the broader "Resource Curse Theory."

Political-Economic Incentives

Price liberalization has often been the first step in reforming the command-and-control system. Akyuz (1993) points out that, unlike price liberalization, privatization has progressed very slowly. Transition economies are now weighing the "pros and cons, the way and means" of privatization. Akyuz notes:

> A properly functioning market economy cannot spring up spontaneously with the dismantling of the command-and-control system. Governments need to act not only to dismantle the old structures of central planning but also to intervene in new ways to give shape to the new market system, and to cushion the transition from one system to another (p. 3).

But what exactly does that mean? Certainly those who espouse rapid reform would recognize some role for the central government. The question seems to be to what extent the central government should or will intervene in the natural working of the free market system. Furthermore, can this be determined and modeled so as to provide reasonable inference as to the outcome of a reform program?

My study assumes that the behavior of the central government is determined by public choice theory and, therefore, predictable and able to be modeled. Lal and Myint (1996) provide an overview of recent areas in which public choice theorists have applied economic principles to political institutions. Much of this recent literature has effectively bridged the gap between economic principle and political science. Lal and Myint label these "the new political economy." Seeking economic solutions to political problems is not a new idea. Olson (1967), for example, recognized that,

> Economic theory is, indeed, relevant whenever actors have determinate wants or objectives and at the same time do not have such an abundance of the means needed to achieve these ends that all of their desires are satisfied. The ends in question may be social status or political power, and the means will be anything that is in fact price on the market. This means that economic (or more precisely micro-economic) theory is in a fundamental sense more nearly a theory of rational behavior than a theory of material goods (Olson 1967, 9 as cited in Lal and Myint 1996, 10).

Olson's comments are therefore particularly relevant for this study as the incentives of the various political agents in a transition economy are identified.

Several authors have examined the incentives of the various agents within the reform process (Downs, 1957; Radetzki, 1985; Hewett, 1988; Kennedy, 1995; Boycko et al., 1996; Mellow, 1997). Boycko et al. identify four agents, each with their own set of incentives: 1) the reformer, whose constituents are taxpayers rather than the beneficiaries of public largesse (examples of reformers would be Margaret Thatcher in Britain, Carlos Salinas in Mexico, or Vaclav Klaus in the Czech Republic), 2) the politicians, whose constituents are the working class, including labor unions (in representing their

constituents the politicians' objectives are to maintain high national employment), 3) the firm managers, who act as owners in certain scenarios of privatization, and 4) the shareholders, who protect the interests of capital.

Both the third and fourth agent types identified by Boycko et al. act as owners. However, their incentives differ. Following a power struggle between the pro-capitalist and pro-Communist legislators in 1993, President Yeltsin implemented a voucher privatization program designed to transfer ownership of a large portion of Russian industry to the population at large. Craig Mellow (1997, 124) documents the result of this policy. "The majority of factories ended up being given away to their 'working collectives,' a solution that sounded noble enough to the Communist-bred electorate. But the real control lapsed to incumbent bosses." However, efficient management is possible only when shareholders are able to establish incentives, through contracts, protective of capital.[3] Without these pro-shareholder incentives, Boycko et al. point out that when acting as owners, the pro-labor incentives of managers to maintain high employment often exceed those of the politicians. Without independent agents protecting the firms' capital, managers will often be allied with the workers, or, in fact, elected by the workers to represent their interests. This situation, incidentally, is justification against "voucher" privatization techniques designed to return ownership to the workers. Workers acting as

[3]See Little (1952) and Drucker (1974) for discussions on the need for management to act on behalf of stockholders.

owners will predictably protect the interests of labor over capital. This finding is consistent with other studies examining the role of employee ownership (see Hansmann, 1990; Lipton and Sachs, 1990; Boycko et al., 1993). The incentives of shareholders, on the other hand, are to maximize the value of capital. Shleifer and Vishny (1986), Frydman and Rapaczynski (1991), and Phelps et al. (1993) document the efficiency of outside investors in protecting the interests of capital.

Boycko, et al. establish a series of objective functions representing the various agents. The politicians gain utility through high employment and initially control the level of spending directed toward maintaining excess labor. Following privatization, politicians control the amount of labor employed through tax rebates, subsidies, or other financial incitements paid directly to the managers (or shareholders in the extended model). Boycko, et al. find that the political cost of maintaining excess labor rises after privatization owing to the shift in the source of funds allocated to excess labor. Prior to privatization, the cost is derived from the less apparent lost profits of state industry. Because this is a relatively transparent lost opportunity cost, the political cost to the politician is negligible. Following privatization, the cost is directly accountable through redirected government revenue implying a much higher cost to the politician. This result provides continued justification for a positive role of political agents in the privatization process.

As privatization progresses in the Boycko et al. study, managers gain increased authority over costs through privatization. At this point, given a Western manager trained in free market incentives, the argument could be advanced that the firm would operate with profit-maximizing objectives. In reality, the incumbent managers often continue to adhere to incentives learned from years of command control. Hewett (1988, 181) comments:

> One of the potentially formidable barriers to a successful radical economic reform in the USSR is the management cadre itself. Is it possible, one might ask, for managers who have been nurtured for a half-century by a central plan to suddenly accept responsibility for their own actions, live with the uncertainty associated with markets, and take initiatives on their own?

Kay and Thompson (1986, 18) further state that the prospect of privatization may be "distinctly unwelcome to the management concerned" because of the increased demands required of managers in a free market system. McDonald (1993, 49) echoes this sentiment noting that many of the old guard managers "simply lack the skills and experience to convert a company from its old communist predilections to a genuine market orientation."

Clearly, the incentives of the various agents must be accounted for when modeling privatization. As Kennedy (1995, 6) notes:

> One of the reasons that change is so difficult is that leaving the old system behind inevitably creates winners (private entrepreneurs, consumers, well-connected or unscrupulous state managers) and losers (bureaucrats, workers who are unable to adapt). This type of transformation is truly a

> problem of political economy because all of these groups fight for their interests in both the political and economic realms.

Although Boycko, et al. focus on the political incentive of employing excess labor, their study alludes to the broader incentive of reelection—low unemployment equals more votes. Political scientists have recognized for years that politicians are not directly motivated by the traditional economic incentives of profit and utility maximization. Rather, "Legislators, as legislators seek mainly to maximize their chances of remaining in office" (Riker, 1976, p. 54). Anthony Downs (1957, 295) hypothesizes, "Parties in democratic politics are analogous to entrepreneurs in a profit-seeking economy. So as to attain their private ends, they formulate whatever policies they believe will gain the most votes, just as entrepreneurs produce whatever policies they believe will gain the most profits." In recognizing the reelection incentive of policymakers, my study introduces a principal-agent paradigm to distinguish between the actions of reformers and the actions of politicians.

A Principal-Agent Problem

I use a modified version of Boycko, et al. to model the actions of political agents. The political agents in my study represent two competing parties acting in response to the welfare of their constituents—the politicians representing traditional workers (including managers) and reformers representing entrepreneurs (shareholders). The actions of politicians and reformers are of first concern when considering privatization because they

determine the when, how much, and the method by which firms are transferred to private owners. Yet, even when considering privatization, politicians will act to further their interests in appeasing their constituents. Specifically, when considering privatization, the actions of politicians will reflect the desires of the traditional voting class (labor or managers), and the actions of reformers will reflect the desires of the entrepreneurial class (capital-owners).

In this study the strength of each voting class is measured relative to the other. The model will not measure the number of people that will vote for reform-minded political candidates. Rather, the model measures differences in welfare between a base case and counterfactual scenario for each voting class. Perhaps, in the case of capital-owners, strength of welfare correlates into the number of voters in the class. However, this is not what we are concerned with. What can be said with certainty is that in decision theory agents will choose outcomes so as to maximize expected utility. Given a base-case welfare and a counterfactual welfare, our representative agents will rank these according to their relative payoff.

The principal-agent paradigm is used in this study to focus on the actions and inactions of governments concerning the rate of reform in a transitional economy. In reviewing the recent history of reforming economies, trends have emerged regarding successful growth vs. stagnation. A clear indication of successful reform seems to be the strength of the entrepreneurial class of constituents. Conversely, policies protective of

labor often stifle entrepreneurial activity and result in economic stagnation. The strength of entrepreneurial activity in determining successful reform is the primary topic discussed in the next section.

Enterprise Reform: The Case of Poland

Robert Kennedy (1995) in his analysis of privatization in Poland, finds two emerging economies—one based on successful privatization and one still dominated by state-owned enterprise. His findings demonstrate the strength of competition as a catalyst for enterprise reform. Through a free trade policy, domestic enterprise is faced with world prices for imported goods. These prices, in conjunction with a tight credit policy, act as a form of competition forcing high cost producers to reform.

However, Kennedy's primary contribution is in noting the advantages to enterprise turnover (starting from the ground up) rather than to firm level restructuring. The catalyst for firm turnover or restructuring is competition, and competition is associated with low barriers to entry. "Entry increases the competitive pressure on incumbent firms, making them more likely to restructure. When the rate of entry is high, incumbents who fail to adapt are swept aside" (p. 24).

While industry transformation can occur by restructuring or turnover when barriers to entry are low and competition is strong, Kennedy argues that fewer conditions are necessary for transformation by turnover than by restructuring. My only response to

Kennedy would be to suggest that the "two economies" he finds is actually a natural dichotomy between activity that lends itself to entrepreneurial participation and activity characteristic of, or approaching, natural monopoly. Therefore, policies for industry characterized by ease of entry may differ from policies for industry characterized by increased barriers.

Kay and Thompson (1986) point out several obstacles to the promotion of competition in industries characterized by natural monopoly, statutory monopoly, or industry characterized by non-profitable objectives.[4] Rather than focus on the negative aspects of privatization of existing state controlled enterprise, Kennedy could better have taken the approach that efficiency gains are realized by turnover and entrepreneurial activity. This is the approach taken by Johnson and Loveman (1995) and Akyuz (1993).

Productive Advantage of Start-up Enterprises

Like Kennedy, Johnson and Loveman (1995) examine the case of Poland. Their results indicate that a large portion of economic renewal is directly attributable to the start-up of new firms rather than to the reorganization of existing state enterprise through privatization. Akyuz (1993, 23) notes, "Promoting new enterprises and private capital accumulation could be much more effective in creating genuine owners and also entrepreneurs than transferring the ownership of existing enterprises."

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[4] See Sharkey (1982) for an exposition on natural monopoly.

Although supporters of the shock therapy approach to reform, Johnson and Loveman document the failure of its stated objectives in Poland. In fact, their conclusion is something on the order of rejecting all objectives other than those that support the creation of an environment conducive of entrepreneurial activity. They note that restructuring state enterprise has met with limited success. Inflation was not reduced to sufficiently low levels, lingering at 30 percent. As a result, financial reform has responded dismally, especially in providing affordable credit to entrepreneurial sectors. Policy makers were and are unwilling or unable to tighten credit to state enterprises "that had no prospects of being able to repay" (p. xvii).

Johnson and Loveman also admit that unemployment remains a serious problem at over 25 percent in some regions. They note that critics of shock therapy maintain that some sort of direct intervention would have been desirable. Their response is to suggest that any intervention or gradualist approach would have hindered "the replacement of old enterprises and ineffective work organization with new businesses better suited to a market economy" (p. 13).

While I do not disagree with any of Johnson and Loveman's conclusions, I would point out that even in this classic example of rapid reform, the incentives of the politicians "won" in that they provided credit for jobs. While I will not suggest that interventionist policies are more efficient, I will suggest that this is the positive reality. When modeling a reforming country, therefore, some degree of interventionist policy is

appropriate reflecting the interplay between pro-reformers and pro-welfare political agents. If the incentives of traditional workers prevail in influencing policy, politicians may act to delay privatization until optimal capital to labor ratios are achieved. In this case the government's objective would be to protect labor though capital expenditure. The actual policy would reflect a more gradualist approach to reform.

Reformers, on the other hand, seek to maximize the return to capital. Clearly, capital-owners would seek to substitute capital for labor, thus increasing the value of capital. In a transition economy, such policies are reflective of market pricing whereby excess labor is unemployed in favor of the marginally less expensive capital. Such policies are consistent with the "shock therapy" approach to reform. The following section furthers this argument by briefly reviewing the two approaches of shock therapy and gradualism while introducing the decision problem methodology that will be used in this study to determine how governments will choose between the two. The complete methodology is fully defined in chapters 3 and 4.

Shock Therapy

One of the first economists to espouse the virtues of shock therapy was Jeffery Sachs. His early work on the subject is found in *Poland's Jump to the Market Economy* published in 1993, in which he reviews the stabilization and liberation program

introduced in Poland on January 1, 1990. The program, initially termed "the big bang," came to be known as "shock therapy."

In 1989, Tadeusz Mazowiecki, the first non-communist prime minister of postwar Poland, appointed Leszek Balcerowicz as Deputy Prime Minister for the economy. Working together with Sachs and David Lipton, Balcerowicz initiated what would eventually be called the "Balcerowicz Plan." The plan consisted of five areas of reform. These were: 1) macroeconomic stabilization, 2) liberalization of prices, trade, and raw material use, 3) privatization and creation of a legal framework supporting private ownership, 4) development of a social safety net, and 5) mobilization of international credit to assist the transformation process.

These reforms were implemented on January 1, 1990, with the most immediate impact coming from the macroeconomic stabilization policies and the price liberalization policies. Poland was determined to stop inflation, reduce its debt, and create a stable exchange rate for its currency. To accomplish these reforms, subsidies were eliminated, wages were frozen, credit was tightened, the currency was devalued, and international markets were freely opened. The immediate results were skyrocketing prices and hoarding by the suppliers. The medium term results were high rates of unemployment and political unrest.

Although these reforms were initially devastating to the Polish population, it is at this point that Sachs makes his argument in favor of radical reforms. He cites examples

of countries that succeeded in stabilizing their economies. The countries, Bolivia, Israel, and Mexico, acted decisively to reduce debt, tighten credit, reduce inflation and stabilize their exchange rates. Countries that chose a gradual approach, Nicaragua, Peru, Argentina, Brazil, and Yugoslavia, for example, failed to achieve stabilization.

Although the foundation for privatization was laid on January 1, 1990, Poland has struggled to eliminate state control of its major industrial sectors. Sachs (p. 48) states, "It is in the area of privatization that the reform government was faced with its greatest intellectual and political challenges." He readily admits that, after three years into the reform process and "painful dislocations, especially higher unemployment" (p. 79), privatization had not yet succeeded. At this point Sachs seems unable, (or unwilling), to fully analyze why "privatization had not yet succeeded." Yet, he argues, "Rapid privatization of large industrial enterprises has become ever more urgent" (p. 80), to assure that the gains achieved during the previous years remain.

After having so urgently emphasized the need for continued privatization, Sachs seems to contradict himself by suggesting that privatization without qualification will not work. Consistent with others, he suggests that employee or management ownership does not provide the incentive either to protect the enterprise assets or effect painful restructuring. At this point Sachs is in agreement with the Johnson and Loveman results as he concludes his thoughts on privatization by emphasizing the need for strong ownership to provide governance over enterprise assets. The results of my study suggest

the need for an underlying ability to respond to price signals—regardless of the ownership structure.

In my model, I assume that the ability to act in accordance with price responsive signals is captured in an economy's capacity to transform, whereby factors are optimally employed according to marginal productivity. Furthermore, my model captures this ability in the incentives of entrepreneurs and their government agents. In seeking to maximize the value to the economy of productive factors (especially capital), my results indicate that entrepreneurs and reformers will dominantly prefer a shock therapy approach to reform.

Traditional workers, on the other hand, are dominantly adverse to the cost of price responsive factor relocation (i.e., unemployment). Politicians, in response to the incentives of traditional workers, will prefer a slower rate of reform or perhaps no reform at all, if the cost of reform exceeds the perceived benefit. In seeking to minimize the disruptive effects of shock therapy, governments have introduced interventionist policies. Although used to describe divergent approaches to reform, the idea of a government-managed reform effort (and the resulting slower rate of reform) has been termed "gradualism."

Gradualism

Many would agree with the Akyuz (1993, 22) conclusion, "Perhaps the most important lesson to be drawn is that while a serious macroeconomic disorder, such as hyperinflation, may require shock therapy, the same approach to structural and institutional change causes more shock than therapy." Szamuely (1993) points out that the disillusionment resulting from the economic stagnation and decline following reforms have caused many to question the benefits of the free market system. Studies by both the World Bank (Kikeri et al., 1992, p. 1) and the United Nations Economic Commission for Europe (ECE, 1993, p. 1) have conceded this point. Szamuely concludes that the "neo-liberal" approach of identifying the proper set of institutional reforms and implementing them as quickly as possible is simplistic. Rather, the state has a role. He states, "It is the common view of [some] scholars and politicians that the State should perform at least two indispensable functions in the dismantling of state socialism, namely the stabilization and privatization of the economy" (p. 32).

The core of the gradualist approach is continued government intervention through some sort of managed reform. Roland (1997), who cites himself as the main source for the theory of gradualism, suggests that the gradualist approach "aims at overcoming *ex post* political constraints by using reform sequencing to build constituents for further reform" (p. 174). Roland's view of gradualism is founded on the positive view of political economy. However, the question remains whether the state is capable of

maintaining an objective role in a gradualist approach. Governments may claim to be reformist, and even institute policies consistent with a reformist approach, yet fail to overcome the entrenched status quo.

The Reform Policy Decision Analysis

In my study two decision analysis problems are used to examine the likely outcome between the pro-reform and pro-welfare political agents. The input for the decision problems comes directly from the GEM output. The GEM output represents society's most desirable outcome. However, the best case may not be attainable. The decision analysis is used to capture the uncertainty in attaining a given outcome. For example, the first decision problem examines the probability of the state effectively investing in firm-level reengineering prior to privatization. Society's welfare is measured through a Von Neumann-Morgenstern maximization of the expected utility between successful investment and unsuccessful investment. If society perceives that government will most likely fail in directing reform efforts, they will prefer welfare to government involvement in firm-level restructuring.

Sachs points out that society is willing to accept rapid reform if "governments take care to provide targeted relief for the most vulnerable groups in society." In my study, society's willingness to accept reform is measured in society's perception of the risk to vulnerable groups. However, in the case of shock therapy, the traditional workers

are the vulnerable group. Using decision analysis, my results indicate that traditional workers and their political agents are unwilling to accept the full consequences of the dislocation of factors (especially labor) associated with shock therapy unless they perceive that reform can be accomplished without substantial economic cost. This would be the unlikely case of firms being efficient prior to privatization and facing a stable macroeconomic situation following privatization. This result confirms Balcerowicz's (1997) view suggesting that the success of the Czech Republic was due to inherited conditions enabling them to "produce relatively more economic gain and less economic pain during the economic transition" (p. 162). Balcerowicz calls these inherited situations which allow for quick economic improvement "hidden treasures." These are ideal situations in that society unambiguously benefits through a Pareto superior improvement in welfare.

If, on the other hand, society perceives that reform will exact a substantial economic cost, they will prefer a more gradualist approach to reform. The gradualist approach to reform is reflective of the greater objectives of politicians as the welfare of traditional workers is of primary concern. In this way, the inherited economic conditions facing a transitional government impact the leeway governments have in accelerating or delaying the transformation process. However, viewed from a general equilibrium perspective, governments choose to delay reform, not because of misinformation or lack of education, but rather because the gradualist approach is the economically superior

choice. When policymakers choose a gradualist approach, the economic cost of quick transition is perceived as greater than the cost of continued government intervention.

Additionally, the results of my study indicate that economic "lock-in" is a real possibility. If society perceives the economy to be very inefficient and prefers a gradualist approach to reform, and if society perceives that the government is unable to efficiently re-engineer firms and prefers welfare to investment, then society would be locked into the inefficient state managed economy. Such a society would continue as an inefficient welfare state. The decision analysis problems are fully described in chapter 4.

Reform-Related General Equilibrium Models

Several authors have undertaken to capture elements of transition in computable general equilibrium models. The majority of these models have tended to be very general, focusing on individual aspects of the reform issue. Nguyen and Whalley (1986, 1990), Deacon and Sonstelie (1985), and Dreze (1975), for example, focus their studies on price distortions and rationing schemes prevalent in controlled economies. Extending these studies to capture other distortions found in transition economies would be difficult.

Other models have focused more specifically on transition issues. Several models present before-and-after scenarios designed to demonstrate the benefit to society by enacting reform and the detriment of partial reform (Patterson, 1994; Fender and Laing, 1993; Boycko, 1992; Murphy, Shleifer, and Vishny, 1992; Lane and Dinopoulos, 1991).

Fender and Lang (1993), for example, develop a two-period model to demonstrate the effect of queuing on an economy. Excess demand and chronic shortages characterize the pre-reform period. In the post-reform period, goods are sold at market clearing prices. The study concludes that market-based reduction of the monetary overhang may lead to improved social welfare. Boycko (1992) demonstrates the detriment of partial reform. In his model wages are freed but consumer prices remain fixed. The resulting excess demand may lead to more queuing. Queuing in this model creates a non-productive drain on labor factor supply reducing national output and thus a lower social welfare.

Other models demonstrate a positive role for government participation in the transition process (Aghion, 1993; Gibson and Dutt, 1993; Lin, 1993; Bonin, 1992; Rausser and Simon, 1992; Mandler and Ryterman, 1991). Mandler and Ryterman (1991), for example, demonstrate the benefit of continued price distortions in the transition process as a means of providing a social safety net to those groups that could be hurt the most during the transition period. Bonin (1992) argues for government support through restructuring or forgiving newly privatized enterprise debt burden. The author demonstrates that without intervention no efficient bargain may exist.

A Model of Efficient Allocation and Expanded Output for Entrepreneurial Activity

Pogodzinski and Antes (1992) develop a computable general equilibrium model to examine reform of centrally planned economies. Although their results violate

intuitive economic behavior, the approach provides a foundation by which productivity and privatization issues may be examined. Their results demonstrate that by losing the income of state enterprise through privatization, the state balance of payments may actually drop. However, this can only be the case when revenue exceeds costs, which is clearly not the case in a state-subsidized environment.

The Pogodzinski-Antes model's most damaging flaw, however, is its lack of structuralist constructs characterizing centrally planned economies. Specifically, the model assumes that the state is motivated by price-responsive behavior. "The 'state sector' relies exclusively on profit maximization and decentralized price signals" (p. 142). My model attempts to model both the non-price responsive behavior of a command economy through structuralist constructs, and the self-preserving incentives of the state sector. The state's objective is to maintain political administration by minimizing unemployment and the associated political instability.

Pogodzinski and Antes develop their model to study the role of the government in transition. This model extends the Wellisz-Findlay (1986) model of the Soviet "second economy." The "second economy" model provides an empirical representation of the interaction of simultaneously existing state and private sectors. Among other experiments, Pogodzinski and Antes compare varying efficiency ratios between the state and private sectors. The model assumes that, given the private sector (the second economy), the economy will operate at a constrained optimal below the "first economy's"

production possibilities frontier. It is a constrained optimum caused by private sector inefficiency. The Wellisz-Findlay assumption is that the private sector is less efficient because of its inability to obtain state-owned capital. This condition is depicted in figure 1. The converse condition of an expanded production possibilities frontier due to the second economy is also modeled by Pogodzinski-Antes. In this case, capital is available to the second economy. The model assumes that the second economy is more productive in its use of factor inputs due to its responsiveness to price signals. This condition is depicted in figure 2.

The final point of interest regarding the Pogodzinski-Antes model is the use of what is referred to by Wellisz and Findlay as the "Kantorovich Ray." In a two-good economy, where good A is capital intensive and good B is labor intensive, the Kantorovich Ray describes the state-directed proportion of capital to consumer goods to be produced. This may be close to or far from optimal depending on the skill of the central planners who direct the proportion.

Typically, the state sector prefers capital goods over consumer goods. This is consistent with the economic profile of Eastern European countries having redundant heavy industry and lacking service industry. State sector production is therefore skewed toward capital goods. The private sector production is then added, changing the economy's output away from that desired by the state. The economy operates somewhere in between the state-directed proportion and the output choice determined by the second economy.

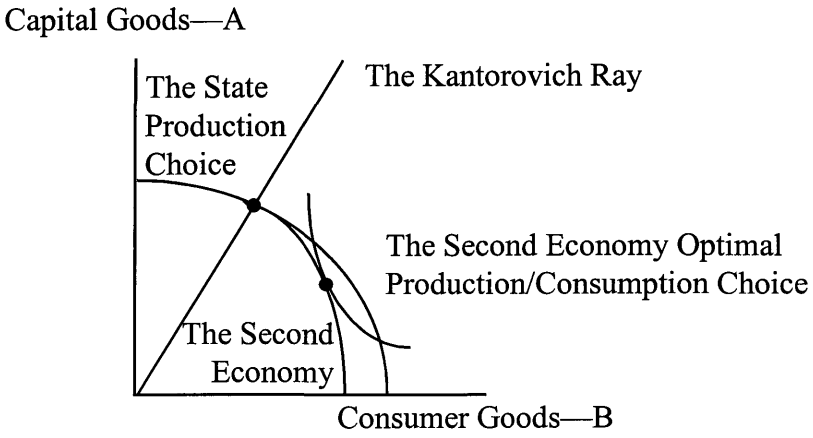

Figure 1.1. The Kantorovich Ray and A Less Efficient Second Economy

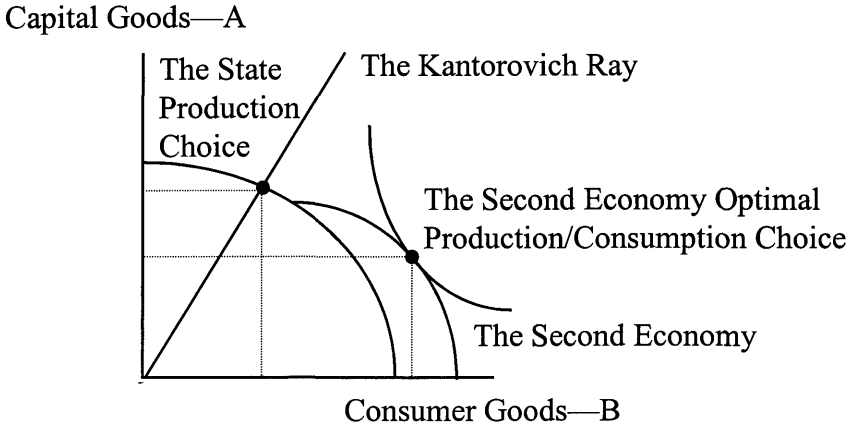

Figure 1.2. The Kantorovich Ray and More Efficient Second Economy

The Pogodzinski and Antes work can be extended to model the privatization process, given the assumptions of Johnson and Loveman. As privatization proceeds and factor resources are allowed to reallocate according to price responsiveness, the private sector and, specifically, the entrepreneurial new start-up sector become the source of recovery and growth. The private sector in general is assumed to hold an efficiency advantage owing to the allocation of factor inputs through price-responsive, cost-minimizing behavior.

A Model of Government Mandated Pricing

Patterson (1994) develops several models to examine the ordering of transition policies. Her research comprises three essays addressing different aspects of the reform process from centrally planned to free market. Her models provide a framework for addressing queuing and optimal capital transfer from state control to price-responsive free-market control. This framework provides a basis for analyzing more substantive reform questions. Patterson provides key stylized facts, in the structuralist tradition, fundamental to the behavior of reforming economies. Specifically, she models queuing as a time constraint. In her model, households maximize the following utility function subject to its associated budget constraint:

$$\begin{aligned} &\max U(x_i, z_i, \ell_i,) = x_i^a \cdot z_i^b \cdot \ell_i^{1-a-b} \\ &\text{st. } x_i + Pz_i = \theta_i \end{aligned} \tag{1.1}$$

where x and z are consumer goods, preference parameters (a and b) are set identical for both consumers (i = 1, 2), P = Pz / Px is the market clearing price (with good x serving as the numeraire), and θ_i equates to total available goods. Good z is subsidized by the central government and, therefore, subject to queuing and excess demand. Consumers must allocate their time choosing between leisure (ℓ_i), or queuing to obtain good z. This is modeled as the following constraint:

$$\text{st. } \ell_i + tz_i \leq T \tag{1.2}$$

where t is time spent queuing and T is the total time available. The model is solved numerically such that consumers maximize their allocation at stated prices, and all markets clear. My model extends this idea by considering both the relative prices of the consumption goods as well as the price of labor, which, in a more complicated model must also be considered a market driven factor. The amount of subsidized good demand, therefore, is contingent upon both its own price as well as the value of labor (and leisure).

A Model of Capacity to Transform

Patterson's work can be extended to better represent the privatization process. Although she is accurate in depicting privatization in terms of capital transfer from state to private control, differences in the three principal privatization agents' "capacity to transform" should also be accounted for. In describing capacity to transform, Kindleberger (1962, 99) argues that countries face constant change:

> Change is both internal and external. Within a country, at a minimum, population is likely to change. If economic growth occurs, there will also be changes in capital supply and technology, perhaps discovery of new resources and, with luck, growth of income per capita. Change abroad is more certain and likely to be more far-reaching. It occurs in every aspect of demand and supply, of both a country's exports and imports. The question is how a country's foreign trade reacts to change.

Kindleberger goes on to explain 'capacity to transform' as the response to change—both positive, in terms of expanding domestic innovation and growth in response to increased demand, but also in responding to more negative change such as changing tastes and preferences, or competition abroad.

Kindleberger argues that countries can respond to change in one of three ways: 1) no response, 2) a one-time response, or 3) a continuous response. First, they may resist change. Such is the case in a traditional society where "production and consumption are carried on in the same way from generation to generation" (p. 100). In such a society, tradition takes precedent over profit motives. Factors are not mobile as "succeeding generations follow in the same occupation" (p. 100).

The second response to change may be a once-and-for-all transformation. Such was the case noted by Myint (1954-55, in Kindleberger, 1962) when a direct investment in plantations in the Far East created a once-and-for-all specialization.

> Specialization was achieved, together with production for the market, even a transformation, but no capacity to transform on an evolving basis. Myint calls the process 'fossilization.' One traditional society had been exchanged for another—a more productive one to be sure, but one which a world of change would ultimately turn against (p. 102).

These two responses to change, Kindleberger argues, cause an economy to stagnate. In each case, incremental investment of new factors of production occurs in traditional sectors of the economy in disregard of price signals. Investment, in this case, should occur according to the relative rates of return, or opportunity costs, characteristic of each sector such that marginal productivities are equal across sectors.

In the case of a competing import, for example cloth imports impinging on production in early India, factors of production will not mobilize according to comparative advantage. Rather, such industries will continue to operate at a loss, and eventually be "wiped out." If labor is unable to mobilize following the demise of an import-competing industry, as Haberler (1950) noted, the economy would be adversely affected by the loss of factors of production. Clearly an ability to transform is an asset to an economy.

Kindleberger goes on to explore the consequences in terms of trade for both developing and developed countries. In each case, the advantage of a high capacity to transform is demonstrated along with the consequences for those unable to transform. The current situation facing the former communist reforming economies presents a unique opportunity to extend the idea of "capacity to transform." These countries are now faced with industries both responsive and non-responsive to free-market price responsive activity.

The former system of command pricing can be characterized as having a low capacity to transform. Such is the case with state-owned firms. Newly privatized state firms, as previously argued, require a learning-by-doing adjustment process by which old ways are forgotten and new ways are learned. Entrepreneurial firms, on the other hand, are characterized as having a high capacity to transform. In order to model a transition economy, it is therefore necessary to explicitly differentiate between state, private, and entrepreneurial agents.

My study incorporates "capacity to transform" into each agent's production function. The study assumes that each agent has access to identical technology and, thus, would be characterized by identical production functions in the empirical model. Given this assumption, production functions can be redefined as transformation functions.

In my model, capacity to transform is captured through varying the substitution elasticity parameter of the constant elasticity of substitution (CES) functional form. The changes in substitution elasticity occur along a continuum. The model depicts state firms with elasticities of substitution near zero, analogous to Leontief technology, representing an inability to transform according to price signals. Privatized firms are depicted with elasticities of substitution equal to 0.5, representing an intermediate capacity to transform. Entrepreneurial firms are characterized by elasticities of substitution equal to one, analogous to Cobb-Douglas technology and representing a strong ability to respond

to price signals. Entrepreneurial firms therefore exhibit a strong capacity to transform. These, in essence, become the transformation constraints active in a reforming economy.

Natural Resources and Growth

The literature from natural resource theory related to this study can be broadly summarized as dealing with how resources affect an economy, and the use and misuse of resource rents. Although the effect of resource abundance has been studied in relation to developing and least developed economies, my study is the first to examine how resource abundance affects transitional economies. The literature in this section provides a foundation for anticipating how resource abundance may affect reforming economies.

To date, the net benefit of resource endowment, negative or positive, is debated among economic circles. Several renowned economists have concluded that natural resource endowments are detrimental to a country's economic growth. Yet, neoclassical economic intuition suggests that resource endowments will improve growth. In fact, it has been noted that resource windfalls, when computed in a general equilibrium framework, are growth producing, even when spending suboptimalities and sticky prices and wages are taken into account (Davis, 1995, p. 1768).

Far fewer studies have shown that resource endowments do not hinder growth, but in fact improve a society's welfare when measured in GDP growth and in more comprehensive welfare measures. These are consistent with neoclassical arguments that

suggest increased availability of factors of production, in this case, resources, will increase growth. The studies that have suggested resources are detrimental to society have termed the effect "resource curse theory." The following section will address this theory.

Resource Curse Theory

In considering the origins of the resource curse theory, Davis (1995) points to Argentinian economist Raul Prebisch, who, in the 1930s, was seeking responses to Argentina's balance-of-payments problems (Hunt, 1989). Using suspect data,[5] Prebisch linked reduced terms of trade to primary commodity exports. Publishing his work in 1949, Prebisch recommended that primary resource exporting Latin American governments intervene to promote industrialization of their countries. This view gained widespread acceptance as a means of achieving growth.

One unfortunate consequence of Prebisch's work was the perception that specializing in primary commodity production was economically undesirable. This perception has since been reinforced by many studies.[6] These studies have purportedly

[5] His data series, British trade data from 1876-1947, has been criticized as misleading (Hunt, 1989, pp. 145-148, from Davis 1995, p.1766).

[6] Studies demonstrating the negative influences or failure of resource-led growth include Prebisch (1949), Myint (1954), Baran (1957), Hirshman (1958), Seers (1964), Baldwin (1966), Frank (1966), Banaji (1972), Amuzeger (1982), Van Wijnbergen (1984), Wheeler (1984), Roemer (1985), Chenery, Robinson and Syrquin (1986), Krugman (1987), Gelb (1985b,1988), Lewis (1989), Auty (1990, 1993), Jourdan (1992), Auty and Evans (1994), Berg et al. (1994), and Sachs and Warner (1995), Karl (1997), among others.

demonstrated that mineral exporting economies have historically "performed worse than non-mineral economies and strikingly worse than manufacturing exporters" (Auty and Evans, 1994). Studies have used this data to demonstrate that misuse of resource rents can actually harm or reduce economic growth (Gelb, 1985b, 1988). Gelb suggests that the difficulties of economic management through uncertain windfall gains are so severe as to erode their large ex-ante value, perhaps turning them into a net liability (1985b). Auty (1993, 1 and 124) states that, "The new evidence suggests that not only may resource-rich countries fail to benefit from a favorable endowment, they may actually perform worse than less well-endowed countries." Because of these arguments, the authors of these studies have recommended government intervention on the basis that classical and neoclassical theories are deficient.

Consistent with these ideas, Sachs and Warner (1995) find a significant correlation between resource endowment and low growth rates. Their model utilizes cross-country growth equations described in Barro and Sala-I-Martin (1995). The study controls for traditional measures of growth including trade policy, government efficiency, investment rates, external terms of trade, and income inequality between the very rich and the very poor. In all cases the study finds a statistically significant negative relationship between natural resource production and growth. The higher the economy's dependence on natural resource production the lower the growth. Thus, the results apparently confirm the resource curse thesis.

Consistent with the results of Sachs and Warner (1995), Askari, et al. (1997) examine the low sustained growth of the group of states known as the Gulf Cooperation Counsel, consisting of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. Because of oil revenue, the average per capita GDP of these countries went from $1,000 in 1970 to $12,742 in 1976. However, with a 1993 average per capita GDP of $12,012, growth has clearly remained constant from 1976 to 1993. This lack of growth is the concern and focus of the Askari, et al. study. However, Askari, et al. admit, "Oil has financed a total transformation of economic life for the citizens of these countries and this at an unparalleled pace." They further admit that there has been "a dramatic improvement in the welfare of the general population as indicated by almost any social indicator" (p. 2). These benefits, of course, include improved health, higher life expectancy at birth, and better education. I further elaborate on this contradiction in the results section of my study. However, suffice it to say at this point that studies such as Sachs and Warner (1995) and Askari, et al. (1997) that focus solely on growth and disregard broader welfare measures misrepresent the social value of resource endowments.

In analyzing the impact of resources on an economy, Gelb (1988, 136-7) establishes two sets of theories to account for the "lack of economic diversification and the poor growth in the sample countries." First, booming-sector and neoclassical growth theories emphasizing the allocative consequences of windfall gains. Second, linkage and

macro-instability theories emphasizing the quality, nature, and degree of use of windfall gains and of domestic factors of production.

Gelb finds that about two-thirds of the windfall in his study group should have been saved abroad. "This would maintain the quality of capital formation and avoid a severe recession as well as losses in output and growth because of below-capacity production at the end of the boom" (p. 140). Nonetheless, he admits that policies of saving or dissaving abroad are very sensitive to the expectations of future prices following the boom. If prices were to keep rising, borrowing against future revenue in support of a larger current account deficit may be preferred to saving. Although Gelb suggests arguments for borrowing or saving are both legitimate depending on the expectations of resource prices, he concludes, "The costs of overoptimistic projections are far greater than the costs of overcautious ones, so that a spending policy based on less than the expected price trend is to be preferred."

Gelb also suggests that slower rates of spending would allow countries to better direct investment projects. His findings suggest that resource-boom governments tended to choose investment projects that yielded low returns on investment in the long run. An obvious solution to inefficient government investment is to disburse revenues directly to the population. Gelb (p. 141) addresses this possibility yet concludes that an improved macroeconomic outcome is uncertain due to "congestion effects when demand rises and surplus capacity when it falls." The demand effects would tend to offset the gains due to

efficient investment. However, as seen in a general equilibrium framework, Gelb's concerns about demand are inaccurate. Rather than changing the *amount* of demand, the effect would be a *shift* in demand—from government agents to households. From my study, I argue in chapter 5 that the optimal strategy is for governments to empower the entrepreneurial agents within the economy by windfall disbursement, because the incentives of the entrepreneurs will assure investment according to comparative advantage. Governments, on the other hand, will choose investments based on furthering political objectives.

Finally, in analyzing the impact of Dutch disease, Gelb (p. 143) points out that countries that dynamically invested in increasing the (labor) productivity of non-oil traded sectors performed better following the shift in labor to the booming sectors. Gelb concludes:

> Because of the association of the windfalls with greater global uncertainty (which also affected importing countries), it is indeed possible to make the case that oil exporters ended the period [1974-81] worse off than they would have been with a far lower, more predictable rate of increase in oil prices or, indeed, with constant real oil prices.

This conclusion is clearly not a carteblanc endorsement of the resource curse theory. He simply states that greater gains could have been possible if resource prices had been stable. Gelb's choice of words would lead some to conclude that these countries were "worse off" for having resources, especially since this is the research question he is

addressing in the study (i.e., from the book title). However, Gelb fails to directly address the question. He then states:

> This conclusion may not apply to all the countries, because of real consumption gains during the windfall in most countries, because of the possible long-run impact on growth of infrastructural and educational investments in some countries, and because some residents of some countries have built up sizable foreign assets. (p. 143)

Gelb admits that his conclusions fail to fully account for broader welfare measures. As with the Sachs and Warner study, by disregarding broader welfare measures, Gelb misrepresents the social value of resource endowments.

As with Sachs and Warner and Gelb, Auty and Evans (1994, 77) disregard broader welfare measures and focus on comparative growth rates and case studies. Although their results are somewhat mixed, they conclude, "Performance of the mineral economies is compatible with the 'resource curse' thesis." In econometrically measuring the performance of thirty mineral exporting countries, the strongest finding of their study is that real exchange rate variability is negatively correlated with growth performance. They state, "In this context, the issue of a resource stabilization fund to help iron out the worst of the short-run Dutch Disease effects is essential, combined with consistent monetary, fiscal, and money exchange rate policy" (p. 3). However, in summarizing the results of the statistical analysis and the conclusions drawn from the case studies they state:

> There was no evidence found in either the statistical or in the case study section of a medium or long-run 'mineral curse' operating through

> medium or long-run Dutch Disease effects. This result was clear in section 2.1 where none of the regressions reported showed a statistically significant sign on the real exchange rate trend term [suggesting that there were no medium or long term Dutch disease effects].

However, the study does seem to confirm the problem of leading sector price volatility. Wheeler (1984), in an economic analysis of sub-Saharan African countries, demonstrates that the mineral economies had greater difficulty in handling commodity price volatility than did non-mineral economies.

Other studies have focused on the consequences of shifting to a natural resource-based leading sector. These consequences include reductions in other sectors (specifically, a Dutch disease driven reduction in the tradable sector) and the fiscal vulnerability associated with variable resource prices. A recent study by the United Nations Conference on Trade and Development (1994) suggests that during the 1980s, short-term demand-supply adjustment proved far more difficult to achieve when faced with the high production costs and erratic prices of large mineral-producing economies. The study examines the performance of "mining countries"[7] during the 1980s. These countries experienced severe recession and debt crisis during this period. By examining foreign debt as a percentage of GDP for mineral-based economies, the authors conclude that in many countries, the political dynamics associated with the use of mineral rents

[7] A "mining country" is generally defined as a country in which non-fuel mineral exports account for more than 40 percent of exports. A resource-based economy can be likewise defined as the economy of a country where primary products account for more than 40 percent of exports.

make it difficult or impossible to institute policies designed to overcome the negative impacts of "Dutch disease" (p.14). Studies by the World Bank also corroborate this view. Based on the assumption that natural resource endowments are harmful, Faini and de Melo (1990), suggest that market-based solutions alone overestimate the capacity of pre-newly industrializing developing countries to overcome Dutch disease effects from dominate mineral sectors.

However, the conclusions drawn from the UNCDAT study are misleading because, by only focusing on 1980's price slump, they tell only half the story. Davis (1995) finds that from 1970 to 1990 the mineral economies outperformed the non-mineral economies. Auty and Evans (1994) also find that during the 1970-1980 price boom, mineral economies as a whole outperformed the developing country aggregate. Davis (1998, 25) concludes that, "mineral economy performance is extremely heterogeneous, these economies being among the fastest growing and the slowest growing economies over the past two decades." Because of the heterogeneous performance and the price-boom-and-bust variability of resource economies, selecting intertemporal or single-country case studies will most likely generate misleading results.

Gelb (1988) and Auty (1993) provide a more comprehensive analysis of effects of a leading resource sector. According to Auty, commenting on Gelb, governments attempting to manage windfall rents encounter four critical problems: 1) an insufficiency of savings during booms, 2) the establishment of unstable patterns of consumption and

investment during booms, 3) the neglect of the competitiveness of the lagging non-mining tradable sector during booms, and 4) tardy adjustment to post-boom price downswings.

An Insufficiency of Savings. Both Auty and Gelb strongly recommend policies of "sterilization" designed to limit absorption through increased savings abroad and limit access to foreign borrowing. In fact Gelb states that, "The most important recommendation to emerge out of this study is that spending levels should have been adjusted to sharp rises in oil income far more cautiously than they actually were." Rather than saving the oil windfall, governments face pressure to use oil income for either subsidies or public investment. In this regard, Gelb states, "The main problem is then to render long-run saving abroad politically acceptable. This may not be easy; indeed, it may be impossible for a country whose government faces (or consists of) powerful groups competing for a share of the rent" (p. 141).

Gelb suggests that the political structure (more or less democratic) and the homogeneity of interest groups (the number and strength of divergent interests) represented in the government to a large degree determine how resource windfalls are used. In any case, Gelb points out that public investment tended to be inefficient.

> In many cases these projects were inadequately planned and encountered substantial cost and time overruns; sometimes decisions did not properly account for uncertainty. Risk was high because of the very specific nature of investments; the scale of plants, which was far larger than warranted by

> the size of the guaranteed domestic markets; and the correlation of returns to a wide set of plants similarly affected by the level of global activity. (p. 137)

In discussing the importance of savings, Auty points out, "The accumulation of savings performs two important functions: it slows the rate of domestic windfall absorption through investment in overseas financial instruments and it provides a cushion to ease adjustment through any subsequent downswings" (p. 18). A particularly effective form of this policy has been the promotion of a resource stabilization fund. These savings are then available in times of price recession when revenue from the resource sector declines. Rather than saving, many resource-rich countries have tended to accelerate absorption causing inflation and unsustainable patterns of consumption and investment.

Unstable Patterns of Consumption and Investment. In studying the investment patterns of resource rich developing countries Auty (1990a), confirms Gelb (1988). His results indicate that although these countries increased overall investment, government-directed investment projects void of mitigating price signals were often misconceived and frequently resulted in a negative return on investment. Often, what would otherwise be valid production expansion activity becomes rent-seeking activity where private sectors invest in securing a share of the resource windfalls (Krueger, 1974).

Additionally, oil exporters showed a marked preference for value-added production industries geared toward the resources providing both primary product rents and foreign exchange. Where these value-added industries were intended to increase revenue lost from diverting the primary products, they often resulted in industries facing comparative disadvantage on world markets and incapable of operating without government subsidies. In addition, the large expenditure programs would often exhaust available resources, including labor, intermediate inputs, and transport facilities, triggering cost inflation. Johnson and Loveman also noted that the Soviet planners have tended to favor capital intensive industries.

During boom times, resource-rich governments have also tended to promote high rates of domestic absorption through subsidies or delayed taxation, and through directly or indirectly promoting wage inflation. Consumption patterns change, reflecting society's marginal rate of product substitution toward the less expensive subsidized sectors. Gelb and Auty have found that tax rates and key prices in these countries have historically lagged inflation. The price of basic consumption goods, such as fuel and basic foods, fell well below world standards. Subsidized commodities increased their burden on government expenditures.

Additionally, owing to an excessive optimism regarding future prices, many resource-rich countries borrowed against their potential earnings. As pointed out earlier, had resource prices continued to rise, such policies may have been justified. However,

often the debt was used to increase absorption rather than to promote economically viable investment. As a result, many countries found themselves painfully in debt when anticipated future income decreased following the oil booms. This led to what was termed the "debt crises."

Neglect of the Lagging Non-mining Tradable Sector. A third difficulty discussed by Gelb results from what has been described as a medium-term deindustrialization of the economy. It has been shown that foreign exchange windfalls from resource-based economies cause real exchange-rate appreciation through the resulting rise in price of non-tradables relative to tradables. This characteristic of mineral exporting economies has been termed "Dutch disease" after the negative impact on the industrial sector in The Netherlands following the discovery of natural gas in the North Sea in the 1960s (Kremers, 1986).[8] Davis (1995) points out that the term is often used synonymously with the resource curse theory, but in reality only describes the very specific case of lagging sector shrinkage (which results in de-industrialization if the sector is manufacturing-related).

[8] Among the first authors to introduce the concept of "Dutch disease" was P. Cats "The Dutch Disease," *Management Today*, March 1977, p. 78-81. For a comprehensive discussion of the theory, see Cook and Sieper (1984), Corden (1984), Corden and Neary (1982), and Gelb (1988, pp. 23-26).

The impact of a sudden increase of exogenous foreign exchange flows on the structure of an economy has traditionally been described with the help of simple two- and three-sector models (see Buiter and Purvis,1982; Corden and Neary, 1982; and Van Wijnbergen, 1980, 1981, 1984; Benjamin, Devarajan, and Weiner, 1989; Benjamin, 1990; and Bandara, 1991).

Corden and Neary (1982) construct a three-sector model to analyze the effects of Dutch disease. The model consists of a leading sector, a lagging sector, and a non-tradable sector. The leading sector represents a windfall producing resource industry. The lagging sector represents non-mineral tradables such as agriculture and manufacturing. The non-tradable sector represents service, construction, financial services, health care, etc.

The model identifies two impacts on the economy from resource-based windfalls: a spending (demand-side) effect and a resource movement (supply-side) effect. During a mineral boom, and the resulting inflow of foreign exchange, domestic spending increases. The natural demand side reaction is for prices to rise. However, the prices of traded goods are restrained by international competition. The prices of non-traded sectors, therefore, rise relative to traded sectors. Real currency appreciation (strengthening) occurs so that the exchange rate is over-valued for lagging sector industries. Imported substitutes become less expensive relative to domestically produced tradables making competition more difficult.

The resource movement effect, or supply-side effect, according to the Corden and Neary model, is triggered by the prospect of higher returns in the leading mineral sector and the strengthening non-tradable sector. Factor inputs are (optimally) drawn from the lagging tradable sector into the booming mineral and non-tradable sectors causing the traded sector to contract. The result is a "disproportionate" ratio of traded to non-traded sectors as well as an overvalued exchange rate.

In Gelb's analysis, it is implied that the new equilibrium is welfare reducing, although this assumption is not substantiated. One point to consider is the fact that the movement to the new equilibrium is a result of optimal price-responsive behavior. The new position is clearly a benefit to society in the medium term. The question at hand relates to what will be the net long-term effect. As noted, the natural supply response is for factors to shift to the non-tradable sector. These forces cause a structural shift in the economy and a slowed ability to readjust during times of price downswing.

Delayed Adjustment Following Price Downswings. The fourth and final difficulty encountered by resource-rich developing countries during the 1970s and 1980s was their delayed response to price downswings. These countries were unable to compensate adequately for the loss of resource-based revenue. Value-added industries were (according to Gelb) "faulty," non-mineral trade related industries were atrophied, and demand was difficult to restrain.

This represents a period of surplus capacity as demand shifts to the new prices, and labor reallocates to the new equilibrium. Schydlowsky (1986) argues that given price shocks following a mining sector boom, the rapid adjustments required by market-based solutions simply cannot be made by the majority of Latin American economies due to these structural shifts occurring during times of price boom. Auty (1993) points to an over optimism concerning resource prices within governments following price downswings that led to a failure to enact policies compensating for the loss of revenue from the resource sector following the price downswing.

Traditionally, policies have overlooked the volatility of resource prices. Gelb (1988) confirms the problems related to resource price volatility. In his study, six oil-exporting countries are examined during the 1974-78 and 1979-81 energy price booms. His results indicate that even strong governments have difficulty resisting over-rapid windfall absorption during the booms and delaying adjustment policies following price downswings.

Based on these problems faced by mineral exporting developing countries, many economists have begun doubting the intuitive positive impact that resource rents can have on an economy. These criticisms have led structuralists to advocate an increased role for governments in economic management. This view has been especially popular in Latin America and sub-Sahara Africa where it was argued that developing countries require increased intervention due to their lagged response to macroeconomic incentives, most

notably exchange rate shifts (Schydlowsky, 1986). This is in direct contrast to the views of the neoclassicists who have found developing country governments the very source of the market failures that prompted structuralists to advocate government intervention (Lal, 1983).

The Benefits of Natural Resource Abundance

Davis (1998), focusing on deterministic sectorial studies, identifies several problems with the resource curse thesis. Sectorial studies attempt to deterministically equate economic performance by categorizing the leading sector. Sectorialists would equate, for example, a light-manufacturing leading sector with a strong stable democracy and rapid development, and a resource-based leading sector with a weak and unstable government and slow development. However, rather than demonstrating negative effects from a leading resource sector, the argument against resource-based economies presumes a resource-cures paradigm. In his study, Davis suggests four problems with the argument. First, he points out that there is very little evidence from comparative case studies or empirical studies that primary resource abundance causes subsequent bureaucratic inefficiency. He suggests that state capacity may be more easily determined through ethnic diversity than through mineral abundance. Furthermore, Davis finds that "the alleged structural lock-in and consequent inability of mineral economy governments to adjust to external mineral price shocks to be unsubstantiated" (p. 15). Rather, case

studies suggest that economies adjust accordingly when faced with price downswings and resource exhaustion. Furthermore, "specific factors" arguments (such as those of Blainey, 1993 and Duffy, 1994, that suggest factors employed in the mining sector cannot be re-deployed elsewhere) tend to be exaggerated. Studies have demonstrated that, for example, "mining-related infrastructure expenditures, such as power lines, rail links, and roads, can and have served to open up the agricultural potential of the interior" (p.16).

Second, Davis questions the assumption that the strength of a government determines the strength of the economy's growth. Rather, causality supports the converse—the strength of the economy determines the strength of the government. Davis (p. 18) cites Deaton and Miller (1995), who conclude that the causality must run from economic performance to political performance. "The policy advice is then to avoid slow economic growth, which may or may not mean forced diversification away from mineral extraction."

Third, Davis highlights the sectoralists' reliance on the unsubstantiated notion that a resource-based leading sector is to be avoided at all cost. In these studies, Davis says "Any mineral economy government that fails to suppress its mineral sector is seen as captured by the mining elite or labor unions, rather than as adhering to the dictates of comparative advantage in the neoclassical tradition" (p. 18). Davis attacks this assumption from several angles. Much of the argument is based on the assumption that a manufacturing-based leading sector causes higher growth rates than a resource-based

leading sector. Davis, however, argues that rapid growth determines the strength of the manufacturing sector, not the converse assumed by the sectorialists.

In neoclassical growth theory, growth occurs by expanding the production possibilities frontier (PPF). In the simplest case, given *ceteris paribus* assumptions and two-factor inputs, growth depends on increases in the labor force and in capital formation. If labor is abundant and capital is scarce, as is typical of low-income countries, then domestic savings constrains capital formation and, hence, growth. In the simplest sense, the first constraint to growth is the supply of labor and capital (domestic savings). Davis points out that according to neoclassical growth theory, "mineral-based economies producing according to comparative advantage are expected to excel given their large capital stock and the slackening of the growth constraint created by mineral sector reserves" (p. 19).

Where labor and other domestic inputs are in ready supply but production is limited by scarcity of importable inputs, the availability of foreign exchange also becomes a constraint to growth. Historically, developing countries have encountered foreign exchange shortages as documented by Krueger (1978). Development and planning research of the 1960s identified this problem as the "foreign exchange gap." The two-gap model was first elaborated by Chenery and Bruno (1962) and Chenery and Strout (1966).

Another constraint to growth is in the availability of fiscal revenues. The availability of fiscal revenues constrains growth when the public sector plays a major role in capital formation and public infrastructure is needed to generate private investment. This becomes a third gap constraining growth. Mineral and energy sector windfalls, when wisely used, can provide relief from all three of these constraints to growth.

Davis (1998, 19) additionally points out that exchange rate appreciation associated with mineral exports are in fact a natural, and "even a desirable 'Dutch disease' result of producing mineral according to comparative advantage (Corden and Neary 1982)."

> The exchange rate appreciation that mineral booms create has an important and intended economic effect; it signals the high opportunity cost of restricting the natural flow of resources away from the traditional manufacturing sector and into the exporting mineral sector. As such, the traditional manufacturing sector (optimally) shrinks in favor of the booming mineral sector. (p. 19)

Finally, Davis reviews several studies regarding the impact of price volatility on economic performance. He summarizes these reviews by suggesting that, "there is no clear relationship between export earnings instability and economic growth" (p. 21). The problems with reliance on a minerals sector occur when the sector looses its value through commodity price collapse or resource exhaustion. In either case, the economy is faced with a new set of comparative marginal productivities and, as I will argue later in my study, economic prosperity is determined by the economy's response to the new prices. In considering the previous arguments, Davis concludes that there is insufficient

evidence to suggest that countries avoid having a dominant mineral sector in all circumstances.

A fourth and final criticism by Davis (1998, 22) is the "presumption underlying all of this analysis is that the mineral economies have as a group underperformed." Much of this criticism is based on Davis's 1995 work in which he seeks to identify whether mineral endowments have in fact contributed negatively to the historical long-run growth and development of mineral-producing countries as a whole. In his analysis, he examines a twenty-year period for a broad ranking of mineral producing countries. It is interesting to note that from 1970 to 1991 only one country, Tunisia, succeeded in diversifying its economy away from primary product exports. Davis suggests, "This indicates that mineral endowment-related comparative advantages are very slow to change, and that it is difficult, if not impossible, to force diversification of a resource-endowed economy contrary to comparative advantage" (p. 1772).

Despite the efforts of world development agencies to promote structuralist industrial development, Davis finds that mineral endowments, natural trade patterns, and probable Dutch disease effects contributed to these countries maintaining their mineral dependence status. More to the point, Davis investigates the development performance of these mineral economies and finds that mineral economies as a group significantly outperformed the non-mineral economies. By comparing simple GNP per capita, Davis finds, "There is no evidence that the mineral producers as a whole were being debilitated

by their resource endowments" (p. 1773). The study then focuses on a broader range of welfare measures.

Davis (1998, 1772) clearly explains the problem of using simple GNP growth as a measure of development:

> First, the rents from the mineral extraction, even though simply a conversion of underground assets into cash flows, are counted as income in the national accounts, without recognition of the asset base. Thus we might expect the mineral economies to have higher indicated GNPs than non-mineral producers, although this does not represent sustainable economic performance. Second, economic growth is a subset of development, the latter defined by Sen as the expansion of people's entitlements and capabilities (Hunt, 1989, p. 346). GNP per capita is thus only a subset of economic development, and its level has been shown to be a poor reflection of development performance (Hicks and Streeten, 1979). Third, many mineral economies, and particular South Africa and Brazil, have income inequality problems that are masked by the per capita income index. Finally, there is concern that the poorer countries—in this case the nonmineral producers—are penalized by the use of market exchange rates in calculating their U.S. dollar GNP equivalent. Purchasing power parity (PPP) equivalent GNPs are more reflective of economic status, and are currently being developed by the World Bank and the United Nations.

Davis uses a second set of welfare indicators patterned after the Hicks and Streeten (1979) "Basic Needs Indicators" of human development:

1) Life expectancy at birth (years)

2) Infant mortality rate (per 1,000 live births)

3) Calorie supply per capita (% of daily requirements)

4) Population with access to sanitation (%)

5) Primary school enrollment (gross % of age group)

6) Adult literacy rate (%)

7) Human Development Index (maximum = 1)

The Human Development Index[9] combines relative scales of longevity, education, and resources for an all-encompassing measure of welfare. The indicator is somewhat controversial but is gaining acceptance among development economists (Streeten, 1994). By comparing long-term mineral economies to never-mineral economies, Davis finds that in every category the mineral-producing countries perform better than the never-mineral economies. The study finds that even the percentage improvement over the period tested was greater for the long-term mineral economies. From this evidence, Davis concludes that the resource curse is, if anything, the exception rather then the rule.

In my study, resource abundance is a net benefit to society when measured by change in welfare. However, the various agents are affected differently. Traditional workers unambiguously benefit from resource abundance—both through increased income and through efficiency gains resulting from increased imports. Entrepreneurs, on the other hand, unambiguously lose welfare in the short-run because of the natural shift

[9] The Human Development Index was developed by the United Nations Development Programme as "A measure of people's ability to live a long and healthy life, to communicate and to participate in the life of the community and to have sufficient resources to obtain a decent living" (UNDP, 1993, p. 104).

away from value-added tradable production.[10] The result confirms the Dutch disease theory.

Additionally, the magnitude of loss will increase if the economy prevents, slows, or otherwise disrupts the natural shift in factor allocation. Factors of production are optimally employed where their marginal productivities are maximized and equal across the economy. I demonstrate that Dutch disease effectively changes society's relative prices and marginal factor productivities. The resulting structural shift in the output mix of the economy is a natural response to changing prices according to the law of comparative advantage. If the economy is allowed to shift into its low cost product (in this case resource production), the entrepreneurs' short-run losses are minimized. In my model, this effect is seen in relation to capacity to transform where a low capacity to transform results greater welfare losses to the entrepreneurial agents.

Additionally, my study suggests that society benefits from an abundant resource sector through the broader welfare measures suggested by Davis (1995). Comparing these to corporate dividends, I demonstrate that society benefits both through economic growth and through receiving dividends attributed to the resource windfall. In the long-run, if society is careful to maximize the benefit of these dividends while the resource

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[10] My study best characterizes the short-run due to the use of specific capital. In the long-run, entrepreneurs theoretically would transfer capital from the shrinking tradable sector into the booming resource and services sectors. In this case, entrepreneurs may also gain from a booming resource sector. I leave the long-run analysis for further study.

sector is the low cost product, society is better able to shift into its next low cost product when prices change. However, shifting according to comparative advantage is not possible if governments persist in supporting non-competitive sectors. The entrepreneurs are seen as best able to identify society's competitive advantage.

Conclusions

In this chapter I have reviewed the foundational studies related to my work. These studies broadly fall into three categories—privatization and reform, political-economic studies, and natural resources and growth. The principal issues related to privatization and reform are the rate of reform, specifically what has been termed shock therapy vs. gradualism, and models that have been developed to capture stylized facts regarding transitional economies.

Additionally, I have reviewed issues related to the incentives of policy makers in transitional economies. Combining political incentives with economic principal broadly describes the political-economic perspective of transitional economies. Economically, the strength of profit maximization embodied in the entrepreneurial class is demonstrated. Politically, the incentive of governments to protect the traditional worker class is described. From this literature, I am able to establish a principal-agent paradigm to describe the actions and inactions of governments in my model. Broadly, reforming governments contain reformers and politicians. Reformers are the agents of capital-

owners and politicians are the agents of traditional workers. Using this paradigm, my model is able to predict government policy from the relative strength of the principal/agents.

The third foundational area of literature relates to the economic benefit or liability of country's natural resource endowments. Although the affect of resource abundance has been studied in relation to developing and least developed economies, my study is the first to examine how resource abundance affects transitional economies. Previous studies are used as a foundation for anticipating how resource abundance will affect reforming economies. However, to date, the net benefit of resource endowment, negative or positive, is debated among economic circles. The dominant economic paradigm suggests that a resource endowment is a net liability. Such a view is consistent with the resource curse thesis. However, Davis (1995, 1998) points out several problems with the resource curse thesis. This chapter reviewed these criticisms.

Chapter 3

METHODOLOGY: THE MPS/GE MIXED COMPLEMENTARITY PROBLEM (MCP)

In this chapter I develop the methodology used in the study. Specifically, I will explain the mixed complementarity problem (MCP) approach and equation set. An example problem is used to derive the cost functions used to calculate the general equilibrium solution. The methodology is based on the traditional Arrow-Debreu general equilibrium formulation (Arrow and Hahn, 1971). The economy is characterized by two sets of commodities: a factor market and a goods market. The consumers are specified by a set H_r (where, in my model, r =capital owners, labor, and government). Each consumer has an initial factor endowment and a set of preferences, resulting in demand functions for each commodity. Market demands are the sum of each consumer's demands. Commodity market demands depend on all prices, and are continuous, nonnegative, homogenous of degree zero (i.e., no money illusion), and satisfy Walras' law (i.e., that at any set of prices, the total value of consumer expenditures equals consumer incomes).

On the production side, technology is described by either constant-returns-to-scale activities or nonincreasing-returns-to-scale production functions. Producers are assumed to maximize profits. The zero homogeneity of demand functions and linear homogeneity

of profits in prices (i.e., doubling all prices doubles money profits) imply that only relative prices are of any significance in such a model.

Consumption and production are characterized by inputs (demand) and represented by negative numbers. Outputs (endowments and supply) are represented by positive numbers. Equilibrium is characterized by a set of prices and levels of production in each industry, such that the market demand equals supply for all commodities (including disposal if any commodity is a free good). Since producers are assumed to maximize profits, this implies that in the constant-returns-to-scale case, no activity does any better than break even at the equilibrium prices (i.e., zero-profit conditions).

A traditional formulation of a general equilibrium problem would be to maximize some objective function, e.g., society's welfare (utility), for example, subject to production, income, and factor supply constraints. In the case of a two-good, two-factor society, the formulation would be as follows:

Maximize:

$$U = U(X,Y),$$

subject to:

Production $\quad X = X(P_L, P_K)$, and $Y = Y(P_L, P_K)$;

Income $\quad M = P_L L^* + P_K K^* = P_X X + P_Y Y$;

Factor Supply $\quad L^* = L_X + L_Y$;

$\quad K^* = K_X + K_Y$.

where U, society's welfare, is a function of activities X and Y, activities X and Y are functions of factor prices in profit maximizing production choices, the total value of income (M) from factor endowments (L^* and K^*) cannot exceed the total value of commodities demanded, L^* and K^* are the total factor supply available, and where L_X, K_X and L_Y, K_Y are the shares of each factor used by productive activity X and Y respectively.

The above optimization can be formulated as a system of equations (Rutherford 1995).[11] Optimization occurs through derivation of unit cost and unit expenditure functions. The unit cost functions for X and Y are:

$$c_X = c_X(P_L, P_K), \text{ and } c_Y = c_Y(P_L, P_K).$$

The unit cost (expenditure) function for W is:

$$e = e(P_X, P_Y), \text{ where } W \text{ is a Hicksian welfare index.}$$

Using these functions, the following system of nine equations, in nine unknowns, fully identifies an equilibrium. Equations (3.1) through (3.3) represent the zero-profit class of

[11] I am using GAMS MPS/GE solver for this study. GAMS stands for General Algebraic Modeling System. It was originally designed to solve linear and non-linear programming optimization problems. MPS/GE stands for Mixed Inequality and Non-Linear Equation Solver. It is a module of GAMS designed for equilibrium problems. MPS/GE is best suited to solving systems of equations and inequalities. MPS/GE, written by Tom Rutherford, uses an algorithm and methodology also developed by Tom Rutherford. He has named his method MCP, for Mixed Complementarity Problem. Rutherford has written several tutorial papers explaining the MCP GEM methodology. These papers are available at www.gams.com. Of specific note is the paper entitled "GAMS/MPSGE: The Modeling Framework and Syntax."

equations. These are unit conditions equating price to marginal cost (expenditure) and are represented as follows:

1) Zero-profit for X $$P_X = c_X(P_L, P_K); \quad (3.1)$$

2) Zero-profit for Y $$P_Y = c_Y(P_L, P_K); \quad (3.2)$$

3) Zero-profit for W $$P_W = e(P_X, P_Y). \quad (3.3)$$

The market clearance class of equations equate supply with demand for commodities X and Y, and factors L and K. Using Shephard's Lemma, if the profit function $(\Pi_{X,Y})$ is differentiable in prices, the unique profit-maximizing supply functions are:

$$X(P_X, P_Y, P_L, P_K) = \frac{\partial \Pi_X}{\partial P_X} \text{ , and } X(P_X, P_Y, P_L, P_K) = \frac{\partial \Pi_X}{\partial P_X}, \quad (3.4)$$

and the factor share (derived-demand) functions are:

$$L_X(P_X, P_Y, P_L, P_K) = \frac{\partial \Pi_X}{\partial P_L}, L_Y(P_X, P_Y, P_L, P_K) = \frac{\partial \Pi_Y}{\partial P_L}$$

$$K_X(P_X, P_Y, P_L, P_K) = \frac{\partial \Pi_X}{\partial P_K} \text{ , and } K_Y(P_X, P_Y, P_L, P_K) = \frac{\partial \Pi_Y}{\partial P_K}, \quad (3.5)$$

where X and Y are the profit-maximizing quantities of supply and L_X, L_Y, K_X, and K_Y are the profit-maximizing derived-factor demand (see Chung, 1994, p. 126).

Given the derivation of unit cost, I use Shephard's Lemma to determine intermediate and final commodity demands. If total cost for activity Y is $\overline{Y} \cdot c_Y$ (where $\overline{Y}$ is the benchmark activity level) the portion of commodity X demanded by activity Y is:

$$x_Y = \overline{Y} \frac{\partial c_Y}{\partial P_X} \ , \tag{3. 6}$$

where

$$x_Y + x_X = x_{\text{int}} \tag{3. 7}$$

is the total intermediate demand for commodity X. Likewise, final demand for commodity X is expressed as:

$$x_{\text{final}} = \frac{\partial e}{\partial P_X} W \ . \tag{3. 8}$$

In equilibrium, total demanded must equal total supplied:

$$x_{\text{int}} + x_{\text{final}} = X_{\text{demand}} = X_{\text{supply}} \ . \tag{3. 9}$$

The market-clearance equations express this condition and are represented by equations (3.10) through (3.14). Note that the equations include both a bared variable (a constant) and a non-bared variable (the activity index). The bared values represent the benchmark calibration. The non-bared values are the variables we are solving for in the counterfactual experiments. The non-bared variables are equal to one in the

benchmark and represent the percentage change in activity levels and prices in the counterfactual experiments.

4) Supply = Demand for X $$X = \frac{\partial e}{\partial P_X} W + \overline{X} \frac{\partial c_X}{\partial P_X} X + \overline{Y} \frac{\partial c_Y}{\partial P_X} Y. \quad (3.10)$$

5) Supply = Demand for Y $$Y = \frac{\partial e}{\partial P_Y} W + \overline{X} \frac{\partial c_X}{\partial P_Y} X + \overline{Y} \frac{\partial c_Y}{\partial P_Y} Y. \quad (3.11)$$

6) Supply = Demand for W $$\overline{M} \cdot W = \frac{M}{P_W}. \quad (3.12)$$

7) Supply = Demand for L $$L^* = \overline{X} \frac{\partial c_X}{\partial P_L} X + \overline{Y} \frac{\partial c_Y}{\partial P_L} Y. \quad (3.13)$$

8) Supply = Demand for K $$K^* = \overline{X} \frac{\partial c_X}{\partial P_K} X + \overline{Y} \frac{\partial c_Y}{\partial P_K} Y. \quad (3.14)$$

The final equation, equation (3.15), requires income balance. The total value of income (M) from factor endowments (L^* and K^*) cannot exceed the total value of commodities demanded.

9) Income $$M = P_L L^* + P_K K^*. \quad (3.15)$$

Where

Production sectors are identified as:

- $\overline{X}$ Benchmark activity level for productive sector X,
- X Activity index for sector X equal to 1 in the benchmark,
- $\overline{Y}$ Benchmark activity level for productive sector Y,
- Y Activity index for sector Y equal to 1 in the benchmark,
- W Hicksian welfare index equal to 1 in the benchmark.

Commodities or markets are identified as:

- P_X Price index for commodity X equal to one in the benchmark,

P_Y Price index for commodity Y equal to one in the benchmark,

P_W Hicksian welfare price index (expenditure) equal to 1 in the benchmark,

P_K Price index for capital equal to 1 in the benchmark,

P_L Price index for labor equal to 1 in the benchmark.

Consumers are identified as:

$\overline{M}$ Benchmark income level of the representative household,

M Nominal income level of the representative household.

Factor endowments are identified as:

K^* Capital endowment,

L^* Labor endowment.

These nine equations can be solved for the nine unknowns: X, Y, W, P_X, P_Y, P_W, P_K, P_L, and M. The correct specification occurs through the use of Kuhn-Tucker conditions. If an equation is not binding (a corner solution), the Kuhn-Tucker conditions assure that the equation is dropped from the solution set. Additionally, Walras' Law requires

$$\sum_{i=1}^{N} P_i\left(D_i - S_i\right) \equiv 0, \text{ for all commodities } i = 1 \text{ to N.}$$

Using the Kuhn-Tucker conditions is a convenient method to assure that either excess supply is zero or price is zero. If excess supply is not zero the Kuhn-Tucker complementarity condition binds and price equals zero, assuring Walras' Law is satisfied. The shadow variable is therefore always included with each equation as a reminder that the corner solution must be checked.

The mixed complementarity syntax methodology relies on the use of unit functions. These are average profit and cost functions. The first-order condition of profit maximization requires marginal profits be equal to zero. In addition, market clearance

conditions require price to be equal to marginal cost for the firm's profit maximizing output choice. Using the Shepard-Samuelson Theorem, the shadow multiplier is shown to be equal to marginal cost, average cost and price for the cost minimizing production choice and the firms long-run profit condition under perfect competition (Chung, 1994, p. 200). Given this result, in perfect competition, unit profit and unit cost functions are equal to marginal profit and marginal cost, respectively. The first three zero profit conditions shown above, therefore, set price equal to marginal cost.

Using the MPS/GE (Rutherford, 1995) solver, the social accounting matrix (SAM) is represented with both positive and negative numbers. Negative numbers represent expenditures (purchases). These are flows out of the economy in the form of intermediate or final demand (see figure 3.1). Positive entries represent receipts (sales), or flows into the economy via commodity and factor supply. Columns represent all revenue and expenditure transactions associated with a particular productive activity or representative consumer. Rows represent all supply and demand transactions for commodities and factors across activities and consumers. MPS/GE uses the information contained in the rows and columns in constructing the three classes of equations represented in the equilibrium equation set. The columns contain data for firms and consumers. Columns containing activity output and cost data are used to construct zero-profit equations. Columns containing consumer income and consumption data are used to construct income balance equations. The rows, containing commodity supply and

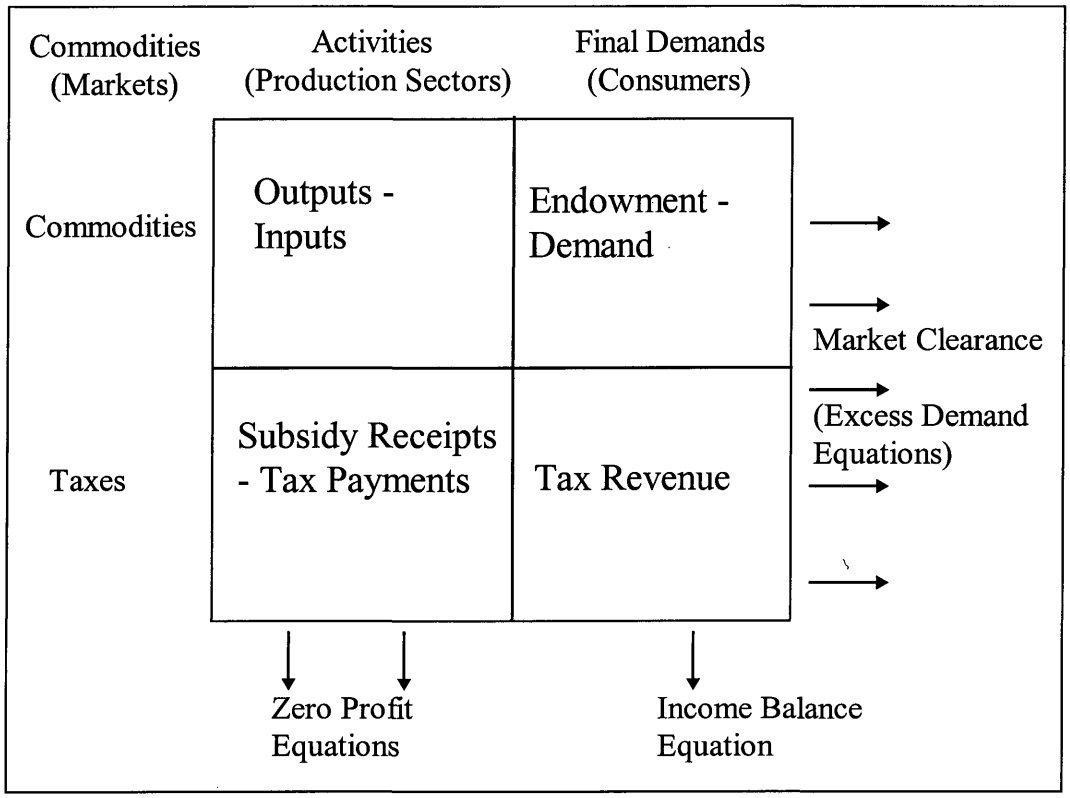

Figure 3.1. Conventional SAM Formation and Benchmark Equilibrium Equation Set

demand data, construct excess demand equations. Therefore, a balanced SAM implies that the sum of the rows must equal the sum of the columns. The values contained in the SAM are then used to calibrate the model to replicate the base year.

A Simple Example

Markusen and Rutherford (1995) have developed a series of simple models to both teach foundational economic principles and to provide an initial understanding of the MPS/GE methodology. The first model, *m1-1s – Closed 2x2 Economy: A Quick*

Introduction to the Basics, is numerically replicated here. By using this model as an example, MPS/GE syntax is introduced to familiarize the reader with the methodology of a MPC GEM. The *m1-1s* example uses a rectangular social accounting matrix where there is one row for every market (traded commodity). In this case there are five markets, for goods *X* and *Y*, factors *L* and *K*, and welfare *W*. In the SAM, the commodity markets are referenced with prices. There are two types of columns, one representing productive activity and a second representing consumption activity. In this case there are three production sectors, *X*, *Y*, and *W*, and a single consumer *CONS*. Although not necessary, an extra column (*W*) and extra row (P_W) are introduced to represent an aggregate consumption index and the corresponding price index. The introduction of activity *W* is convenient in that changes in *W* reflect changes in Hicksian income—a real measure of change in welfare. The *m1-1s Closed 2x2 Economy* social accounting matrix is shown in figure 3.2.

Obtaining the general equilibrium solution is a two-stage process. First, underlying cost-(expenditure) minimization problems are derived through the cost-minimizing first-order conditions. On the production side, we solve for unit cost functions $c_X = c_X(P_L, P_K)$ and $c_Y = c_Y(P_L, P_K)$. On the consumer side, we solve for the unit expenditure function $e = e(P_X, P_Y)$. The cost-minimization problems can, therefore be expressed as a Lagrangian optimization problem using exogenously defined production and utility functions.

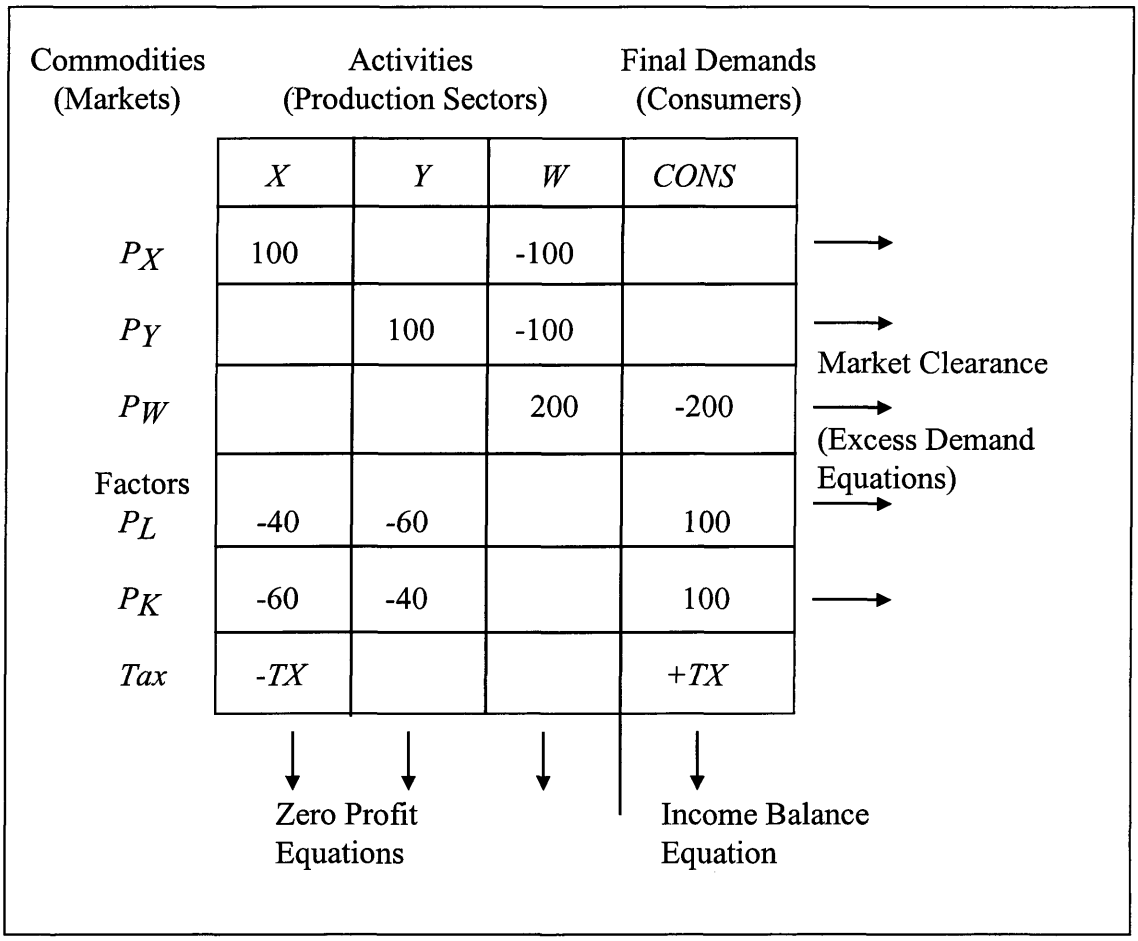

Figure 3.2. The *m1-1s Closed 2x2 Economy* Example Social Accounting Matrix

The Cobb-Douglas production functions for j activities and i commodities are:

$$y_j = A_j \prod_{i=1}^{N} x_i^{\alpha_j^i} , \tag{3. 16}$$

where for the constant returns to scale case

$$A_j > 0,\ 0 < \alpha_j^i < 1, \text{ and } \sum_i \alpha_j^i = 1,\ \forall_j ,$$

A_j is a scale parameter, α_j^i is a share parameter, x_i is a factor input, intermediate input, or a nested function of intermediate and factor variables. Likewise, the Cobb-Douglas utility function for H households is:

$$U_H = A_H \prod_{i=1}^{N} x_i^{\alpha_H^i} , \tag{3. 17}$$

where

$$A_H > 0,\ 0 < \alpha_H^i < 1, \text{ and } \sum_i \alpha_H^i = 1,\ \forall_H ,$$

A_H is a scale parameter, α_H^i is a share parameter, x_i is a consumption good.

On the production side of the economy, the cost minimization problem can, therefore, be expressed as:

$$\min\ TC_j = \sum p_j^i x_j^i$$

$$\text{s.t. } \bar{y}_j = A_j \prod_{i=1}^{N} x_i^{\alpha_j^i} , \tag{3. 18}$$

where $\bar{y}_j$ is the benchmark activity level and for the constant returns to scale case,

$$A_j > 0,\ 0 < \alpha_j^i < 1, \text{ and } \sum_i \alpha_j^i = 1,\ \forall_j .$$

In constructing the production and utility functions associated with the *m1-1s Closed 2x2 Economy* SAM in figure 3.2, technology and preferences are calibrated to the input quantities and prices. There are an infinite number of points on a given isoquant, each of which could be taken to calibrate a given functional form. The trick is to choose a point that is convenient. It is important to note that the numbers in the SAM are in units of value. It is convenient, therefore, to choose the point where either prices equal one, or where quantities equal one. For example, two points for calibrating the underlying technology for sector *X* are shown in figure 3.3. The values are taken from the SAM for sector *X*:

	MPS/GE Syntax:		
Point 1:			
Given an Output Quantity	Q:100		
Labor Quantity	Q:40	at Price	P:1
Capital Quantity	Q:60	at Price	P:1
Point 2:			
Given an Output Quantity	Q:100		
Labor Quantity	Q:1	at Price	P:40
Capital Quantity	Q:1	at Price	P:60

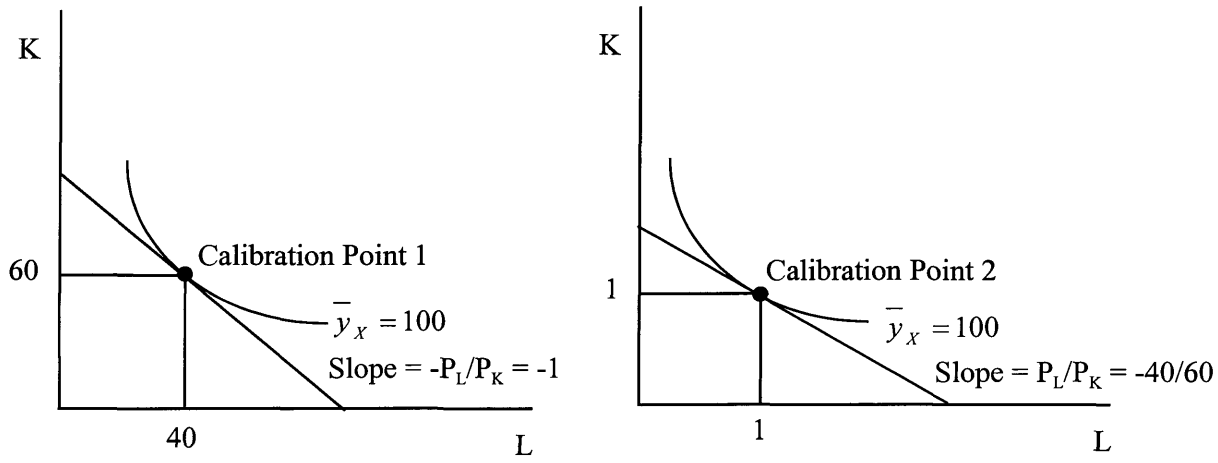

Figure 3.3 The *m1-1s* Underlying Technology for Sector $\bar{y}_X$

The reference price fields are used solely to establish the marginal rate of substitution (i.e., the slope of the isoquant) at the benchmark point. The slope of the isoquant equals the ratio of the reference prices. The calibration point, therefore, could alternatively be as follows:

Alternative calibration point: MPS/GE Syntax

Given an Output Quantity	Q:100		
Labor Quantity	Q:100	at Price	P:0.4
Capital Quantity	Q:100	at Price	P:0.6
Alternative calibration point:			
Given an Output Quantity	Q:100		
Labor Quantity	Q:40	at Price	P:1
Capital Quantity	Q:40	at Price	P:1.5

The associated production function, calibrated at point 1, is therefore:

$$\bar{y}_X = A(L^{0.4}K^{0.6}), \quad \text{where } A = 1.96, \text{ and } \bar{y}_X = 100. \tag{3. 19}$$

For activity $j = X$, the firm's optimization problem is expressed as:

$$\begin{aligned} &\min\ TC_X = P_L L(1+TX) + P_K K(1+TX) \\ &\text{s.t. } \bar{y}_X = A(L^{0.4}K^{0.6}). \end{aligned} \tag{3. 20}$$

The Lagrangian expression for the firm's cost-minimization problem is:

$$\mathbf{L}_X = P_L L(1+TX) + P_K K(1+TX) + \lambda\left(\bar{y}_X - A\left[L^{0.4}K^{0.6}\right]\right). \tag{3. 21}$$

The first-order conditions for minimization are:

$$\frac{\partial \mathbf{L}}{\partial L} = P_L(1+TX) - \lambda^* 0.4A\left(\frac{K^*}{L^*}\right)^{0.6} = 0; \tag{3. 22}$$

$$\frac{\partial \mathbf{L}}{\partial K} = P_K(1+TX) - \lambda^* 0.6A\left(\frac{L^*}{K^*}\right)^{0.4} = 0; \tag{3. 23}$$

$$\frac{\partial \mathbf{L}}{\partial \lambda} = \bar{y}_X - A\left(L^{*0.4}K^{*0.6}\right) = 0. \tag{3. 24}$$

Solving for all λ^* and setting these equal :

$$\lambda^* = \frac{-P_L(1+TX)}{0.4A\left(\frac{K}{L}\right)^{0.6}} = \frac{-P_K(1+TX)}{0.6A\left(\frac{L}{K}\right)^{0.4}}. \tag{3. 25}$$

Collecting terms and solving for K^*:

$$\frac{P_L}{P_K} = \frac{2}{3}\frac{K^*}{L^*}; \tag{3.26}$$

$$K^* = \frac{3}{2}\frac{L^* P_L}{P_K}. \tag{3.27}$$

Substituting back into 3.14:

$$\bar{y}_X - A\left(L^{*0.4}\left(\frac{3L^* P_L}{2P_K}\right)^{0.6}\right) = 0. \tag{3.28}$$

Solving for L^*:

$$L^* = \frac{\bar{y}_X}{A}\left(\frac{2P_K}{3P_L}\right)^{0.6} \quad \text{(conditional demand for } L\text{)}. \tag{3.29}$$

Substituting back into 3.17:

$$K^* = \frac{\bar{y}_X}{A}\frac{3}{2}\frac{P_L}{P_K}\left(\frac{2P_K}{3P_L}\right)^{0.6}; \tag{3.30}$$

$$K^* = \frac{\bar{y}_X}{A}\left(\frac{3P_L}{2P_K}\right)^{0.4} \quad \text{(conditional demand for } K\text{)}. \tag{3.31}$$

Dividing both sides of equations (3.29) and (3.31) by $\bar{y}_X$ results in per unit factor demand. Substituting these into the objective function results in the per unit cost function for sector *X*,

$$c_X = P_L l^*(1+TX) + P_K k^*(1+TX), \quad \text{where } l^* = \frac{L^*}{\bar{y}_X}, \text{ and } k^* = \frac{K^*}{\bar{y}_X}$$

$$c_X = \frac{P_L}{A}\left(\frac{2P_K}{3P_L}\right)^{0.6}(1+TX) + \frac{P_K}{A}\left(\frac{3P_L}{2P_K}\right)^{0.4}(1+TX)$$

$$c_X = P_L^{0.4} P_K^{0.6}(1+TX)\frac{\left(\frac{2}{3}\right)^{0.6} + \left(\frac{3}{2}\right)^{0.4}}{A}, \text{ where } A = 1.96$$

$$c_X = P_L^{\,0.4} P_K^{\,0.6}(1+TX). \tag{3.32}$$

In addition to the unit cost for sector *X*, similar optimization problems are solved for sector *Y* and for society's welfare *W*:

$$c_Y = P_L^{\,0.6} P_K^{\,0.4}; \tag{3.33}$$

$$e = P_X^{\,0.5} P_Y^{\,0.5}. \tag{3.34}$$

The resulting unit cost and expenditure functions are then used to formulate the mixed-complementarity problem (MCP). An equilibrium solution is specified as a

simultaneous system of equations. The system consists of three classes of equations: zero profit, market clearance, and income balance as defined by Eqs. (3.1-3.3, and 3.10-3.15).

The MCP Equation Set

The general form for the zero-profit condition for j activities in i commodities is:

$$-\prod_j(p) = c_j(p) - R_j(p) \geq 0, \tag{3.35}$$

where p is a vector of prices, $\prod_j(p)$ is the unit profit, $c_j(p)$ is the unit cost, and $R_j(p)$ is the unit revenue. Because these are unit functions, revenue, $R_j(p)$, is equal to the price of the commodity associated with the activity - that is: $P_j = c_j(p)$, and for this case:

$$P_j = \prod_{i=1}^{N} P_i^{\alpha_j^i}, \text{ where } 0 < \alpha_j^i < 1, \text{ and } \sum_i \alpha_j^i = 1, \ \forall_j \tag{3.36}$$

For the *m1-1s* example, the zero-profit equations are:

1) Zero-profit for X: $$P_X = P_L^{0.4} P_K^{0.6}(1 + TX). \tag{3.37}$$

2) Zero-profit for Y: $$P_Y = P_L^{0.6} P_K^{0.4}. \tag{3.38}$$

3) Zero-profit for W: $$P_W = P_X^{0.5} P_Y^{0.5}. \tag{3.39}$$

4) Supply = Demand for X:

$$x = W\frac{\partial e}{\partial P_X};$$

$$x = W\frac{P_X^{0.5}P_Y^{0.5}}{P_X}. \tag{3.40}$$

5) Supply = Demand for Y:

$$y = W\frac{\partial e_Y}{\partial P_Y};$$

$$y = W\frac{P_X^{0.5}P_Y^{0.5}}{P_Y}. \tag{3.41}$$

6) Supply = Demand for W:

$$200W = \frac{CONS}{P_W}. \tag{3.42}$$

7) Supply = Demand for L:

$$L^* = \overline{X}\frac{\partial c_X}{\partial P_L}x + \overline{Y}\frac{\partial c_Y}{\partial P_L}y$$

$$100 = (100)\cdot 0.4\frac{P_L^{0.4}P_K^{0.6}}{P_L}x + (100)\cdot 0.6Y\frac{P_L^{0.6}P_K^{0.4}}{P_L}y. \tag{3.43}$$

8) Supply = Demand for K:

$$K^* = \overline{X}\frac{\partial c_X}{\partial P_K}x + \overline{Y}\frac{\partial c_Y}{\partial P_K}y$$

$$100 = (100)\cdot 0.6\frac{P_L^{0.4}P_K^{0.6}}{P_K}x + (100)\cdot 0.4Y\frac{P_L^{0.6}P_K^{0.4}}{P_K}y. \tag{3.44}$$

9) Income:

$$CONS = L^{*}P_L + K^{*}P_K + \overline{X} \cdot x(P_L^{0.4} P_K^{0.6})TX . \quad (3.45)$$

Equations 3.37 through 3.45 define the benchmark equilibrium simultaneous system. There are nine equations for the nine unknowns *x, y, W, CONS,* P_X, P_Y, P_W, P_K, and P_L. In addition to the exogenous parameters identified through the SAM, the model requires exogenously determined elasticity of substitution values. In this example, the elasticity of substitution between factors in production of sectors X and Y is one, representing Cobb-Douglas technology. The elasticity of substitution representing the consumption preferences of the consumer is also one, representing Cobb-Douglas utility. Equations (3.37) through (3.45) are automatically constructed in GAMS by the MPS/GE module. The MPS/GE code for this model and a few notes about the MPS/GE syntax are shown in appendix 1.

Equations (3.37) through (3.45) can be solved independently of MPG/GE. Using GAMS as the solver, for example, if the variables are initialized to benchmark values:

$x = 1$, $y = 1$, $W = 1$, $P_X = 1$, $P_Y = 1$, $P_W = 1$, $P_K = 1$, $P_L = 1$, and $CONS = 200$, and a numerair is chosen (where .FX is MPS/GE syntax):

P_L.FX = 1,

the GAMS solver will return the following solution report shown in table 3.1:

Table 3.1. The Benchmark Solution Report

	LOWER	LEVEL	UPPER	MARGINAL
---- VAR X	.	1.000	+INF	.
---- VAR Y	.	1.000	+INF	.
---- VAR W	.	1.000	+INF	.
---- VAR PX	.	1.000	+INF	.
---- VAR PY	.	1.000	+INF	.
---- VAR PL	1.000	1.000	1.000	EPS
---- VAR PK	.	1.000	+INF	.
---- VAR PW	.	1.000	+INF	.
---- VAR CONS	.	200.000	+INF	.

Because the marginal values are zero, the solution indicates that the model is balanced in the benchmark. MPS/GE solver will return an identical report.

Counterfactual Tax Increase

Now that the model has been specified, it is useful for analyzing various counterfactual scenarios. In the case of model m1-s1, the counterfactual is a study of ad-valorem tax rates applied to sector X factor inputs. The general equilibrium result of increasing the tax rate is shown in table 3.2. In this example, a factor tax of 50% is applied on the inputs to sector X production. Notice from table 3.2 that the price of labor does not change. Recall from the calibrating the functional forms, that an infinite combination of prices and quantities can constitute an equilibrium solution. A Walrasian equilibrium, therefore, determines only relative prices. It is therefore convenient to select one good as a numeraire. In this example, the price of labor was chosen as the numeraire.

Table 3.2. The Counterfactual Solution Report

	LOWER	LEVEL	UPPER	MARGINAL
---- VAR X	.	0.807	+INF	.
---- VAR Y	.	1.191	+INF	.
---- VAR W	.	0.981	+INF	.
---- VAR PX	.	1.430	+INF	.
---- VAR PY	.	0.968	+INF	.
---- VAR PL	1.000	1.000	1.000	EPS
---- VAR PK	.	0.923	+INF	.
---- VAR PW	.	1.177	+INF	.
---- VAR CONS	.	230.769	+INF	.

The results of the counterfactual study have to be interpreted with this in mind—all prices are relative to the price of labor. The results are rather intuitive except to note that the representative consumer receives the factor tax. Having the additional tax revenue, overall consumption increases by 30.769 units. Variable *W* is a measure of Hicksian change in income. The results indicate an overall welfare loss of 1.9% (reported as 0.981 in table 3.2, from the benchmark level of 1.000). The variable PW is a price index. Relative to wages, the economy experienced 17.7% inflation.

Walrasian Equilibrium

It has already been noted that the methodology of general equilibrium is based on determining a Walrasian equilibrium. It has been assumed that competitive markets can arrive at an equilibrium characterized by a set of prices by which supply equals demand in all markets at the same time. Leon Walras was the first economist to demonstrate that

such equilibrium does exist. Walras' problem can be stated formally as: Does there exist an equilibrium set of prices (P^*) such that $D_i(P^*) = S_i$, for all values of i? A Walrasian equilibrium can be formally defined as follows from Kreps (1990, p. 284).

> Given an economy specified by:
> (a) A finite number K of commodities.
> (b) A finite number J of firms. Each j is specified by a production possibilities set $Z^j \subseteq R^K$.
> (c) A finite number I of customers. We assume that each consumer can consume any nonnegative bundle of the K goods, so the consumer's preferences are defined on the positive orthant R^K, denoted X. These preferences are assumed to be representable by a utility function $U_i : X \to R$. We assume throughout that preferences are continuous and are locally insatiable. Each consumer comes with an endowment $e^i \in X$. Each consumer also comes with an entitlement to share in the profits of the firms. Consumer i is entitled to share s^{ij} of the profits of firm j. These shares will be assumed to be nonnegative and o satisfy $\sum_{i=1}^{I} s^{ij} = 1$ for each j; that is, consumers taken together are entitled to all the profits generated by each firm (and no more).
>
> **Definition**: A **Walrasian equilibrium** for a given economy consists of a price vector $p \in R^K$, an array of production plans (z^j), one for each firm j, and an array of consumption plans (x^i), one for each consumer i, such that:
>
> (a) For each firm j, $z^j \in Z^j$ (the production plan of j is feasible), and z^j solves the problem:
> Maximize $p \cdot z$ subject to $z \in Z^j$.
>
> (b) For each consumer i, $x^i \in X$, and x^i solves the problem:
> Maximize $U_i(x)$ subject to $x \in X$, $p \cdot x \leq p \cdot e^i + \sum_{j=1}^{J} s^{ij} p \cdot z^j$.

(c) Markets clear: $\sum_{i=1}^{I} x^i \leq \sum_{i=1}^{I} e^i + \sum_{j=1}^{J} z^j$.

These require that (a) firms maximize profit, (b) consumers maximize utility subject to a budget constraint, and that (c) demand is equal to or less than total available. Note that the budget constraint is equal to the endowments plus the value-added portion of profits paid out by firms.

A Walrasian equilibrium can be shown graphically by using an Edgeworth box with endowments. Figure 3.4 shows the initial endowment of two consumers in a pure exchange economy. The shaded lens gives all the reallocations of the social endowment (that are not wasteful) that give each consumer at least as much utility as at the initial endowment. All points within the shaded area are said to be Pareto superior in that $U_i^e(x^e) \leq U_i^{'}(x^{'})$ for every consumer *i*, with a strict inequality for at least one *i*. The heavy part of the contract curve represents all Pareto efficient reallocations. Given a set *X'* of feasible social outcomes, an allocation $x^* \in X$ ' is said to be Pareto efficient, or Pareto optimal if no other feasible outcome $x' \in X$ ' is Pareto superior to x^*. All reallocations along the heavy part of the contract curve are included in the set of possible Pareto optimal solutions. However, because of the two different equilibrium concepts, the Walrasian equilibrium is in the center of this portion of the contract curve.

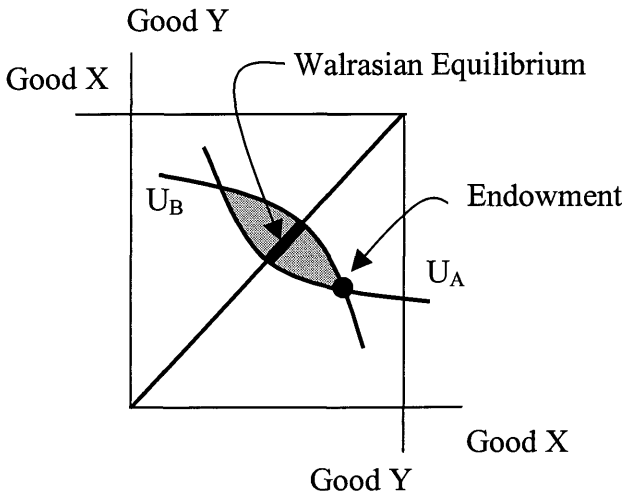

Figure 3.4. A Walrasian Equilibrium

Walras noted several features characterizing the set of equations defined by (c). First, Walras assumed that all demand functions (and excess demand functions) are homogeneous of degree zero in prices. Doubling of all prices has no effect on the quantity demanded. The implication is that only relative prices matter. Second, it was assumed that the demand functions are continuous: If prices were to change by only a small amount, quantities demanded would change by only a small amount. A third assumption requires preferences to be nondecreasing and locally insatiable. This assumption precludes negative prices. A fourth observation by Walras is summarized by what has become known as Walras' Law. It was noted earlier that Walras' Law requires:

$$\sum_{i=1}^{N} P_i\left(D_i - S_i\right) \equiv 0, \text{ for all commodities } i = 1 \text{ to N.} \qquad (3.46)$$

This observation suggests that the excess demand functions defined by (c) are not independent of each other. But rather, the total value of excess demand is zero at any set of prices. Observing that each individual is bound by a budget constraint derives the result.

For a two-good economy (X and Y), and two consumers (A and B) total demand is:

$$D_X = D_A^X + D_B^X, \text{ and } D_Y = D_A^Y + D_B^Y. \tag{3.47}$$

Total supply is likewise:

$$S_X = S_A^X + S_B^X, \text{ and } S_Y = S_A^Y + S_B^Y. \tag{3.48}$$

From the budget constraint, the value of consumer demand must be less than or equal to the value of supply:

$$P_X D_A^X + P_X D_B^X \le P_X S_A^X + P_X S_B^X; \tag{3.49}$$

$$P_Y D_A^Y + P_Y D_B^Y \le P_Y S_A^Y + P_Y S_B^Y. \tag{3.50}$$

By assuming consumers are locally insatiable, these equations will hold with equality, as consumers are sure to spend all of their wealth. Furthermore, demand being less than supply is possible only for goods whose price is equal to zero. From these assumptions, Walras' Law is shown as:

$$P_X\left(D_X - S_X\right) + P_Y\left(D_Y - S_Y\right) \equiv 0, \tag{3.51}$$

$$\sum_{i=1}^{N} P_i\left(D_i - S_i\right) \equiv 0, \text{ for all commodities } i = 1 \text{ to N}. \tag{3.52}$$

Walras' Law is graphically demonstrated in figure 3.5. In panel (a), the initial state of the economy is characterized by excess demand for good X. As the price of good X increases, demand for good X decreases. In panel (b), the initial state of the economy is characterized by excess supply of good Y. As the price of good X is increasing, the price of good Y is simultaneously decreasing causing demand for good Y to increase. Also notice in figure 3.5 that there are movements along the supply and demand curves as well as shifts in position of the curves. In a general equilibrium, supply and demand are functions of all prices. Changes in own price are reflected as movement along the curve. Changes in the prices of other goods are reflected as shifts in the position of the curves.

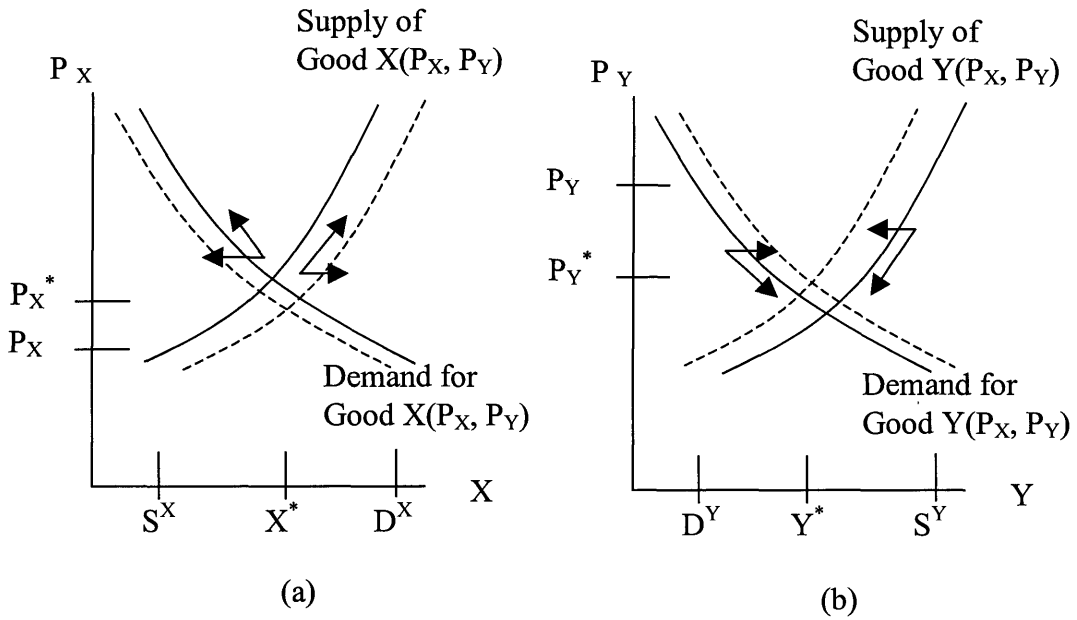

Figure 3.5. Excess Demand Adjustment to Market Equilibrium

It is also important to note how prices adjust to arrive at a Walrasian general equilibrium. In figure 3.6, two consumers are represented in panels (a) and (b). Panel (a) shows the endowment and preferences of consumer (A) for goods X and Y. Likewise, panel (b) shows the endowment and preferences of consumer (B). The second consumer's indifference curve is inverted and an Edgeworth box is constructed in panel (c). In this panel, at the price ratio $\frac{P_X^1}{P_Y^1}$ demand for good X is shown to exceed supply. In panel (d) prices have adjusted such so as to arrive at a Walrasian general equilibrium. At these relative prices, $\frac{P_X^*}{P_Y^*}$, utility of consumer (a) and (b) is maximized subject to budget constrains, and the markets are clearing as demand equals supply. In this way the economy arrives at a Walrasian general equilibrium. At the point of equilibrium, the ratio of all commodity prices across the economy are equal to their respective ratio of marginal utilities.

$$\frac{P_i^*}{P_1^*} = \frac{MU_i^*}{MU_1^*}, \text{ for all commodities } i = 2 \text{ to } n. \tag{3. 53}$$

The production side of the economy likewise arrives at a Walrasian general equilibrium by equating marginal productivities across sectors:

$$\frac{MP_{jf}^*}{MP_{11}^*} = \frac{MP_{jf}^*}{MP_{jf}^*} = \frac{P_f^*}{P_1^*}, \text{ for all factors } f = 2 \text{ to } k, \text{ across all sectors } j = 1 \text{ to } m. \tag{3. 54}$$

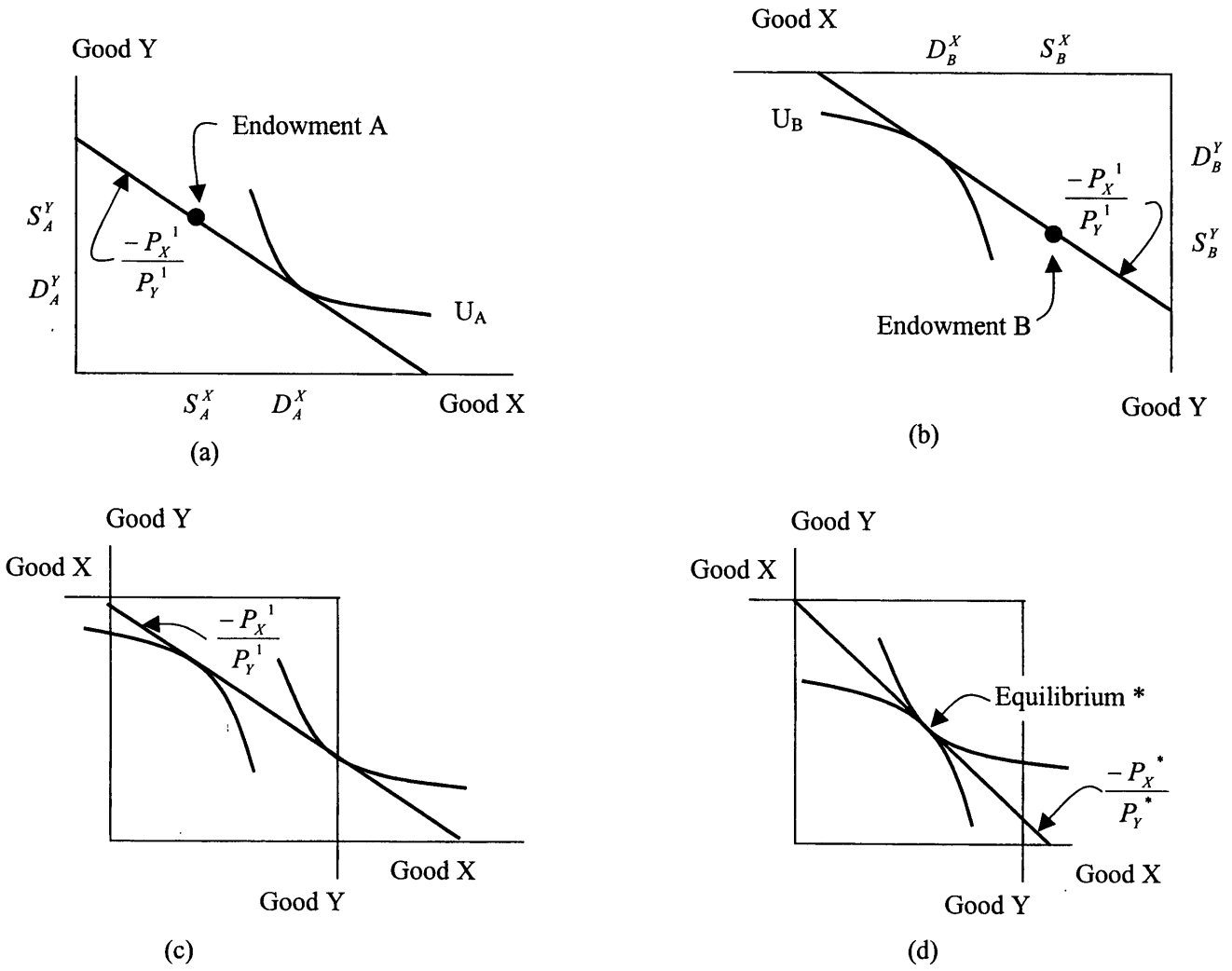

Figure 3.6. Price Adjustment to Market Equilibrium

The MCP equation set utilizes the first order conditions of a Marshallian competitive equilibrium to arrive at a Walrasian general equilibrium. Reiter (1987) briefly notes the relationship between a Walrasian general equilibrium and a Marshaillian competitive equilibrium.

> The welfare theorems stated in terms of equilibrium relative to a price system translate directly into theorems stated in terms of competitive equilibrium. Briefly, every competitive equilibrium allocation in a given classical environment is Pareto optimal in that environment, and every Pareto optimal allocation in a given classical environment can be made a competitive equilibrium allocation of an environment that differs from the given one only in the distribution of the initial endowment (p. 14).

On the consumption side of the economy the movement from $\frac{P_X^1}{P_Y^1}$ to $\frac{P_X^*}{P_Y^*}$ occurs by equating the price ratio to the ratio of marginal utilities for each good such that:

$$\text{Marginal Rate of Substitution (MRS)} = \frac{P_X^*}{P_Y^*} = \frac{MU_X}{MU_Y} = \left.\frac{-dY}{dX}\right|_{\bar{U}}, \tag{3.55}$$

and for the production side of the economy an identical relation exists such that:

$$\text{Marginal Rate of Technical Substitution (MRTS)} = \frac{P_L^*}{P_K^*} = \frac{MP_L}{MU_K} = \left.\frac{-dK}{dL}\right|_{\bar{Q}}. \tag{3.56}$$

Individuals will maximize utility (as producers maximize profit) subject to the relative cost to the consumer for each commodity. The MRS (MRTS) reflects the commodity market prices and the value of these commodities to the consumer at the stated price.

Traditional general equilibrium models require a tatonnement adjustment process in which the prices are exogenously adjusted to eliminate all excess demands. At the point where all excess demands are zero, the economy is at a Walrasian general equilibrium. The MCP equations, however, embody the MRS and MRTS conditions. As demonstrated in the MCP calibration process, the functional forms are defined at a point of Marshallian equilibrium. At the point of calibration the conditions of a competitive equilibrium are met translating directly into a competitive general equilibrium.

Criticism of the General Equilibrium Methodology

There have been several concerns regarding the methodology of general equilibrium. Traditional difficulties have been the need for accurate elasticities of substitution, and the difficulty in modeling technology and other extraneous events effecting economic growth. Elasticities of substitution can either be econometrically determined or inferred from the literature. Clearly, econometrically measuring these elasticities would provide a more certain solution. Unfortunately, it is extremely difficult to accurately measure these elasticities econometrically. The difficulty of econometrically determining elasticities of substitution is discussed in Jorgenson (1984) and MacKinnon (1984).

This study distinguishes between elasticities of input transformation and elasticities of substitution between inputs. Input transformation elasticities are used as a

structuralist feature to capture the price responsiveness between the various productive agents representing an economy in transition. It is important to note that all of the production input transformation elasticities used in this study are one of five generalized point values based upon the continuum shown in figure 3.7. The figure represents classical production technologies. Recall that we are using cost (and expenditure) functions, so an elasticity of substitution of zero is equivalent to perfect complements and Leontief technology. Conversely, an elasticity of substitution of 10 represents high substitution possibilities (a value of infinity is equivalent to perfect substitutes).[12] An elasticity of substitution of one represents Cobb-Douglas technology. The elasticities of substitution between inputs are obtained from the literature (Morris and others, 1997). These are further defined in chapter 4, figures 4.1 and 4.2.

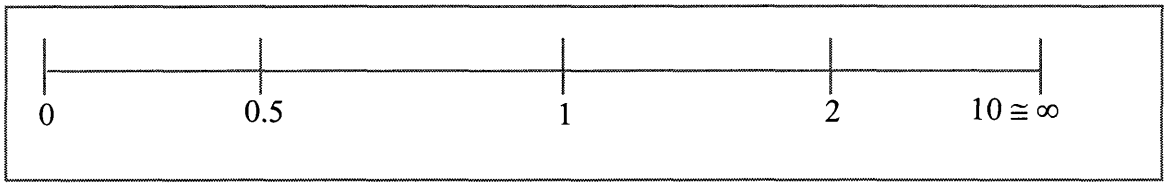

Figure 3.7. The Substitution of Elasticity Continuum for Production Technologies

[12] Although the solver allows values greater than 10, using elasticity of substitution values greater than 10 causes instability in the solution set. As a general rule, when using an MPS/GE production block, elasticity of substitution values should not exceed 10.

The exogenous elasticities characterize the curvature of the respective indifference and isoquant curves. Figure 3.8 shows three indifference curves, all of which share common benchmark prices and quantities. They differ only in their respective elasticities of substitution. The higher the elasticity, the flatter (less convex) the curve. An elasticity of 0, for example, representing Leontif preferences, or perfect complements, would be represented as an L-shaped curve.

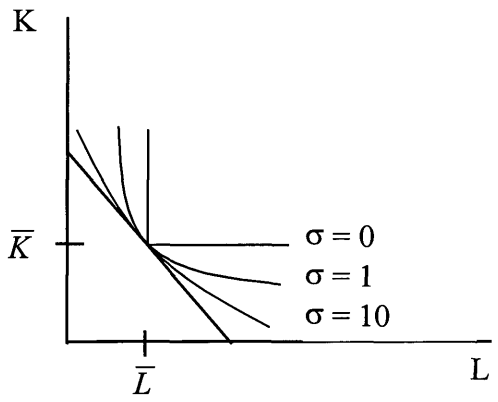

Figure 3.8. The Elasticity of Substitution Affects the Shape of the Isoquant

Consumption elasticities are likewise exogenously fixed. The representative consumer's selection of goods is represented by CES expenditure functions (derived from utility functions) with an elasticity of substitution of one. This is equivalent to Cobb-Douglas preferences and is true for all goods.

A further difficulty regarding GEM concerns the foundational assumptions surrounding the methodology. For example, the process of utility maximization is

founded on the idea of perfect information. Each consumer must have equal and complete information about the relative price of all goods—an unrealistic assumption even in a well functioning market economy. Several non-market features characterize the class of countries this study concerns. These are actual market failures such as trade restrictions, price regulation, non-Pareto optimal taxation, bureaucratic sub-optimization, misdirected public investments, and suppression of environmental information. Kreps (1990) noted:

> Price-mediated exchange in the marketplace and, in particular, the equilibrium notions . . . are "reduced forms" for some unspecified institutional mechanisms of exchange. Especially as we encounter the models of imperfectly competitive markets, questions arise about why (and whether) these are appropriate "reduced forms," questions that seemingly can be resolved only if we are more specific about the institutional mechanisms involved (p. 187).

In heeding Kreps' warning, it is important to design a model containing features characterizing the essential working of the former Soviet economies. Such economies, reflecting patterns of disequilibrium, are best modeled through structuralist general equilibrium models. Structuralist models encompass a broader perspective than traditional neoclassical general equilibrium models as noted by Taylor (1990, p.1) in summarizing the ideas of Lustig 1988.

> Lustig (1988) nicely summarizes the ideas around which they are built: Structuralist thought considers that structural characteristics (the repetition is appropriate) of the economy are fundamental to its behavior. Among the structural factors are the distribution of income and wealth, tenancy relationships on the land, the type and degree of specialization in foreign

> trade, the density of chains of production, the degree of concentration in markets, *control of the means of production by distinct types of actors* [Italics added] (the private sector, the state, or transnational capital), the functioning of financial intermediaries, and penetration of technical advance, as well as sociopolitical factors associated with the extent of organization of the working class and other influential sectors and classes, the geographical and sectoral distribution of the population, and its level of skills.

Taylor (1990) observes that, "Indeed, basing economic analysis on institutions and political economy is the hallmark of the structuralist approach (p. 1)."

The structuralist approach in this study utilizes the classical assumptions to generate an equilibrium condition. Prices and quantities still adjust, given production and consumption conditions. The difference is that structural inefficiencies are imbedded into the model to accurately reflect society's behavior. This study uses several structuralist conditions to accurately reflect a reforming economy.

A structuralist construct is used to model the manager incentives of state-controlled production sectors. First, the state subsidizes the production of all value-added, state-controlled production sectors. The subsidy allows a level of output from these sectors not otherwise attainable. Additionally, the subsidy is used to employ a non-optimal level of labor (the negative consequence being an excessive cost structure). In this way the model is able to reflect the incentives of management (in this case the central government) of maintaining political support from labor.

A second structuralist feature is used to introduce the inefficiency of state-mandated prices. In this study, state-produced goods compete directly with imports and

privately-produced substitutes. Characterizing a command pricing system, the state sets its prices independent of market supply and demand. Typically, the state will price to undercut the market (intentionally or unintentionally). An artificial production sector is introduced to represent a rent-seeking delivery activity resulting from the price distortion caused by the mandated prices of the central government. The distortion manifests itself through an excess demand and a queuing activity, thus drawing labor from the productive sectors. When state goods are priced below market, obtaining these goods creates a cost to society in direct proportion to the magnitude of the price distortion. These features along with the complete model are further defined in chapter 4 of this study.

Conclusion

This chapter introduced the MPS/GE MCP general equilibrium solution methodology. Three classes of equations were introduced: zero-profit, market clearance, and income balance. The chapter demonstrated the two-stage solution technique whereby unit cost and expenditure functions are derived from first-order profit maximization. From Shephard's Lemma, the partial derivative of the unit cost and expenditure functions are then used to determine the derived-demands.

The chapter reviews Walrasian general equilibrium theory, and demonstrates how the MCP equation set establishes a Walrasian equilibrium in the benchmark calibration.

Finally, traditional criticisms of the general equilibrium methodology are discussed and the concept of a structuralist general equilibrium model is introduced.

Chapter 4

FORMULATION OF A GENERAL EQUILIBRIUM MODEL FOR A RESOURCE BASED TRANSITIONAL ECONOMY

This chapter develops the structural general equilibrium model used to examine the role of natural resources in the reform process from a centrally planned to a market economy. The model establishes a social objective and structural features characteristic of a reforming economy. First, consistent with the methodology introduced in chapter 3 for the Cobb-Douglas case, the constant elasticity of substitution (CES) cost functions are derived from the first order optimization of the corresponding production functions. The 1991 Uzbekistan data set is introduced including a description of the aggregated three-sector economy.

The structural features consistent with an economy in transition are then developed. These features can be used as a baseline for future models of transition economies. Society's objective is to maximize the welfare of various voting classes. The strength of each voting class is observed through exogenous privatization modeled as the free movement of productive factors from state control to entrepreneurial agents. The structural features are 1) the introduction of price wedges and rent-seeking activity representing market failure, 2) varying input transformation elasticies (capacity to transform) across productive agents, 3) inefficient state production in both inputs and

outputs, and 4) the use of natural resource abundance as the source of investment capital (or social welfare).

The fourth feature, natural resource abundance, is described in relation to the counterfactual scenarios. The counterfactual scenarios are developed using two decision analysis problems. The decision analysis problems receive the output of the general equilibrium model, define policy options, and define the perceptions about the likely success or failure of the policy options. The results are used to arrive at society's expected change in welfare for each policy option. The counterfactual scenarios and the decision analysis problems are presented and further defined.

The chapter concludes by defining the Uzbekistan transitional economy general equilibrium model mixed-complementarity problem (MCP) equation set. The equation set is summarized in table 4.14. A glossary of variables is found in table 4.13. The discussion surrounding the MCP equation set relies on the methodology reviewed in chapter 3.

First Order Optimization: Production and Consumption

As demonstrated in chapter 3, obtaining the general equilibrium solution is a two-stage process. First, underlying cost-(expenditure) minimization problems are arrived at by using cost-minimizing first-order conditions. On the production side, we solve for unit cost functions $c_X = c_X(P_L, P_K)$ and $c_Y = c_Y(P_L, P_K)$. On the consumer side, we solve for the unit expenditure function $e = e(P_X, P_Y)$. The cost-minimization problems can

therefore be expressed as a Lagrangian optimization problem using CES production and utility functions.

The CES production functions is:

$$y_j = A_j\left[\sum_i \alpha_j^i x_j^{i\,\frac{\sigma^j-1}{\sigma^j}}\right]^{\frac{\sigma^j}{\sigma^j-1}}, \tag{4.1}$$

where $A_j > 0$, $0 < \alpha_j^i < 1$, and $\sum_i \alpha_j^i = 1,\ \forall_j$,

and where A_j is a scale parameter, α_i is a share parameter, x_i is a factor input, intermediate input, or nested function of intermediate and factor variables, and σ^j is the elasticity of substitution between inputs. Likewise, the CES utility function is:

$$U_H = A_H\left[\sum_i \alpha_H^i x_H^{i\,\frac{\sigma^H-1}{\sigma^H}}\right]^{\frac{\sigma^H}{\sigma^H-1}}, \tag{4.2}$$

where $A_H > 0$, $0 < \alpha_H^i < 1$, and $\sum_i \alpha_H^i = 1,\ \forall_H$,

and where A_H is a scale parameter, α_H is a share parameter, x_H is a consumption good, and σ^H is the elasticity of substitution between goods.

Define $\rho = \frac{\sigma - 1}{\sigma}$, where ρ is a elasticity index. $\rho = 1$, for example, is equivalent to $\sigma = \infty$. Equation (4.1), the sector production function, can be expressed as:

$$f(x)_j = A_j\left[\sum_i \alpha_i x_i^{\rho}\right]^{\frac{1}{\rho}}. \tag{4.3}$$

On the production side of the economy, the cost minimization problem can therefore be expressed as:

$$\min\ TC_j = \sum_i \bar{p}_j^i x_j^i \tag{4.4}$$

$$\text{s.t. } \bar{y}_j = A_j \left[\sum_i \alpha_j^i x_j^{i\rho} \right]^{\frac{1}{\rho}}.$$

The Lagrangian for a given sector j is:

$$\mathbf{L} = \sum_i \bar{p}_i x_i + \lambda \left(\bar{y} - A \left[\sum_i \alpha_i x_i^{\rho} \right]^{\frac{1}{\rho}} \right). \tag{4.5}$$

The first-order conditions are:

$$\frac{\partial \mathbf{L}}{\partial f_i} = \bar{p}_i + \lambda^* \left(A \frac{1}{\rho} \left[\sum_i \alpha_i x_i^{\rho} \right]^{\frac{1}{\rho}-1} \alpha_i \rho x_i^{\rho-1} \right) = 0, \tag{4.6}$$

and

$$\frac{\partial \mathbf{L}}{\partial \lambda} = \bar{y} - A \left[\sum_i \alpha_i x_i^{\rho} \right]^{\frac{1}{\rho}} = 0. \tag{4.7}$$

Solving for all λ^* and setting these equal

$$\lambda_i^* = \frac{-\bar{p}_i}{A \frac{1}{\rho} \left[\sum_i \alpha_i x_i^{\rho} \right]^{\frac{1}{\rho}-1} \alpha_i \rho x_i^{\rho-1}} = \lambda_1^* = \frac{-\bar{p}_1}{A \frac{1}{\rho} \left[\sum_i \alpha_i x_i^{\rho} \right]^{\frac{1}{\rho}-1} \alpha_1 \rho x_1^{\rho-1}}. \tag{4.7}$$

Solving for x_i^* in terms of x_1^*

$$x_i^* = \left(\frac{\bar{p}_i}{\bar{p}_1}\right)^{\frac{1}{\rho-1}} \left(\frac{\alpha_1}{\alpha_i}\right)^{\frac{1}{\rho-1}} x_1^*, \tag{4.8}$$

but $\sigma = \frac{1}{1-\rho}$, so

$$x_i^* = \left(\frac{\bar{p}_1}{\bar{p}_i}\right)^{\sigma} \left(\frac{\alpha_i}{\alpha_1}\right)^{\sigma} x_1^*. \tag{4.9}$$

Solving for all x_i^* in terms of x_1^* and substituting these back into:

$$\bar{y} - A\left[\sum_i \alpha_i x_i^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} = 0, \tag{4.10}$$

and solving for x_1^*

$$x_1^* = \left(\frac{\bar{y}}{A}\right) \left(\frac{\alpha_1 \left[\sum_i \alpha_i^{\sigma} \bar{p}_i^{1-\sigma}\right]^{\frac{1}{1-\sigma}}}{\bar{p}_1} \right)^{\sigma} \quad \text{Conditional Demand for } x_1. \tag{4.11}$$

Dividing both sides of equation (4.12) by $(\bar{y})$ results in a per unit normalized demand. Following a similar procedure for all x_i, and substituting these into the objective function results in the per unit cost function for sector *y*. Cost functions are likewise defined for each activity *y* and expenditure functions are defined for each consumer *H*. The general form unit cost and expenditure functions are:

$$c_j = [\sum_i \alpha_j^{i\,\sigma^j} p_j^{i\,1-\sigma^j}]^{\frac{1}{1-\sigma^j}} \geq 0, \tag{4.13}$$

where $0 \leq \alpha_j^i \leq 1, \sum_i \alpha_j^i = 1, \ \forall_j$

$$e_H = [\sum_i \alpha_H^{i\,\sigma^H} p_H^{i\,1-\sigma^H}]^{\frac{1}{1-\sigma^H}} \geq 0, \tag{4.14}$$

where $0 \leq \alpha_H^i \leq 1, \sum_i \alpha_H^i = 1, \ \forall_H$.

The resulting unit cost and expenditure functions are then used to formulate the mixed-complementarity problem (MCP). An equilibrium solution is specified as a simultaneous system of equations. The system consists of three classes of equations: zero profit, market clearance, and income balance as defined in chapter 3.

Using first order optimization described above by equations (4.1) through (4.14), the simultaneous system of equations for the 1991 Uzbekistan Transitional Economy Model is likewise defined. In the following discussion, production functions are used to describe the actual empirical model and its structural features. Following the model description, the associated cost functions are defined. The cost functions form the MCP equation set used to solve the equilibrium model. Although no further derivations are presented, it is understood that the cost functions are derived from the associated production functions.

The social accounting matrix (SAM) used for the 1991 Uzbekistan Transitional Economy Model is shown in table 4.1. The variables used in the SAM are defined in

table 4.2. Additionally, table 4.2 maps the variable convention used in the SAM (and the MPS/GE code) to that used in the remainder of this chapter (the empirical model). The data for Uzbekistan is published by The Central Calculating Center of the Government Committee for Statistics of the Republic of Uzbekistan for the year 1991. The data for 1991 represent a former Soviet economy in the very beginning stages of reform.

The SAM additionally describes the aggregation used in constructing the model. A traditional three-sector economy is used to isolate the Dutch disease effects. There are three production sectors: resources, services and government (non-tradable), and industrial production (tradable). Following the production sectors are what I have labeled agents. These are the three different types of firms producing industrial goods (tradable): state, newly privatized, and entrepreneurial. The agents produce an identical good using different cost structures. The three industrial goods are combined to arrive at the total industrial production, which in turn are then available for intermediate consumption, export, or final demand. Additionally, the state can subsidize its good causing a rent-seeking queuing activity. This queuing feature follows the agents' section. It is a structuralist feature for delivery of state produced industrial goods to households. Next is the trade section of the SAM, followed by an investment activity. Three welfare blocks are used to quantify the percentage change in Hicksian income of the three classes of consumers: traditional households, entrepreneurial households, and government. Traditional households are endowed with labor, and entrepreneurial households are endowed with capital.

Table 4.1. The Social Accounting Matrix for Uzbekistan, 1991

		Production Sectors			Agents				Trade			Welfare			Consumers		
		Resource Sector (Less Energy)	Services and Government Sector	Total Industrial Production	State Industrial Production	Privatized Industrial Production	Entrepreneurial Industrial Production	Delivery Activity of sx to Households	Exports	Imports	Investment	Traditional Households Welfare	Entrepreneurial Households Welfare	Government Welfare	Traditional Households (Workers)	Entrepreneurial Households (Owners)	Government Consumption
		R	S	X	SX	OX	EX	QX	E	M	INV	WT	WE	WG	HT	HE	GOVT
I costs of production (expenditures)																	
Resource Production (Less Energy)	PR	329.38027	-4.52038		-165.639200	-20.704900	-20.704900		-16.29698		-28.15696	-67.836470	-1.951594	-3.568886			
Services Including Government (Non-Tradable)	PS	-16.51083	197.72284		-53.247472	-6.655934	-6.655934				-111.73496		-1.031465	-1.886245			
Industry (Tradable Production) Including:	PX	-63.29771	-76.08646	574.138671	-210.485640	-26.310705	-26.310705			40.07198	-11.58508	-172.407541	-9.801949	-17.924861			
State Production	PSX				528.089935			-528.089935									
Privatized Production	POX			-66.215366		66.215366											
Entrepreneurial Production	PEX			-67.848359			67.848359										
Rent Seeking Queuing Activity	VQX			-440.074946				440.074946									
Foreign Exchange (Imports)	PFX								16.29698	-40.07198							23.775000
Savings	PSAV										151.47700			-151.477000			
II wages and net income																	
Wages	PL	-134.94412	-81.02067		-54.274319	-6.385214	-3.192607	88.014989						-106.169290	240.244011		57.727220
Specific Capital:																	
Resource Sector Capital	PKR	-108.55770															108.557700
Service Sector Capital	PKS		-32.25933														32.259330
State Sector Capital	PKSX				-51.140032									-5.628370			56.768402
Privatized Sector Capital	PKOX					-6.392504										6.392504	
Entrepreneurial Sector Capital	PKEX						-6.392504									6.392504	
Traditional Household Welfare	PTW											240.244011			-240.244011		
Entrepreneurial Household Welfare	PEW												12.785008			-12.785008	
Government Welfare	PGW													286.654652			-286.654652
subsidies	SUB				43.430400	4.825600											-48.256000
tax	TAX	-6.06991	-3.83600		-36.733672	-4.591709	-4.591709										55.823000

Notes:
Sector r output of 329.38027 = 394.43599 - 65.05572 (Total output less intermediate resources used in the resource sector)
Sector s output of 197.72284 = 201.747 - 4.02416 (Total output less intermediate services used in the service sector)

Table 4.2. Variable Mapping – MPS/GE Code to Empirical Model

SAM and MPS/GE Code,	Empirical Equivalent,	Description
SECTORS:		
R	y_R	Activity level of resource sector
S	y_S	Activity level of service sector
X	y_X	Activity level of tradable sector
SX	y_{SX}	Activity level of state tradable sector
OX	y_{OX}	Activity level of privatized tradable sector
EX	y_{EX}	Activity level of entrepreneurial tradable sector
WT	y_{WT}	Hisksian welfare of traditional representative agent
WE	y_{WE}	Hicksian welfare of entrepreneurial representative agent
WG	y_{WG}	Hicksian welfare of government agent
E	y_E	Activity level of export sector
M	y_M	Activity level of import sector
INV	y_{INV}	Investment activity
QX	y_{QX}	Rent-seeking queuing activity
COMMODITIES:		
PR	P_R	Price index for commodity R (natural resources)
PS	P_S	Price index for commodity S (services -- non-tradables)
PX	P_X	Price index for commodity X (tradables)
PSX	P_{SX}	Price index for commodity SX (state produced tradables)
POX	P_{OX}	Price index for commodity OX (privatized tradables)
PEX	P_{EX}	Price index for commodity EX (entrepreneurial tradables)
PL	P_{Labor}	Price index for primary factor L (Labor)
PKR	P_{KR}	Price index for resource specific factor K (capital)
PKS	P_{KS}	Price index for service specific primary factor K (capital)
PKSX	P_{KSX}	Price index for state tradable specific factor K (capital)
PKOX	P_{KOX}	Price index for newly privatized specific factor (capital)
PKEX	P_{KEX}	Price index for entrepreneurial specific factor K (capital)
FX	P_{FX}	Price index for foreign exchange -- numeraire
VQX	P_{QX}	Price index for commodity VQX (rent-seeking delivery)

(continued)

Table 4.2 (Continued)

SAM and MPS/GE Code,	Empirical Equivalent,	Description
PWT	P_{WT}	Price index for traditional households welfare
PWE	P_{WE}	Price index for entrepreneurial households welfare
PWG	P_{WG}	Price index for government welfare
PSAV	P_{SAV}	Price index savings activity
CONSUMERS:		
HT	M_{HT}	Traditional households representative agent (labor)
HE	M_{HE}	Entrepreneurial households (capital owners)
GOVT	M_{GOVT}	Government

The SAM also identifies the commodities, which correspond to the activities. The commodities are listed vertically, in the first column. In addition to commodities, the column lists the factor inputs, including labor and specific capital. These are followed by a price index block used to identify percentage change in real income. Finally, the subsidies and taxes are identified. The SAM fully identifies the activities, commodities, and structural activities used in the transitional economy model.

In addition to the balanced SAM, the model relies on the nest structure defined by figures 4.1 and 4.2. Figure 4.1 represents the production-side nesting. Figure 4.2 represents the consumption-side nesting. At each level of nesting the inputs are combined into a composite input that is then used at the next level of nesting.
The values of elasticities for sectors R (resources) and S (services) are obtained from literature (Morris and others, 1977). The values of the elasticities indicate the ease with which various inputs can be substituted for each other. The values of elasticities for sectors SX (state tradables), OX (newly privatized tradables), and EX (entrepreneurial tradables) are redefined as input transformation elasticities. Input transformation elasticities measure the relative price responsiveness of the three tradable activity sectors. These elasticities are shown in figure 4.1.

The productive activities are each defined as a nested production function of value-added and intermediate inputs:

$$y_j = \left[\alpha_j^{va} va_j^{\frac{\sigma^j - 1}{\sigma^j}} + \sum_i \alpha_j^i \, \mathrm{int}_j^{i\,\frac{\sigma^j - 1}{\sigma^j}} \right]^{\frac{\sigma^j}{\sigma^j - 1}}, \qquad (4.15)$$

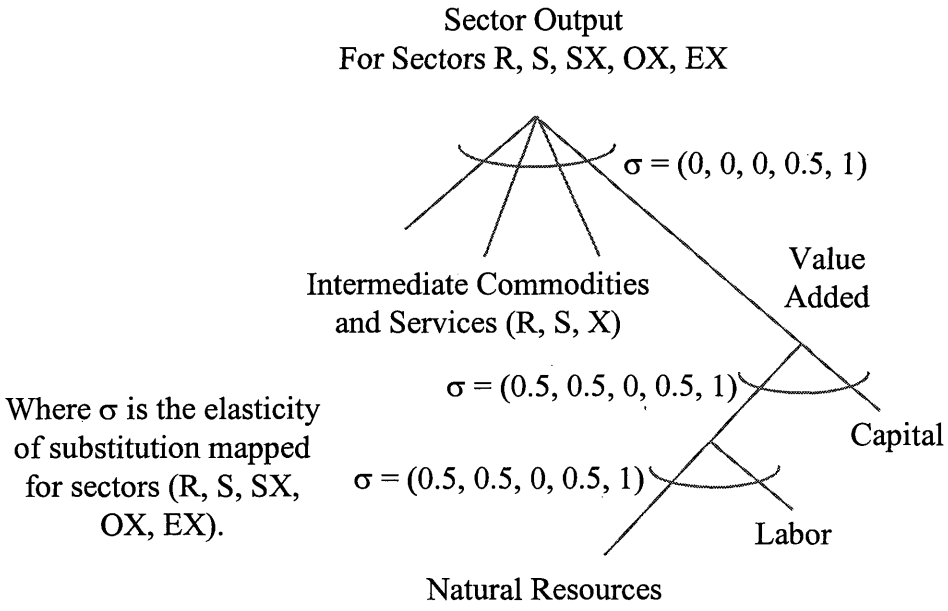

Figure 4.1. CES Nesting for Production Sectors R, S, SX, OX, and EX

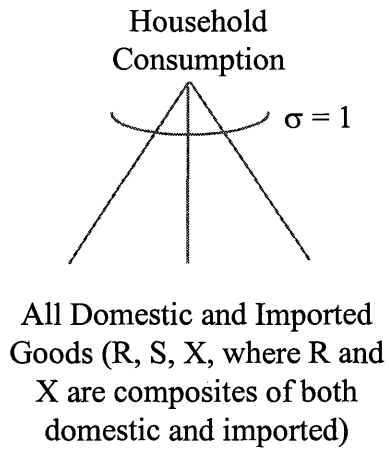

Figure 4.2. CES Nesting Structure for Household Consumption

where $0 < \alpha_j < 1$, and $\sum_i \alpha_j^i + \alpha_j^{va} = 1, \ \forall_{j=R,S,SX,OX,EX}$.

The value-added portion is defined as:

$$va_j = \left[\alpha_j^K K_j (1 - TX_j^K)^{\frac{\sigma_j^{va}-1}{\sigma_j^{va}}} + \alpha_j^{labor} \text{labor}_j^{\frac{\sigma_j^{va}-1}{\sigma_j^{va}}} \right]^{\frac{\sigma_j^{va}}{\sigma_j^{va}-1}}, \tag{4.16}$$

where $0 < \alpha_j < 1, \ \alpha_j^K + \alpha_j^{labor} = 1, \ \forall_{j=R,S,SX,OX,EX}$.

The labor nesting is defined as:

$$\text{labor}_j = \left[\alpha_j^L L_j (1 - TX_j^L)^{\frac{\sigma^L-1}{\sigma^L}} + \sum_e \alpha_j^e x_j^e (1 - TX_j^e)^{\frac{\sigma^L-1}{\sigma^L}} \right]^{\frac{\sigma^L}{\sigma^L-1}}, \tag{4.17}$$

where $0 < \alpha_j < 1$, and $\sum_e \alpha_j^e + \alpha_j^L = 1, \ \forall_{j=R,S,SX,OX,EX}$.

Factor taxes are represented in the CES production function by multiplying the factor demand by (1-TX), where TX is the specific factor tax. Subsidies are likewise applied. The subsidy may either be applied to the worker factor class and represented similar to a tax except the multiplier is (1 +SUB), or additive to the factor quantity.

The substitution structure for households is unity for all commodities demanded. This structure is representative of a Cobb-Douglas production function.

Additional Productive Sectors

Equations (4.15) through (4.17) fully describe activity sectors j = *R, S, SX, OX, EX.* However, there are seven additional activity sectors that do not require the nested structure defined by equations (4.15) through (4.17). These are:

X: The aggregate of society's tradable productive output
QX: The delivery activity of State tradeable output (sx) to households
E: Exports
M: Imports
INV: Investment
WT: Traditional households' welfare
WE: Entrepreneurial households' welfare
WG: Government welfare

These sectors are fully defined by the following production function j activities and i commodities:

$$y_j = A_j \left[\sum_i \alpha_j^i x_j^{i\frac{\sigma^j - 1}{\sigma^j}} \right]^{\frac{\sigma^j}{\sigma^j - 1}}, \tag{4.18}$$

where $A_j > 0$, $0 < \alpha_j^i < 1$, and $\sum_i \alpha_j^i = 1$, $\forall_{j=X,QX,E,M,INV,WT,WE,WG}$,

and where A_j is a scale parameter, α_i is a share parameter, x_i is a factor input, or intermediate input, and σ^j is the elasticity of substitution between inputs.

Investment

In a dynamic model, investment is used to grow the economy's capital endowment over time. In a static model, capital "grows" by becoming more efficient,

analogous to a technology or productivity multiplier. More goods can be produced with the same amount of capital endowment.

Investment uses a production block in the MPS/GE code. The resulting equation set includes zero-profit, market clearance, and income balance equations. The investment feature collects investment from the productive sectors. These are used to produce a proxy commodity called savings. In this way, savings equal investment. Saving is a consumption good, the value of which is given to government. Government income is increased by the value of savings and the value of capital endowment is increased by an equal amount in the benchmark. When the government chooses to invest, the output of the investment activity, savings, is effectively subsidized. The technical interpretation is that fewer inputs (productive commodities) are required to achieve the benchmark capital replacement rates. The investment circular flow in shown in figure 4.3. The investing activity effectively reduces the cost to invest, and increases investment activity.

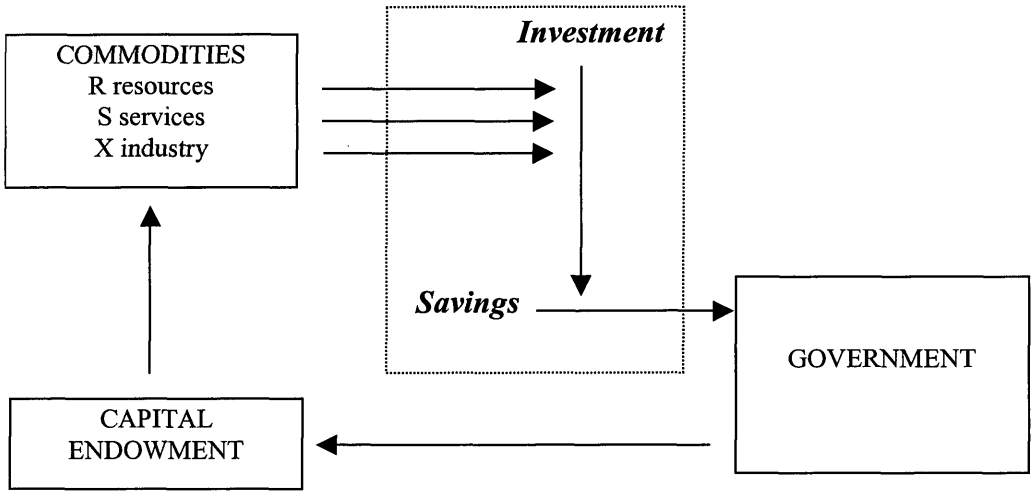

Figure 4.3. The Circular Flow of Investment Activity

Market-Failure-Induced Price Distortions and Rent-Seeking Activity

The central issues explored by this section of my model center on the cost to society due to price distortions introduced by central planning. Patterson (1994, 1996) develops a CGE to analyze economic transition problems faced by Eastern European countries. Her research addresses three aspects of the reform process from centrally planned to free market. Her models provide a framework for addressing queuing and optimal capital transfer from state control to price-responsive, free-market control, thus providing a basis for analyzing more substantive reform questions. Patterson provides key stylized facts, in the structuralist tradition, fundamental to the behavior of reforming economies.

Specific to this study, the structuralist CGE depiction of queuing in a socialist system is utilized as a method of introducing market failure into the empirical model. Command pricing creates a nonprice-responsive externality by drawing labor resources away from productive use into rent-seeking queues. The state-sector may or may not set its prices according to the market demand. To the extent that state sector prices fall below market price, queuing occurs. The economic intuition involves supply and demand disequilibrium caused by the government dictating price and quantity levels of state production sectors in disregard of price signals. Shortages and subsidized prices create excess demand and rent-seeking activity. This model represents this rent-seeking activity by the introduction of queuing activity. But queuing is not without cost. The representative consumers are required to expend a portion of their labor endowment on

obtaining consumption goods. Specifically, consumers must use their labor endowment for queuing activity—the greater the price distortion, the greater the cost of queuing. In this way the disequilibrium of market failure in prices is incorporated into a general equilibrium model. This relationship is shown in table 4.3.

The feature is modeled analogous to a simple traditional productive sector. It is an economic activity that involves queuing. The sector is labeled QX (queuing for X), and represents the act of delivery. The sector input equals the producer cost of the state tradable sector productive output (PSX). It is the total value to the state of the state tradable sector output prior to becoming available for intermediate and final consumption. The sector QX output equals consumer cost (VQX). The difference between the producer cost and consumer cost is a state mandated price wedge—*PXBAR*. As seen in table 4.3, it is the extra labor required to obtain sector SX output, where SX is the state tradable sector. The cost of the price wedge is taken directly from the income of the labor-endowed traditional consumer. *PXBAR* is the increase in activity QX equal to the value of labor use to obtain sector SX output . If *PXBAR* is zero the consumer and producer price are equal. From table 4.3, notice that a 20% price wedge is calibrated into the benchmark data set. This value is arbitrarily introduced into the benchmark data. Therefore, the absolute distortion cannot be measured.

The equation set necessary to represent the rent-seeking price distortion is as follows. The three classes of equations are shown: the zero-profit condition, the market

Table 4.3. The QX Rent-seeking Activity Sector and its Relationship to the Uzbek SAM

		Agents			Welfare	Consumers
		Total Industrial Production	State Industrial Production	Delivery Activity of sx to Households	Traditional Households Welfare	Traditional Households (Workers)
		X	SX	QX	WT	HT
I costs of production (expenditures)						
Resource Production (Less Energy)	PR		-165.639200		-67.836470	
Services Including Government (Non-Tradable Production)	PS		-53.247472			
Industry (Tradable Production) Including:	PX	574.138671	-210.485640		-172.407541	
State Production	PSX		528.089935	-528.089935		
Privatized Production	POX	-66.215366				
Entrepreneurial Production	PEX	-67.848359				
Rent Seeking Queuing Activity	VQX	-440.074946		440.074946		
Foreign Exchange (Imports)	PFX					
Savings	PSAV					
II wages and net income						
Wages	PL		-54.274319	88.014989		240.244011
Specific Capital:						
Resource Sector Capital	PKR					
Service Sector Capital	PKS					
State Sector Capital	PKSX		-51.140032			
Privatized Sector Capital	PKOX					
Entrepreneurial Sector Capital	PKEX					
Traditional Household Welfare	PTW				240.244011	-240.244011
Entrepreneurial Household Welfare	PEW					
Government Welfare	PGW					
subsidies	SUB		43.430400			
tax	TAX		-36.733672			

clearance condition, and the income balance condition. These are further described in the section of this chapter entitled "The MCP Equation Set."

Recall from equation 4.13 that the unit cost function, derived from the associated production function, is $c_x(p)$. The general form for the zero profit condition is therefore: $P_x = c_x(p)$, and specifically for the rent-seeking activity sector:

$$P_{QX} = \left[\alpha_{QX}^{Labor} \left[(1 + PXBAR) P_L \right]^{1-\sigma^{QX}} + \alpha_{QX}^{SX} P_{SX}^{\,1-\sigma QX} \right]^{\frac{1}{1-\sigma^{QX}}},$$

where $0 < \alpha_j < 1$, and $\alpha_{QX}^{Labor} + \alpha_{QX}^{SX} = 1.$ (4.19)

As described in chapter 3, using Shepherd's Lemma and the benchmark activity level $\bar{y}_x$, the market clearing condition is represented as:

$$y_{QX} = \bar{y}_x \frac{\partial c_x}{\partial P_{QX}} y_x . \tag{4.20}$$

This equation requires the total value of supply to equal the total value of demand (excess demand equals zero). The supply of QX is demanded in its entirety by the X activity, where the X activity aggregates the various sources of tradable output prior to them becoming available to the economy. Sector X is further described in the next section.

The income balance conditions are derived from the general form:

$$M_H = \phi_K^H P_K K^* + \phi_L^H P_L L^* + TAX_H, \text{ where } \sum_H \phi_K^H = 1, \text{ and } \sum_H \phi_L^H = 1, \tag{4.21}$$

where ϕ_K^H, and ϕ_L^H are the portion of capital and labor endowment respectively, allocated to each household. For the traditional households, endowed with labor, the rent-seeking price wedge is shown as:

$$M_{labor} = \theta_L^{labor} P_L L(1 - PXBAR) . \tag{4.22}$$

The MPSGE code for this portion of the model is shown in Table 4.4.

Table 4.4. The Rent-seeking Queuing Activity MPSGE Code

```
$PROD:QX
O:VQX        Q:440.074946       A:HT   T:-PXBAR
I:PSX        Q:528.089935

$DEMAND:HT
D:PWT        Q:240.244011
E:PL         Q:328.259000

where
   SCALAR:
     PXBAR  Price wedge: percent distortion /0.2/;
   $SECTORS:
     QX  !Rent seeking queuing activity
   $COMMODITIES:
     PSX !Price index for commodity SX (state produced tradables)
     PL  !Price index for primary factor L (Labor)
     VQX !Price index for commodity VQX (rent seeking delivery)
     PWT !Price index for traditional households welfare
   $CONSUMER:
     HT  !Traditional households representative agent (labor)
```

The Transformation Continuum Across Productive Agents

Several countries have performed well in transitioning from a command system to a free market system including Hungary and the Czech Republic. Yet, perhaps no other reforming country has come so far and so fast as Poland following the breakup of the Soviet Union. Johnson and Loveman (1995), in reviewing Poland's reform process and the reasons for Poland's outstanding success, demonstrate that the gains to Poland come not only from the privatization and re-engineering of former public enterprises, but also from the success of new start-up enterprises. By observing the performance of several firms since the initiation of reform in Poland, Johnson and Loveman demonstrate that short-term gains most often come from the indirect benefit of freeing capital and labor for redistribution to price-responsive economic activity, referring, in the case of Poland, to new start-up companies. The authors conclude that emerging small start-up businesses "have become the driving force for reform at the enterprise level in Poland" (p. 4).

Several authors have observed that privatization by itself does not provide incentives to convert an enterprise from its old communist predilections to a genuine market orientation (McDonald, 1993). Price-responsive behavior is based upon the skills and experience of those managing the enterprise. Privatized Eastern European companies often tend to operate very much along the lines learned in the days of central planning. Privatized firms typically retain existing management and operating habits. In the case of a former command economy, these habits reflect the incentives of the state. Only

through retraining or replacing management, or establishing a strong ownership, can the organization progress to a genuine free market orientation.

In a recent study, Lal and Myint (1996) econometrically show the importance of entrepreneurship for growth performance. They state:

> Those countries which have created institutions and an economic environment which have fostered entrepreneurship, largely by reducing the costs of doing business (transition costs), and a stable system of property rights, have also been able to create more flexible economies. They have weathered the squalls in the world economy since 1973 much better than those economies which, through their attempts to repress private entrepreneurship, have limited their economies' "capacity to transform" (p. 59).

Lal and Myint attribute the phrase "capacity to transform" to Kindleberger (1962). They clearly link the idea of entrepreneurship and capacity to transform by suggesting that an economic environment fostering entrepreneurship would improve capacity to transform.

In modeling a reforming economy, it is important to capture the transformation capacity of the various productive agents active in the economy—state owned producers, privatized producers, and entrepreneurial or start-up producers. This study considers each of these (state firms, privatized firms, and entrepreneurial firms) concurrently active within the economy, and captures capacity to transform as a structural feature within the model. Few empirical models in existing economic literature have attempted to capture the reform process, and no studies have sought to accurately depict the capacity to transform of the state, privatized and entrepreneurial sectors active in the reform process.

My model incorporates capacity to transform into each firm's production function. State firms in the former Soviet Union historically have been characterized by

command production choice, in both inputs and outputs. The choices are based on the incentives of the political agents mandating economic activity. The actual production choices may or may not be Pareto optimal, but most certainly are unresponsive to price signals and characterized by a low capacity to transform. The incentives of newly privatized state firms, on the other hand, comprise mixed objectives. They are characterized by a learning-by-doing process and an intermediate price responsiveness. The third type of firm, the start-up entrepreneurial firms, better reflect the incentives of free market ownership. Entrepreneurial firms are, therefore, characterized by a high capacity to transform.

The study assumes that each firm has access to identical technology and thus would be characterized by identical production functions. Capacity to transform can then be captured through the substitution elasticity of the constant elasticity of substitution (CES) functional form. The changes in substitution elasticity occur along a continuum. The model depicts state firms with elasticities' of substitution near zero (analogous to Leontief technology) representing an inability to transform according to price signals. Privatized firms are depicted with elasticities' of substitution of 0.5 representing neutral capacity to transform. Entrepreneurial firms are characterized by elasticities' of substitution equal to one representing a strong ability to respond to price signals and, therefore, a strong capacity to transform. These, in essence, become the transformation constraints active in a reforming economy. These three sectors use the functional nesting

shown in figure 4.1. The production functions are (as previously shown by equations 4.15 though 4.17):

$$y_j = \left[\alpha_j^{va} va_j^{\frac{\sigma^j - 1}{\sigma^j}} + \sum_i \alpha_j^i \, \text{int}_j^{i \frac{\sigma^j - 1}{\sigma^j}} \right]^{\frac{\sigma^j}{\sigma^j - 1}}, \tag{4.23}$$

where $0 < \alpha_j < 1$, and $\sum_i \alpha_j^i + \alpha_j^{va} = 1$, for $j = SX, OX, EX$.

The value-added portion is defined as:

$$va_j = \left[\alpha_j^K K_j (1 - TX_j^K)^{\frac{\sigma_j^{va} - 1}{\sigma_j^{va}}} + \alpha_j^{labor} \text{labor}_j^{\frac{\sigma_j^{va} - 1}{\sigma_j^{va}}} \right]^{\frac{\sigma_j^{va}}{\sigma_j^{va} - 1}}, \tag{4.24}$$

where $0 < \alpha_j < 1$, $\alpha_j^K + \alpha_j^{labor} = 1$, for $j = SX, OX, EX$.

The labor nesting is defined as:

$$\text{labor}_j = \left[\alpha_j^L L_j (1 - TX_j^L + SUB_j)^{\frac{\sigma_j^L - 1}{\sigma_j^L}} + \sum_e \alpha_j^e x_j^e (1 - TX_j^e)^{\frac{\sigma_j^L - 1}{\sigma_j^L}} \right]^{\frac{\sigma_j^L}{\sigma_j^L - 1}}, \tag{4.25}$$

where $0 < \alpha_j < 1$, and $\sum_e \alpha_j^e + \alpha_j^L = 1$, for $j = SX, OX, EX$.

The activities SX, OX, and EX represent state tradable, privatized tradable and entrepreneurial tradable production respectively. The elasticities of substitution (or input

transformation elasticities) for the nested production function defined by equations (4.23) through (4.25) are shown in table 4.5. These elasticities define the input transformation capacity of the three productive agents active in a transforming economy. The three superscripts referred to in table 4.5 correspond to the three nested functions defined by equations (4.23) through (4.25).

Table 4.5. Tradable Sector Input Transformation Elasticities

	σ^j	σ_j^{va}	σ_j^L
SX	0	0	0
OX	0.5	0.5	0.5
EX	1	1	1

These three tradable activity sectors are assumed to produce an identical good (X). One additional productive activity, therefore, is used to aggregate SX, OX, and EX into X. The single good X is then available to the economy as an intermediate or final consumption good. The substitution parameter $\sigma^x = 10$ indicative of the relative homogeneity of the three input sectors.

$$y_x = \left[\sum_i \alpha_x^i y_x^{i\,\frac{\sigma^x - 1}{\sigma^x}} \right]^{\frac{\sigma^x}{\sigma^x - 1}}, \tag{4.26}$$

where $0 < \alpha_x^i < 1$, and $\sum_i \alpha_x^i = 1$, for i = SX, OX, EX, and $\sigma^x = 10$.

The MPS/GE code for these four sectors are shown in table 4.6. The first three production blocks contain the benchmark data for sectors SX, OX, and EX. The fourth production block aggregates the three tradable sectors into a single tradable commodity X. In production blocks SX and OX, subsidies are added to the sector output. These are shown in the second row of the block (beginning with O:), as the A: and T: fields – A: being the source of the subsidy and T: being the amount. These are scaled identically with the exception of the efficiency switch –*EFF* –in the sector OX subsidy. The OX subsidy is used in the benchmark to calibrate the OX (privatized tradable) sector. For the counterfactual studies, *EFF* eliminates the subsidy, subjecting sector OX to an efficiency disadvantage. Because the elasticity of substitution, $\sigma^{OX} = 0.5$, of the privatized sector is less than that of the entrepreneurial sector, $\sigma^{EX} = 1$, reflecting the learning-by-doing constraint faced by the privatized sector, the privatized sector retains some of the inefficient cost structure inherited from the state-sector without the offsetting subsidy.

Inefficient State Production in Both Inputs and Outputs

This section develops the third structural feature consistent with an economy in transition—that of inefficient state production in both inputs and outputs. The efficiency of the input/output choice is more technically described in terms of allocative and internal efficiency (Vickers and Yarrow, 1988). "Allocative efficiency" focuses on the firm's output choice given a *fixed cost structure*. A fixed cost structure in this model, for example, is analogous to a fixed transformation function and a low capacity to transform

Table 4.6. The Input Transformation Activity MPSGE Code

```
$PROD:SX s:0 k(s):0 l(k):0 r(l):0
O:PSX       Q:528.089935      A:GOVT      T:(-4.3430400/52.8089935)
I:PR        Q:165.639200 r:
I:PS        Q:53.247472
I:PX        Q:210.485640
I:PL        Q:54.274319  l:   P:(1+(36.733672/(54.274319+51.140032)))
            A:GOVT  T:(36.733672/(54.274319+51.140032))
I:PKSX      Q:51.140032  k:   P:(1+(36.733672/(54.274319+51.140032)))
            A:GOVT  T:(36.733672/(54.274319+51.140032))

$PROD:OX s:0.5 k(s):0.5 l(k):0.5 r(l):0.5
O:POX       Q:66.215366       A:GOVT      T:((-4.825600/66.215366)*EFF)
I:PR        Q:20.704900  r:
I:PS        Q:6.655934
I:PX        Q:26.310705
I:PL        Q:6.385214   l:   P:(1+(4.591709/(6.385214+6.392504)))
            A:GOVT T:(4.591709/(6.385214+6.392504))
I:PKOX      Q:6.392504   k:   P:(1+(4.591709/(6.385214+6.392504)))
            A:GOVT T:(4.591709/(6.385214+6.392504))

$PROD:EX s:1 k(s):1 l(k):1 r(l):1
O:PEX       Q:67.848359
I:PR        Q:20.704900  r:
I:PS        Q:6.655934
I:PX        Q:26.310705
I:PL        Q:3.192607   l:   P:(1+(4.591709/(3.192607+6.392504)))
            A:GOVT T:(4.591709/(3.192607+6.392504))
I:PKEX      Q:6.392504   k:   P:(1+(4.591709/(3.192607+6.392504)))
            A:GOVT T:(4.591709/(3.192607+6.392504))

$PROD:X S:10
O:PX        Q:574.138671
I:VQX       Q:440.074946
I:POX       Q:66.215366
I:PEX       Q:67.848359
```

characteristic of state firms. The Kantorovich Ray (Pogodzinski and Antes, 1992), is a method of measuring allocative inefficiency. Any output choice by command-controlled state firms that differs from what a pure price driven market-economy would produce is (allocatively) inefficient. In my model, allocative efficiency is measured across the economy as individual firms choose individual quantities of production that may or may not be appropriate given the marginal factor productivity required for the given output. Allocative inefficiency is built into the benchmark SAM reflecting the state's choice to produce tradable goods. In a three-sector model, the service sector is neglected by artificially supporting the tradable sector. By subsidizing labor in a particular industry, for example, an allocative inefficiency is sustained in that industry.

"Internal efficiency," on the other hand, focuses on the total costs to the firm in producing a *fixed bundle of output*. Internal efficiency requires substitution away from inefficient or high cost inputs.

In this model, entrepreneurial firms are characterized by a high capacity to transform, characteristic of price responsive cost minimizing behavior. More technically, the benefits of entrepreneurship can be described in terms of a productive, efficient allocation of resources: resources allocated within individual firms, resources allocated among firms, and the coordination of a firm's output choices. State firms in a transition economy, on the other hand, are both allocatively and internally inefficient.

Several authors have noted the importance of efficient allocation through entrepreneurial investment in describing growth (Scott 1976, Romer 1986, Lucas 1988,

Schultz 1990, Murphy, Shleifer, and Vishny 1991, and Lal and Myint 1996). Scott (1976, 332-333), for example, states "If investment is essentially a matter of incurring costs to reallocate resources then efficiency with which this is done must affect the yield of investment, and so the proportionate rate of growth in the long run. So long as investment is occurring, reallocation is occurring."

The Pogodzinski and Antes (1992) model, discussed in chapter 2, provides an empirical representation of the interaction of simultaneously existing state and private sectors. The Pogodzinski and Antes model identifies 1) a distorted state-sector production choice (or, in their words, a deviation in the Pareto-dominating allocation) and, in the extended model, and 2) a more productive second economy (using a Hicks neutral technology multiplier) as the enabling reasons the second economy improves the economy. They elude to a technically more efficient allocation of factors of production for the second economy, but since the state is assumed to be perfectly efficient, the second economy can never be more efficient than the state.

My study argues that the state does not efficiently allocate its factors of production (internal effeciency). The state-sector, motivated by political incentives, uses a distorted capital to labor ratio. Historically, governments have tended to utilize state-controlled industry to employ excess factors and specifically labor as a form of social welfare. The excess labor is subsidized through credit from the central bank. The result is internal inefficiently and cost structures burdened by excess labor. This study models

the distortion by establishing a price wedge between the labor costs of state firms and privatized firms.

Labor receives a wage rate P_L. The optimal cost of labor facing entrepreneurial firms is $TC_L^{Entrepreneurial} = L * P_L$. Entrepreneurial firms will employ labor up to $L = \frac{TC}{P_L}$. The state-sector, however, is the recipient of subsidies from the Central Bank, *SUB*. State firms are faced with labor costs of $TC_L^{State} = L * (P_L - SUB)$. The difference, or price wedge, between labor costs of state firms and entrepreneurial firms is $\Delta C = L * SUB$. However, the state firms in former command-and-control economies are not cost minimizers. Rather, in attempting to maximize welfare, they choose to employ excess labor. The state will employ an amount up to $L = \frac{TC}{(P_L - SUB)}$. This price wedge is depicted in figure 4.4. Point A represents the benchmark equilibrium. The budget constraint defining point A is sub-optimal due to the distorted price-ratio of subsidized labor to capital. The economy may move anywhere along the efficiency locus. Points B and C are representative of the potential high and low bounds counterfactual equilibrium states may attain when the subsidy is removed. The budget constraints defining point B and C reflect the market price-ratio. The shaded area in figure 4.4 represents the loss in GDP due to sub-optimal factor pricing. The economy could potentially produce more of good Q_y and Q_{X1} if the economy were to allocate factors along the bold portion of the expansion path bounded by isoquants Q_y and Q_{X1}.

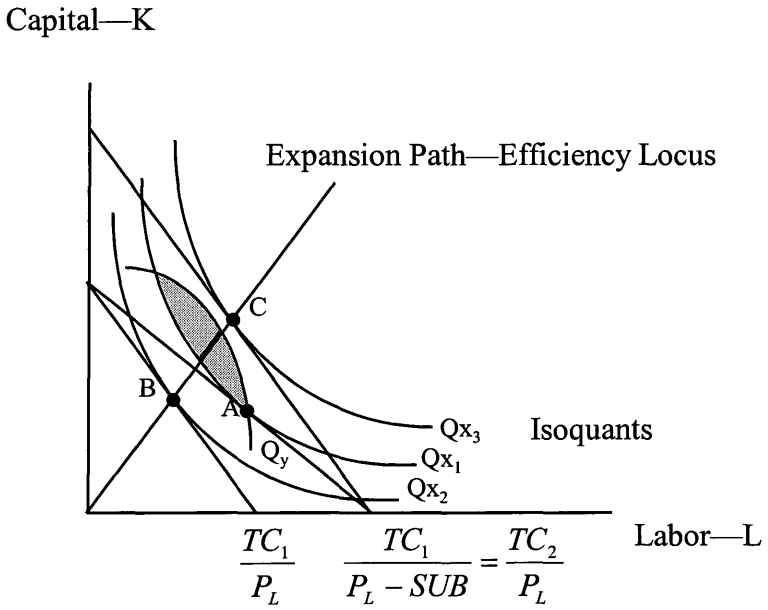

Figure 4.4. The Labor-subsidy Factor Price Distortion

In this study, the economy is shown to improve because of privatization as a result of two factors. First, as in the Pogodzinski and Antes model, privatization corrects a distorted state-sector production choice (a Pareto-dominating allocation of capital vs. consumer goods). Second, privatization corrects an inefficient capital to labor ratio. The first condition, that of a Pareto-dominating production choice results in *movement along* the production possibilities frontier. This condition is shown in figures 4.5 and 4.6. As privatization proceeds and the state-sector decreases (depicted by the arrow moving state production toward zero), the figure depicts the full economy moving toward the Pareto-optimal production choice established by the entrepreneurial sector (depicted by the

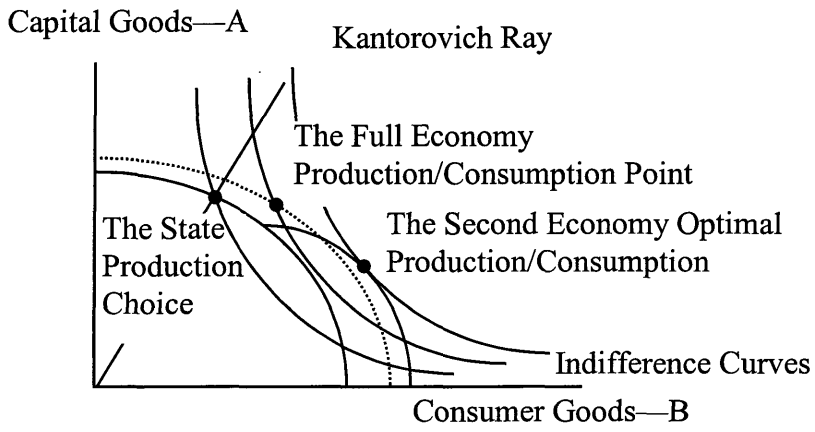

Figure 4.5. Utility in a Mixed Economy

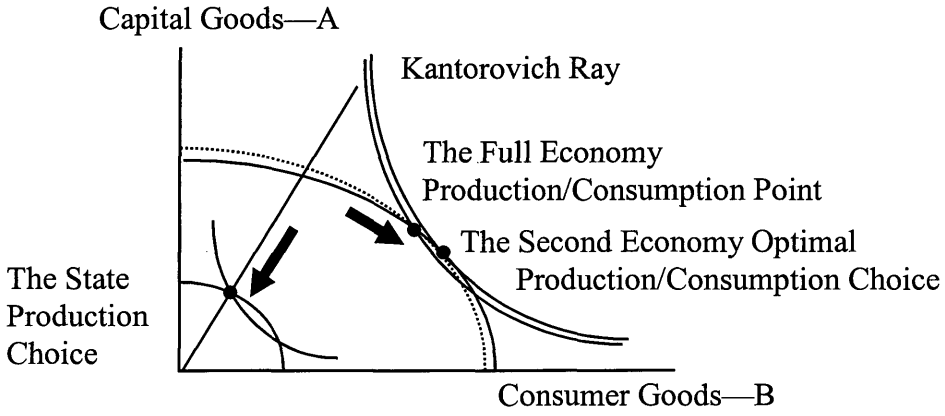

Figure 4.6. Utility Gains from a Reduced State Sector

arrow moving toward the second economy optimal production/consumption choice).

Correcting the second condition, the price wedge and resulting distorted capital to labor ratio, results in *an expansion* of (or movement onto) the production possibilities frontier. This result is demonstrated in figure 4.7. This figure superimposes an Edgeworth Box diagram onto an isoquant map. Point A represents the state allocation of K and L. It is clear from this figure that point A in not an efficient allocation since total output can increase (without a reduction in output in any one good) by movement onto the economy's expansion path defined by point B. By definition, this movement increases the economy's output and, thus, expands the production possibilities frontier.

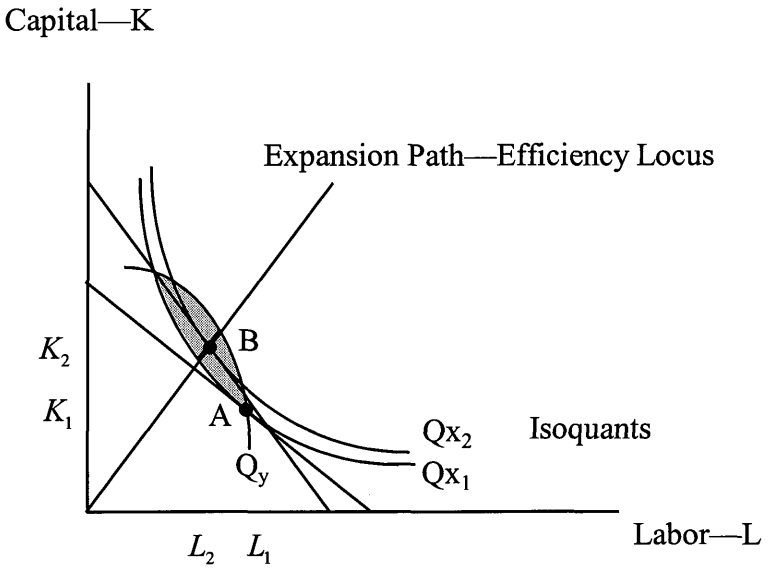

Figure 4.7. Efficient Factor Allocation Following Subsidy Price Distortion

Counterfactual Studies: A Principal-Agent Decision Analysis

After having correctly specified a GEM, the model can be used to examine counterfactual scenarios. Because of the inter-related nature of the general equilibrium approach, the consequences and benefits of various policies are apparent as measured in the change in welfare of the economic players.

The counterfactual scenarios in this study focus on how resources impact government policy choice in privatization. Using switches imbedded in the general equilibrium model eight outcomes are examined in two decision trees. The first decision tree (figure 4.8) represents the choice between an investment regime and a welfare regime. In this figure, both politicians and reformers choose policy independently and simultaneously. Their choice forms the first two branches of the decision tree. The third branch is a chance node representing uncertainty in the final policy outcome.

The second decision tree (figure 4.9) represents the choice between rapid reform (shock therapy) and delayed reform (gradualism). As with the first decision tree, both politicians and reformers choose policy independently and simultaneously. Their choice forms the first two branches of the decision tree. As with the first decision problem, the third branch is a chance node representing uncertainty in the final policy outcome.

Notice that when the politician's and reformer's policy decisions conflict, the outcome is determined by whichever party holds a majority vote. This is the case shown by the boxed outcomes in figures 4.8 and 4.9. When policy decisions conflict, the relative strength of the two political parties in a booming resource economy is compared

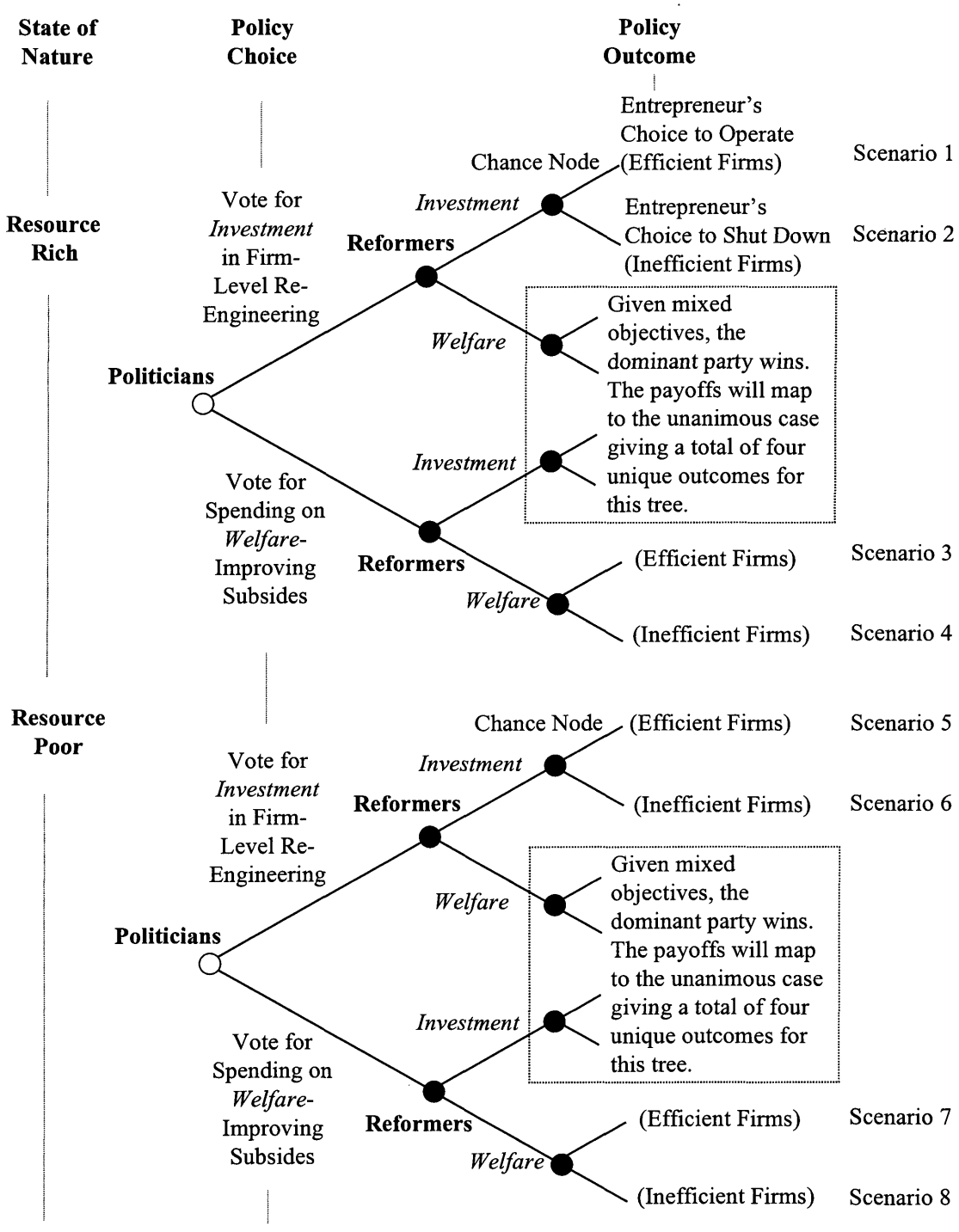

Figure 4.8. The Investment Regime vs. Welfare Regime Decision Tree

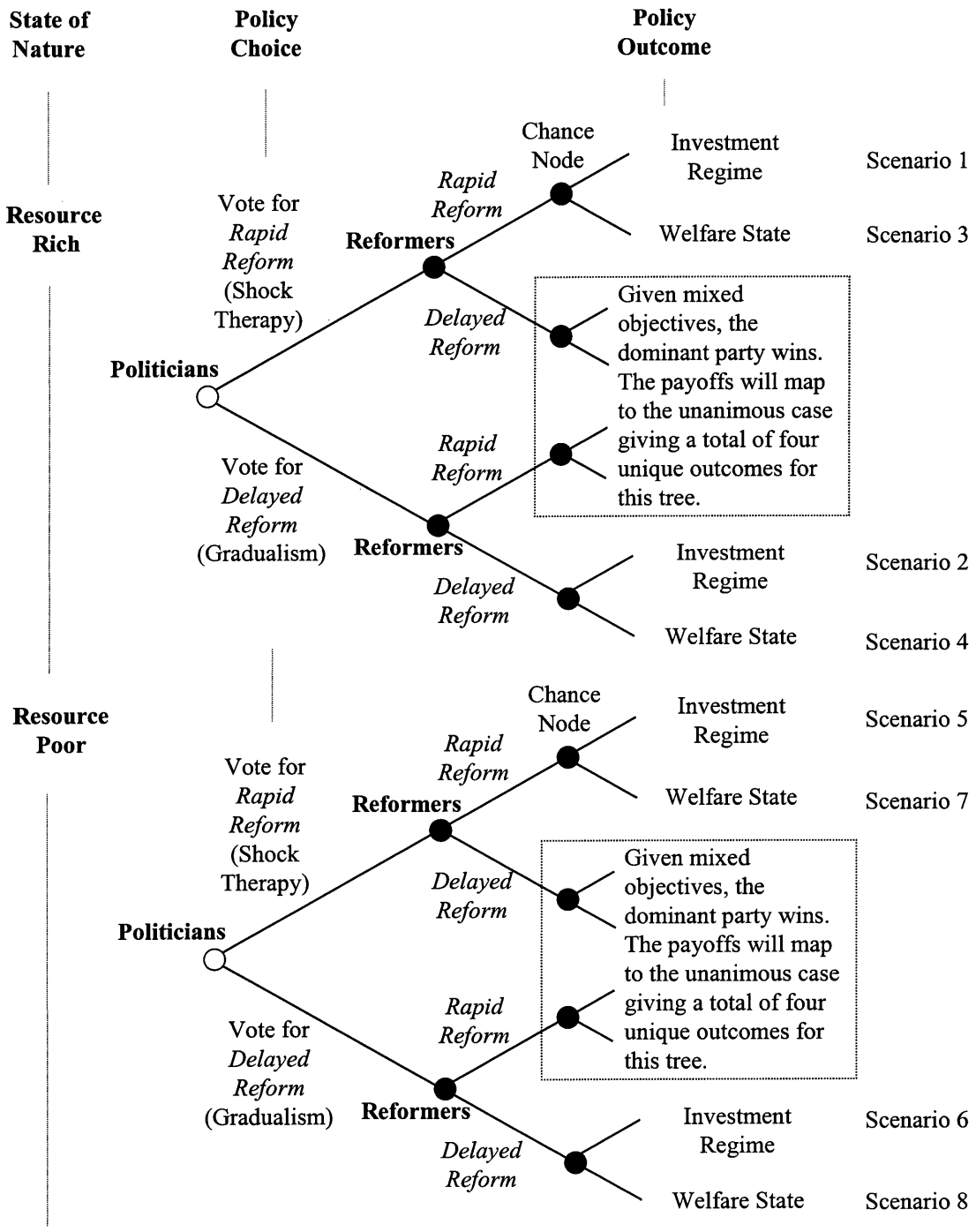

Figure 4.9. The Rapid Reform vs. Delayed Reform Decision Tree

with those in a non-boom economy. By comparing the relative strength of the political agents, the effect of resource abundance on policy choice is apparent.

The two decision problems use the same eight outcomes. However, the interpretation differs regarding the choice faced by the political agents and the uncertainty in obtaining the desired outcome. In the first decision problem, the political agents are faced with deciding between using government income for investment in capital or direct transfers to households. The uncertainty is in the effectiveness of investment and in the social cost of privatizing inefficient firms. The payoffs presented to the political agents from the eight general equilibrium scenarios are based on a 20% privatization. In the second decision problem, following a 20% privatization, the political agents are faced with deciding between continued privatization or delaying the privatization efforts. The choice in the second decision problem is synonymous with deciding between shock therapy or gradualism. The uncertainty in the second problem is in the type of regime that may ultimately gain control of government policy—either an investment regime or a welfare regime. Table 4.7 summarizes the two counterfactual decision problems.

The choices analyzed in the decision problems represent strategies based on positive perceptions about the current or future state of the world. They do not necessarily reflect the policy maker's preferred outcome given normative expectations. For example, in the investment vs. welfare decision problem, policy makers recognize that an economy characterized by efficient firms is preferable to an economy with

Table 4.7. Counterfactual Decision Problem Summary

	The Investment vs. Welfare Decision Problem	**The Shock Therapy vs. Gradualism Decision Problem**
Nature	Nature chooses the relative resource endowment.	Nature chooses the relative resource endowment.
Policy Options	Politicians and reformers independently vote on whether to invest in capital or spend on welfare.	Politicians and reformers independently vote on whether to continue privatizing or to delay further privatization.
Policy Outcome	Nature (chance) determines the relative efficiency of firms immediately following privatization. Inefficient firms are characterized by higher input costs equal to the loss of input subsidy and a low ability to substitute away from high cost factors. This second condition characterizes a low capacity to transform. Probabilities are assigned to the chance node representing society's perception of the ultimate cost and effectiveness of government reform policies. The probabilities are measured by the parameters γ and ε in figure 4.10. A priori intuition suggests a $\gamma > 0.5$ and an $\varepsilon < 0.5$ (choosing investment will result in efficient firms $\rightarrow \gamma > 0.5$, and choosing welfare will result in inefficient firms $\rightarrow \varepsilon < 0.5$).	Nature (chance) determines the eventual regime controlling government policy -- investment or welfare. Probabilities are assigned to the chance node representing the political agents perception of which type of regime will likely gain political control. The probabilities are measured by the parameters δ and α in figure 4.11. A priori intuition suggests a $\delta > 0.5$ and an $\alpha < 0.5$ (choosing continued privatization will result in an investment regime $\rightarrow \delta > 0.5$, and choosing to delay privatization will result in a welfare state $\rightarrow \alpha < 0.5$).

In the model, investment refers to directing the extra income (former subsidies) made available through privatization toward expanding capital endowments. Welfare refers to direct transfers to households of the newly available income. Efficient refers to (specific) privatized capital transferred to productive sectors characterized by flexible factor substitution possibilities. Inefficient refers to privatized capital transferred to productive sectors characterized by inflexible factor substitution possibilities and factor input quantities consistent with state firms, however without the associated subsidy. These, in effect, become high-cost producers.

inefficient firms. However, the choice in the decision problem considers the probability of obtaining efficient firms given a strategy of government-led investment, and also considers the chance that the firms may be a priori efficient prior to privatizing, negating the need for investment strategies. The ultimate choice then is based on the expected outcome rather than the preferred outcome.

The Investment vs. Welfare Decision Problem

In both decision problems, a Von Neumann-Morgenstern maximization of expected utility is used to determine the relative strength of the competing political objectives. Given the uncertainty as to the eventual outcome of their decision, in the investment vs. welfare decision problem policy makers are faced with the following outcomes:

1) Policy makers choose to invest in firm level re-engineering and firms are successfully re-engineered.
2) Policy makers choose to invest in firm level re-engineering. However, firms remain inefficient.
3) Policy makers choose welfare, yet firms are a priori efficient and remain efficient following privatization.
4) Policy makers choose welfare and firms remain inefficient.

The first two outcomes reflect uncertainty about the effectiveness of investment policy. Investment represents a very specific case in which the government prepares

individual firms for privatization by re-engineering or some other form of organizational development. The obvious limitation is that governments are the least capable entity to reorganize a firm according to free market forces. It is unrealistic to expect the same government that created the inefficient cost structure to correct it. Furthermore, even if the incentives changed to favor an efficient cost structure, government agencies lacking price competition are less able to optimize production than private ownership. There is a very real possibility that government investment will fail to correct the inefficiencies.

The second two outcomes reflect uncertainty about the a priori efficiency of the economy. Policy makers may perceive that firms are a priori efficient, and that factor disruption costs will be low following privatization. The alternative perception would suggest high disruption costs as entrepreneurs, gaining control of state firms, disrupt national production through plant closures and layoffs because of inherited high costs and an inability to respond to price signaling. The expectations are measured by the parameters γ and ε shown in figure 4.10.

The Von Neumann-Morgenstern aggregation is used to find all values of γ and ε whereby the payoffs are equal. Equal payoffs imply that the political agent is indifferent to either investment policies or welfare policies. The equation for the indifference curve is found by solving for γ:

$$\gamma\text{Scenario1} + (1-\gamma)\text{Scenario2} = \varepsilon\text{Scenario3} + (1-\varepsilon)\text{Scenario4}\,; \tag{4.27}$$

$$\gamma = \frac{\varepsilon(\text{Scenario3} - \text{Scenario4}) + \text{Scenario4} - \text{Scenario2}}{(\text{Scenario1} - \text{Scenario2})}. \tag{4.28}$$

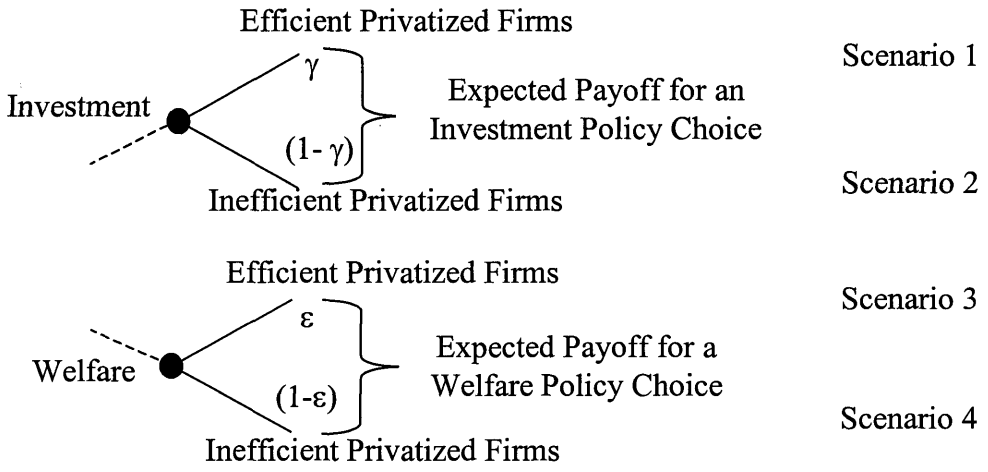

Figure 4.10. The Investment vs. Welfare Von Neumann-Morgenstern Aggregation

The Rapid Reform vs. Delayed Reform Decision Problem

In the second decision problem, choosing rapid reform (shock therapy) vs. delayed reform (gradualism), each policy maker is faced with the four following outcomes:

1) The policy maker chooses rapid reform (shock therapy) and a pro-investment regime controls government policy.
2) The policy maker chooses rapid reform (shock therapy) and a pro-welfare regime controls government policy.
3) The policy maker chooses delayed reform (gradualism) and a pro-investment regime controls government policy.

4) The policy maker chooses delayed reform (gradualism) and a pro-welfare regime controls government policy.

All four outcomes reflect uncertainty about the type of regime gaining control of government policy. The uncertainty reflects the fact that certain constituent classes may benefit more form one type of regime that another. Policy makers may choose a particular reform policy based on their perceptions of the likelihood of a particular regime gaining political control. The expectations are measured by the parameters δ and α shown in figure 4.11.

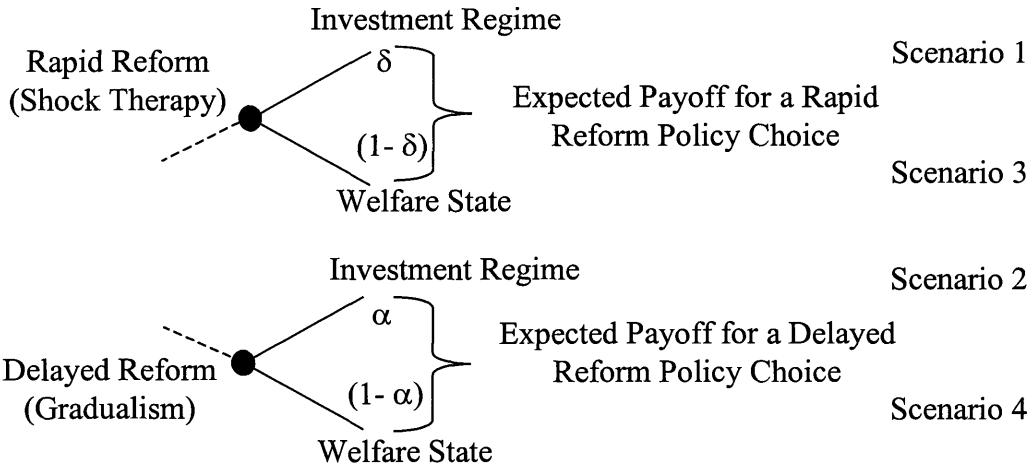

Figure 4.11. The Rapid vs. Delayed Reform Von Neumann-Morgenstern Aggregation

As with the previous investment/welfare decision problem, the Von Neumann-Morgenstern aggregation is used to find all values of δ and α whereby the payoffs are

equal. For this decision problem, equal payoffs imply that the political agent is indifferent to choosing either shock therapy policies or gradualist policies. The equation for the indifference curve is found by solving for α:

$$\delta \text{Scenario1} + (1-\delta)\text{Scenario3} = \alpha \text{Scenario2} + (1-\alpha)\text{Scenario4}; \tag{4.29}$$

$$\alpha = \frac{\delta(\text{Scenario1} - \text{Scenario3}) + \text{Scenario3} - \text{Scenario4}}{(\text{Scenario2} - \text{Scenario4})}. \tag{4.30}$$

Resource-Boom vs. Non-Boom Comparisons

When the actions of reformers and politicians conflict, the majority wins. However, this model cannot determine who will win the majority of popular vote. The model is measuring ordinal rankings of change in welfare. Translating ordinal utility rankings into an absolute number of voters represented by each payoff is beyond the scope of this study.

Although the number of voters in each class cannot be determined, the relative strength of each class can be inferred. A loss in the entrepreneur's welfare translates directly to a reduction of that class of constituent. For example, loss of welfare for capital means bankrupt business and a loss or transfer of assets. Gains in entrepreneurial welfare will result in a rent-seeking effect and entry into that class. A change in the number of voters in favor of the reformer's position is therefore implied by a change in the ordinal utility of the capital-endowed representative household.

An opposite effect is true of labor-endowed traditional households. A reduction in the welfare of labor-endowed households translates to an increase in social unrest. Welfare losses will strengthen labor-endowed households as marginal voters move to express their dissatisfaction. The opposite is not necessarily true of the traditional worker class in that an increase in welfare will not necessarily reduce the voting strength of that class.

These inferences can be used to suggest measures of relative strength of political parties. Payoffs can be expressed in terms of increases and decreases in the probability of an outcome—in this case the probability of either the politicians or the reformers determining transition policy. For example, if a counterfactual policy reduces the welfare of capital-endowed households, the outcome will infer fewer votes for the reformer's position. The absolute position, or number of votes, is not suggested. However, relative to the benchmark, the probability of a majority vote favoring the reformer's position is unambiguously reduced. From this result, the outcomes of the decision problems are compared relative to a resource-boom and a non-boom economy. The comparison is used to determine how resource endowment effects reform policy.

The Counterfactual Switch Set

The model uses three switches to arrive at the eight final outcomes. The switches represent a specific structural variable within the general equilibrium model and, as such, have a singular effect. However, the interpretation of the effect varies in the two decision

problems. For example, in the first decision problem switch one represents nature, and sets the relative level of resource endowment. The second switch represents the government's fiscal policy in choosing either to invest in capital development or spend on direct subsidies to households. The third switch, representing policy outcome, sets the efficiency of firms, characterized by either flexible substitution possibilities, or inflexible possibilities and high-cost production.

In the second decision problem switch three represents the government's choice of reform policy, and switch two sets policy outcome. In the second decision problem, government chooses between rapid reform or delayed reform, and the policy outcome varies between a resulting investment regime or welfare state. This section fully defines the function of the three switches within the GEM model. The switch set is summarized in Table 4.8.

Switch One: The Relative Resource Endowment

In this model a resource booming economy is modeled as an exogenous multiplier applied directly to the resource sector output. The multiplier changes the value of resource output given a fixed cost structure. The multiplier effectively models a country's ore grade and cost position relative to world production. The multiplier is shown in the resource sector (R) production function as:

$$y_R = SW1 \cdot f(x)_R \ , \tag{4.31}$$

Table 4.8. Scenario Summary and Decision Problem Interpretation

Decision problem 1	**Switch 1: Resource Level**	**Switch 2: Fiscal Policy**	**Switch 3: Policy Outcome**	**Model:**	**Interpretation:**
Scenario 1: **Scenario 5:**	ON OFF	ON	OFF	Investment in capital and flexible substitution possibilities.	Successful investment policies.
Scenario 2: **Scenario 6:**	ON OFF	ON	ON	Investment in capital, inflexible substitution possibilities, and high cost production.	Unsuccessful investment policies.
Scenario 3: **Scenario 7:**	ON OFF	OFF	OFF	Welfare and flexible substitution possibilities.	A priori efficient economy.
Scenario 4: **Scenario 8:**	ON OFF	OFF	ON	Welfare, inflexible substitution possibilities, and high cost production.	An inefficient welfare state.
Decision Problem 2	**Switch 1: Resource Level**	**Switch 3: Reform Policy**	**Switch 2: Policy Outcome**	**Model:**	**Interpretation:**
Scenario 1: **Scenario 5:**	ON OFF	OFF	ON	Investment in capital and flexible substitution possibilities.	Rapid reform policies (shock therapy) and a controlling investment regime.
Scenario 2: **Scenario 6:**	ON OFF	ON	ON	Investment in capital, inflexible substitution possibilities, and high cost production.	Delayed reform policies (gradualism) and a controlling investment regime.
Scenario 3: **Scenario 7:**	ON OFF	OFF	OFF	Welfare and flexible substitution possibilities.	Rapid reform policies (shock therapy) and a controlling welfare regime.
Scenario 4: **Scenario 8:**	ON OFF	ON	OFF	Welfare, inflexible substitution possibilities, and high cost production.	Delayed reform policies (gradualism) and a controlling welfare regime.

where $SW1$ is the booming sector multiplier and,

$SW1 = 1$ is the benchmark endowment,

$SW1 = 2$ is a 100% increase in the value of the resource sector.

Table 4.9 contains the MPS/GE code for the resource sector. The booming sector multiplier is shown in the second line containing the value of activity output (O:PR). The first line contains information about the functional form of $f(x)_R$. The values for the CES substitution elasticities (coded as: s:0 k(s):0.5 l(k):0.5 r(l):1) corresponds to the nesting depicted in figure 4.1.

Table 4.9. The Resource Sector and Booming Sector Multiplier MPSGE Code

```
$PROD:R s:0 k(s):0.5 l(k):0.5 r(l):1
O:PR        Q:(394.43599*SW1)
I:PR        Q:65.055720  r:
I:PS        Q:16.510830
I:PX        Q:63.297710
I:PL        Q:134.944120 l: P:(1+(6.069910/(134.944120+108.557700)))+
                  A:GOVT  T:(6.069910/(134.944120+108.557700))
I:PKR       Q:108.557700 k:   P:(1+(6.069910/(134.944120+108.557700)))+
                  A:GOVT  T:(6.069910/(134.944120+108.557700))
where
     SCALAR:
       SW1   Switch one: 1=benchmark endowment, 2=resource boom /1/
     $SECTORS:
        R  !Activity level of resource sector
     $COMMODITIES:
       PR  !Price index for commodity SX (state produced tradables)
       PS  !Price index for commodity PS (services - non-tradables)
       PX  !Price index for commodity X (tradables)
       PL  !Price index for primary factor L (Labor)
       PKR !Price index for resource specific factor K (capital)
```

Switch Two: Capital Investment vs. Welfare Subsidies

Switch two is used to direct government expenditure toward either capital investment or welfare increasing subsidies. The revenue available for the invest/spend decision is taken directly from funds saved because of privatization. Funds that are otherwise used to support state production become available for discretionary spending. This is shown in the following MPG/GE code in table 4.10 for the welfare portion of the model. In determining welfare, a production block is used and therefore an associated production function is used to capture the welfare effects. The subsidy is indirectly multiplied by the output of the production function similar to *SW*1 shown above. In the second line, A:GOVT establishes the government as the source of the subsidy. The value

Table 4.10. Traditional Households Welfare Production MPS/GE Code

```
$PROD:WT s:1
O:PWT  Q:240.244011 A:GOVT  T:((-43.430400/240.244011)*(1-SW2)*(1-
PRIV))
I:PR   Q:67.836470
I:PS   Q:0
I:PX   Q:172.407541

where
     SCALAR:
       SW2   Switch two: 1=investment, 2=consumption /1/
      PRIV  Exogenous privatization: 1=government owns capital
                                     0=entrepreneures own capital /1/
     $SECTORS:
        WT  !Hicksian welfare of traditional representative agent
     $COMMODITIES:
        PWT !Price index for traditional households welfare
        PR  !Price index for commodity PR (natural resources)
        PS  !Price index for commodity PS (services - non-tradables)
        PX  !Price index for commodity X (tradables)
```

for T:((-43.430400/240.244011)*(1-SW2)*(1-PRIV)) is the proportional amount of subsidy, where 43.4304 is the total amount spent on subsidizing state production. This amount is scaled by (1-PRIV), where PRIV =0.8 in the counterfactual scenarios representing 20% privatization.

The production function associated with the traditional household welfare function is:

$$y_{WT}(1+WELFARE) = A_{WT}\left[\sum_i \alpha^i_{WT} x^i_{WT}{}^{\frac{\sigma^{WT}-1}{\sigma^{WT}}}\right]^{\frac{\sigma^{WT}}{\sigma^{WT}-1}}, \tag{4.32}$$

where $A > 0$, $0 < \alpha^i_{WT} < 1$, $\sum_i \alpha^i_{WT} = 1$, and

$$WELFARE = \frac{StateSubsidy}{y_{WT}}(1-SW2)(1-PRIV), \tag{4.33}$$

where A_{WT} is a technology multiplier, α_i is a share parameter, x_i is a factor input, intermediate input, or nested function of intermediate and factor variables, and σ^{WT} is the elasticity of substitution between inputs.

An identical relationship holds for investment. The production function for investment is:

$$y_{INV}(1+WELFARE) = A_{INV}\left[\sum_i \alpha^i_{INV} x^i_{INV}{}^{\frac{\sigma^{INV}-1}{\sigma^{INV}}}\right]^{\frac{\sigma^{INV}}{\sigma^{INV}-1}}, \tag{4.34}$$

where $A > 0$, $0 < \alpha^i_{INV} < 1$, $\sum_i \alpha^i_{INV} = 1$, and

$$WELFARE = \frac{StateSubsidy}{y_{INV}} SW2(1 - PRIV). \tag{4.35}$$

Notice that for $SW2$=0 revenue is directed toward traditional households welfare and for $SW2$=1 revenue is directed toward investment. The investment feature is further defined below.

Switch Three: Flexible Substitution vs. Inflexible Substitution and High Cost Firms

Switch three is used to determine the state of firms following privatization. The privatization process exogenously transfers capital from government to entrepreneurial agents. Capital is either transferred as entrepreneurial capital (PKEX) or newly privatized capital (PKOX). Using specific capital forces the corresponding sector (either EX or OX) to be active in the privatization process. Firms are either efficient (EX) or inefficient (OX). If state capital endowment is transferred to the entrepreneurial capital endowment, the functional form used by the entrepreneurial sector will be active in the economy. Conversely, if state capital endowment is transferred to the newly privatized capital endowment, firms are characterized by the functional form used by the newly privatized sector. The MPS/GE code used for the entrepreneurial households to collect the capital transfer during privatization is shown in table 4.11. The income balance equation formulated from this block is as follows:

$$\begin{aligned} M_{HE} = {} & P_{KOX} KOX(1 + SW3(1 - PRIV)KSX) \\ & + P_{KEX} KEX(1 + (1 - SW3)(1 - PRIV)KSX). \end{aligned} \tag{4.36}$$

Table 4.11. Entrepreneurial Households Income MPS/GE Code

```
$DEMAND:HE
D:PWE       Q:12.785008
E:PKOX      Q:(6.392504 + SW3*(1-PRIV)*56.768402)
E:PKEX      Q:(6.392504 + (1-SW3)*(1-PRIV)*56.768402)

where
     SCALAR:
       SW3   Switch three: 1=inefficient, 2=efficient /1/
      PRIV   Exogenous privatization: 1=government owns capital
                                      0=entrepreneures own capital /1/
     $CONSUMER:
        HE  !Entrepreneurial households representative agent (capital
                                                              owners)
     $COMMODITIES:
        PWE   !Price index for entrepreneurial households welfare
        PKOX  !Price index for newly privatized specific capital
        PKEX  !Price index for entrepreneurial specific capital
```

It was noted earlier that the inefficiencies built into the newly privatized sector are of two categories. Inefficient firms are characterized both by higher input costs equal to the loss of input subsidy and a low ability to substitute away from high cost factors. This second condition characterizes a low capacity to transform.

In order to formulate the first condition, high input costs, the newly privatized sector is calibrated in the benchmark with a proportionally identical subsidy as received by state firms. In the counterfactual scenarios the subsidy is removed, effectively burdening the sector with high costs. The second feature, capacity to transform, is contained in the CES substitution elasticities previously discussed and shown in figure 4.1. The calibration parameter *EFF* and substitution elasticities are shown in table 4.12.

Notice from the MPS/GE code shown in Table 4.10 that the calibration subsidy is applied directly to labor (PL) and is subtracted from the factor tax. Again, A:GOVT determines that the government gets the tax and the T: field determines the amount of tax. The nested production function representing the newly privatized sector is,

$$y_{OX} = \left[\alpha_{ox}^{va} va_{ox}^{\frac{\sigma^{ox}-1}{\sigma^{ox}}} + \sum_i \alpha_{ox}^{i} \text{int}_{ox}^{i\,\frac{\sigma^{ox}-1}{\sigma^{ox}}} \right]^{\frac{\sigma^{ox}}{\sigma^{ox}-1}}, \tag{4.37}$$

where $0 < \alpha_{ox} < 1$, and $\sum_i \alpha_{ox}^{i} + \alpha_{ox}^{va} = 1$.

Table 4.12. The Newly Privatized Sector MPS/GE Code

```
$PROD:OX s:0.5 k(s):0.5 l(k):0.5 r(l):0.5
O:POX       Q:66.215366
I:PR        Q:20.704900  r:
I:PS        Q:6.655934
I:PX        Q:26.310705
I:PL        Q:6.385214   l:   P:(1+(4.591709/(6.385214+6.392504))-
((4.825600/6.385214))  A:GOVT T:((4.591709/(6.385214+6.392504))-
((4.825600/6.385214)*EFF))
I:PKOX      Q:6.392504   k:   P:(1+(4.591709/(6.385214+6.392504)))
                 A:GOVT T:(4.591709/(6.385214+6.392504))

where
     SCALAR:
       EFF   Newly privatized calibration subsidy: 1=sub 0=no sub /1/
     $SECTORS:
        OX     !Activity level of privatized tradable sector
     $COMMODITIES:
        POX    !Price index for commodity OX (privatized tradables)
        PR     !Price index for commodity R (natural resources)
        PS     !Price index for commodity S (services - non-tradables)
        PX     !Price index for commodity X (tradables)
        PL     !Price index for primary factor L (labor)
        PKOX   !Price index for newly privatized specific capital
```

The value-added portion is defined as:

$$va_{ox} = \left[\alpha_{ox}^{K} K_{ox} (1 - TX_{ox}^{K})^{\frac{\sigma_{ox}^{va}-1}{\sigma_{ox}^{va}}} + \alpha_{ox}^{labor} \text{labor}_{ox}^{\frac{\sigma_{ox}^{va}-1}{\sigma_{ox}^{va}}} \right]^{\frac{\sigma_{ox}^{va}}{\sigma_{ox}^{va}-1}}, \quad (4.38)$$

where $0 < \alpha_{ox} < 1$, $\alpha_{ox}^{K} + \alpha_{ox}^{labor} = 1$.

The labor nesting is defined as:

$$\text{labor}_{\text{OX}} = \left[\alpha_{\text{OX}}^{L} L_{\text{OX}} (1 - TX_{\text{OX}}^{L} + EFF \cdot SUB_{\text{OX}}^{L})^{\frac{\sigma^{L}-1}{\sigma^{L}}} + \sum_{e} \alpha_{\text{OX}}^{e} x_{\text{OX}}^{e} (1 - TX_{\text{OX}}^{e})^{\frac{\sigma^{L}-1}{\sigma^{L}}} \right]^{\frac{\sigma^{L}}{\sigma^{L}-1}}, \quad (4.39)$$

where $0 < \alpha_{\text{OX}} < 1$, $\sum_{e} \alpha_{\text{OX}}^{e} + \alpha_{\text{OX}}^{L} = 1$, and *e* represents all resource commodities. In my model there is only one resource commodity—R.

The MCP Equation Set

Using the previous production functions and the corresponding cost and expenditure functions, the following MCP equation set fully defines the model. The MCP equation set consists of three classes of equations: zero-profit, market clearance, and income balance.

Zero-Profit: Cost of Production Gross of Tax = Value of Output

The general form for the zero-profit condition for *j* activities in *i* commodities is:

$$-\prod_{j}(p) = C_{j}(p) - R_{j}(p) \geq 0,$$

$$-\prod_j = [\sum_i \alpha_j^i p_j^{i\,1-\sigma^j}]^{\frac{1}{1-\sigma^j}} - R_j \geq 0, \tag{4.40}$$

where $0 < \alpha_j < 1$, and $\sum_i \alpha_j^i = 1$, $\perp j$, $\forall_j$,

and where $\perp j$ represents the shadow variable associated with this equation.

This form is flexible in that groups of commodities may be nested functions, and revenues may be net of subsides and taxes. In addition, several sectors produce more than one commodity. In these cases, output is defined by a CES output transformation function:

$$P_j = [\sum_i \theta_i P_i^{\,1+\eta^j}]^{\frac{1}{1+\eta^j}}, \tag{4.41}$$

where $0 < \alpha_j < 1$, and $\sum_i \theta_i = 1$, $\perp j$, $\forall_j$.

As demonstrated above with the production functions, profit functions will also contain the nesting structure shown in figures 4.1 and 4.2. These follow from the constrained optimization of production and utility functions. The production side of the economy uses the following nested function:

$$-\Pi_j = \left[\alpha_j^{va} P_{va}^{j\,1-\sigma^j} + \sum_{\text{int}} \alpha_j^{\text{int}} P_j^{\text{int}\,1-\sigma^j} \right]^{\frac{1}{1-\sigma^j}} - R_j \geq 0, \tag{4.42}$$

where $0 < \alpha_j < 1$, and $\sum_i \alpha_j^{\text{int}} + \alpha_j^{va} = 1$, $\forall_{j=R,S,SX,OX,EX}$.

Recall that the cost functions were unitized. Revenue, R_j, is therefore defined as unit revenue and equal to the price of the activity. The general form for the zero profit condition is: $P_x = c_x(p)$, and for our case:

$$P_j\,(1+SW1_{j=\mathrm{R}}) = \left[\alpha_j^{va} P_{va}^{j\,1-\sigma^j} + \sum_{\text{int}} \alpha_j^{\text{int}} P_j^{\text{int}\,1-\sigma^j}\right]^{\frac{1}{1-\sigma^j}}, \tag{4.43}$$

where $0 < \alpha_j < 1$, and $\sum_i \alpha_j^{\text{int}} + \alpha_j^{va} = 1,\ \forall_{j=R,S,SX,OX,EX}$.

The value-added portion is defined as:

$$P_{va}^j = \left[\alpha_j^K P_K (1-TX_K^j)^{1-\sigma_j^{va}} + \alpha_j^{labor} P_{labor}^{j\ 1-\sigma_j^{va}}\right]^{\frac{1}{1-\sigma_j^{va}}}, \tag{4.44}$$

where $0 < \alpha_j < 1,\ \alpha_j^K + \alpha_j^{labor} = 1,\ \forall_{j=R,S,SX,OX,EX}$.

The labor nesting is defined as:

$$P_L^j =$$

$$\left[\alpha_j^L P_L\,(1+SUB_j \cdot EFF_{j=OX})(1-TX_L^j)^{1-\sigma^L} + \sum_e \alpha_j^E P_E^j (1-TX_E^j)^{1-\sigma^L}\right]^{\frac{1}{1-\sigma^L}}, \tag{4.45}$$

where $0 < \alpha_j < 1$, and $\sum_e \alpha_j^e + \alpha_j^L = 1,\ \forall_{j=R,S,SX,OX,EX}$.

For activities $j = X, QX, E, M, INV, WT, WE,$ and WG equations (4.43) through (4.45) simplify to:

$$P_j(1-SUB_{j=INV}\cdot SW2)(1-SUB_{j=WT}(1-SW2))$$

$$=[\sum_i \alpha_j(1+PXBAR_{j=QX})P_i^{\,1-\sigma^j}]^{\frac{1}{1-\sigma^j}}\,, \qquad (4.46)$$

where $0<\alpha_j<1$, and $\sum_i \alpha_i = 1, \perp j, \forall_{j=X,QX,E,M,INV,WT,WE,WG}$.

Market Clearance: Output + Initial Endowment = Intermediate + Final Demand

This class of equations equate supply with demand for all commodities *i*. Using Shepherd's lemma, if the profit function (Πj) is differentiable in prices, the unique profit-maximizing supply and derived-demand functions are:

$$y_j(p,w) = \frac{\partial \Pi_j}{\partial p_j}\,, \qquad (4.47)$$

and

$$x_{ij}(p,w) = \frac{\partial \Pi_j}{\partial w_i} \qquad \forall_j, \qquad (4.48)$$

where $y_j(p,w)$ and $x_{ij}(p,w)$ are the respective profit-maximizing quantities, and p, w are the commodity and factor prices respectively (Chung, 1995, p. 126).

Given our derivation of unit cost, we use Shepherd's Lemma to determine intermediate and final commodity demands. If total cost is $c_j y_j$, the portion of commodity *i* demanded by activity *j* is:

$$x_j^i = y_j \frac{\partial c_j}{\partial P_i}, \tag{4.49}$$

where $\sum_j x_j^i = X_i$ is the total intermediate demand of commodity *i*.

The market clearing conditions are represented as:

$$y_j = \sum_j \bar{y}_j \frac{\partial c_j}{\partial P_i} y_j + \sum_H \overline{M}_H \frac{\partial e_H}{\partial P_i} M_H . \tag{4.50}$$

The final term on the right hand side of this equation represents the final demand by consumer *H*, where M_H is the consumer budget condition. This equation requires supply to equal demand (excess demand equals zero).

As with commodities, factors are also subject to excess demand conditions. The market clearing equation for labor is therefore:

$$L^* = \sum_j \bar{x}_j \frac{\partial c_j}{\partial P_L} x_j + \sum_H \overline{M}_H \frac{\partial e_H}{\partial P_L} M_H . \tag{4.51}$$

The last term on the right-hand side allows consumers to choose leisure as an economic good. The market clearing equation for capital is:

$$K^* = \sum_j \bar{x}_j \frac{\partial c_j}{\partial P_K} x_j . \tag{4.52}$$

Income Balance: Expenditure (Consumption) = Factor Income + Tax Revenue

$$M_H = \phi_K^H P_K K^* + \phi_L^H P_L L^* + TAX_H, \quad \text{where} \quad \sum_H \phi_K^H = 1, \text{ and } \sum_H \phi_L^H = 1, \qquad (4.53)$$

where ϕ_K^H, and ϕ_L^H are the portion of capital and labor endowment respectively, allocated to each household.

For entrepreneurs, income is defined as:

$$M_{\text{HE}} = P_{\text{KOX}} KOX^* (1 + SW3(1 - PRIV)KSX) + P_{\text{KEX}} KEX^* (1 + (1 - SW3)(1 - PRIV)KSX). \qquad (4.54)$$

Likewise, for traditional workers:

$$M_{labor} = \theta_L^{labor} P_L L^* (1 - PXBAR). \qquad (4.55)$$

Government receives tax and pays subsidies:

$$M_{govt} = \theta_{\text{KR}}^{govt} P_{\text{KR}} KR^* + \theta_{\text{KS}}^{govt} P_{\text{KS}} KS^* + PRIV \cdot P_{\text{KSX}} KSX^* + \theta_L^{govt} P_L L^* + \theta_{\text{FX}}^{govt} P_{\text{FX}} FX^* + TAX_{\text{GOVT}}, \qquad (4.56)$$

where TAX_{GOVT} is net of subsidies.

TAX in this equation includes all labor and capital tax collected from activities and accrued to the government as well as tax on energy. It is a percent tax on the amount of the factor used by each activity.

These n equations fully define the model and solve for n unknowns. These equations are automatically constructed in GAMS by the MPSGE module. There are also the following exogenous parameters:

$\theta_{i,}\ \eta^{j}$	for $i = 1$ to n, and $j = 1$ to m	(from equation 4.41)
$\alpha_{j}^{va}\ \alpha_{j}^{\text{int}}\ \sigma^{j}$	for $j = R, S, SX, OX, EX$	(from equation 4.43)
$\alpha_{j}^{K}\ \alpha_{j}^{labor}\ \sigma_{j}^{va}$	for $j = R, S, SX, OX, EX$	(from equation 4.44)
$\alpha_{j}^{L}\ \alpha_{j}^{e}\ \sigma^{L}$	for $j = R, S, SX, OX, EX$	(from equation 4.45)
$\alpha_{j}\ \sigma_{j}$	for $j = X, QX, E, M, INV, WT, WE, WG$	(from equation 4.46)
$\theta_{L}^{H}\ \theta_{KR}^{H}\ \theta_{KS}^{H}\ \theta_{KSX}^{H}\ \theta_{KOX}^{H}\ \theta_{KEX}^{H}$	for $H = HE, HT, GOVT$	(from equation 4.53)

The previous set of equations fully define equilibrium at both the benchmark and the counterfactual. The model's objective is to maximize the positive change in welfare moving from the benchmark to the counterfactual solution.

Table 4.13 Glossary of Variables

Scalars are identified as follows:

*SW*1	Switch one: 1=benchmark resource endowment, 2=resource boom
*SW*2	Switch two: 1=capital investment, 0=welfare subsidy
EFF	Newly privatized calibration subsidy: 1=subsidized
*SW*3	Switch three: 1=inefficient firms, 0=efficient firms
PRIV	Exogenous privatization
PXBAR	Price wedge: percent distortion (0.2 in the benchmark)

Production sectors are identified as follows:

$\bar{y}_j$,	for $j = 1$ to m	Benchmark activity level for productive sector y_j
y_j,	for $j = 1$ to m	Activity level for productive sectors
P_j,	for $j = 1$ to m	Price index for productive activities
P_j^{int},	for $j = 1$ to m	Price index for intermediate nesting of productive activities
P_{va}^j,	for $j = 1$ to m	Price index for value-added nesting of productive activities
P_j^{labor},	for $j = 1$ to m	Price index for labor nesting of productive activities
P_e^j,	for $j = 1$ to m	Price index for natural resources nesting of productive activities

Endowed factors are identified as follows:

L^*	Labor endowment
K^*	Capital endowment
P_L	Price index for labor
P_K	Price index for capital

Hicksian welfare (income) is identified as follows:

W_H,	for $H = 1$ to r	Welfare index level
P_W		Real income price index (deflator)

Commodities are identified as follows:

$\bar{x}_i$,	for i = 1 to n	Benchmark activity level for commodity x_i
x_i,	for i = 1 to n	Commodity activity level
P_i,	for i = 1 to n	Commodity price index

Consumers are identified as follows:

$\overline{M}_H$,	for H = 1 to r	Benchmark income level of the representative household
M_H,	for H = 1 to r	Income level for representative consumers
$M_{capital}$		Income level for entrepreneurs
M_{labor}		Income level for labor owners
M_{govt}		Government income level

Table 4.14. MCP Equation Set Summary

1) Zero profit for x_i:

$$P_j(1+SW1_{j=r}) = \left[\alpha_j^{va} P_{va}^{j\,1-\sigma^j} + \sum_{\text{int}} \alpha_j^{\text{int}} P_j^{\text{int}\,1-\sigma^j}\right]^{\frac{1}{1-\sigma^j}}, \qquad (4.43)$$

$$\text{where } 0 < \alpha_j < 1, \text{ and } \sum_i \alpha_j^{\text{int}} + \alpha_j^{va} = 1, \ \forall_{j=R,S,SX,OX,EX}.$$

The value-added portion is defined as:

$$P_{va}^j = \left[\alpha_j^K P_K (1-TX_K^j)^{1-\sigma_j^{va}} + \alpha_j^{labor} P_L^{j\,1-\sigma_j^{va}}\right]^{\frac{1}{1-\sigma_j^{va}}} \qquad (4.44)$$

$$\text{where } 0 < \alpha_j < 1, \ \alpha_j^K + \alpha_j^{labor} = 1, \ \forall_{j=R,S,SX,OX,EX}.$$

The labor nesting is defined as:

$$P_L^j = \left[\alpha_j^L P_L (1+SUB_j \cdot EFF_{j=ox})(1-TX_L^j)^{1-\sigma^L} + \sum_e \alpha_j^e P_e^j (1-TX_e^j)^{1-\sigma^L}\right]^{\frac{1}{1-\sigma^L}} \qquad (4.45)$$

$$\text{where } 0 < \alpha_j < 1, \text{ and } \sum_e \alpha_j^e + \alpha_j^L = 1, \ \forall_{j=R,S,SX,OX,EX}.$$

For activities $j = X, QX, E, M, INV, WT, WE,$ and WG:

$$P_j(1-SUB_{j=inv} \cdot SW2)(1-SUB_{j=wt}(1-SW2)) = \left[\sum_i \alpha_j (1+PXBAR_{j=qx}) P_i^{\,1-\sigma^j}\right]^{\frac{1}{1-\sigma^j}} \qquad (4.46)$$

$$\text{where } 0 < \alpha_j < 1, \text{ and } \sum_i \alpha_i = 1, \perp j, \forall_{j=X,QX,E,M,INV,WT,WE,WG}.$$

2) Supply = Demand for x_i:

$$y_j = \sum_j \bar{y}_j \frac{\partial c_j}{\partial P_i} y + \sum_H \bar{M}_H \frac{\partial e_H}{\partial P_i} M \,. \tag{4.50}$$

3) Supply = Demand for W:

$$\bar{M}_H \cdot W_H = \frac{M_H}{P_W} \,. \tag{4.57}$$

4) Supply = Demand for L:

$$L^* = \sum_j \bar{x}_j \frac{\partial c_j}{\partial P_L} x + \sum_H \bar{M}_H \frac{\partial e_H}{\partial P_L} M \,. \tag{4.51}$$

5) Supply = Demand for K:

$$K^* = \sum_j \bar{x}_j \frac{\partial c_j}{\partial P_K} x \,. \tag{4.52}$$

6) Income:

$$\begin{aligned} M_{HE} &= P_{KOX} KOX^* (1 + SW3(1 - PRIV) KSX) \\ &\quad + P_{KEX} KEX^* (1 + (1 - SW3)(1 - PRIV) KSX) \,; \end{aligned} \tag{4.54}$$

$$M_{labor} = \theta_L^{labor} P_L L^* (1 - PXBAR) \,; \tag{4.55}$$

$$\begin{aligned} M_{govt} &= \theta_{KR}^{govt} P_{KR} KR^* + \theta_{KS}^{govt} P_{KS} KS^* \\ &\quad + PRIV \cdot P_{KSX} KSX^* + \theta_L^{govt} P_L L^* + \theta_{FX}^{govt} P_{FX} FX^* + TAX_{govt} \,. \end{aligned} \tag{4.56}$$

Chapter 5

TRANSITIONAL ECONOMY MODEL RESULTS AND DISCUSSION

This chapter presents the results of the 1991 Uzbekistan transitional economy model. Although there are several interesting results, three observations have the most reaching implications.

First, because of the natural Dutch disease-induced reduction in the tradable sector, booming-sector economies are more likely to experience a more gradualist approach to transition than economies without a booming resource sector. The results indicate that pro-reform political agents in these economies effectively lose voting power because of a Dutch disease led erosion of their constituent base. This result is through a Von Neumann-Morgenstern maximization of expected utility decision analysis. The Von Neumann-Morgenstern equilibrium demonstrates the relative strength of reformers and politicians in a mineral-boom vs. a non-boom economy.

Second, by examining the sensitivity of the GEM counterfactual results to changes in the structural variables, it becomes apparent that the input transformation elasticity, or capacity to transform, may be the most important variable in determining a transitional economy's ability to successfully reform as measured by change in welfare. Capacity to transform measures an economy's ability to respond to market-driven price

signals in allocating factors of production to their marginally most productive employment. In my study, the entrepreneurs, who are highly price responsive, are characterized by high capacity to transform. The strength of the entrepreneurial class, therefore, is shown to be instrumental in directing a successful reform effort.

Third, by establishing the world prices as numeraire, and observing the changes in costs faced by the tradable-sector, the structural shifts in economic output caused by a booming sector are more clearly understood as an economy's movement according to comparative advantage. Factors of production are optimally employed where their marginal productivities are maximized and equal across the economy. I demonstrate that Dutch disease effectively changes society's relative prices and marginal factor productivities. The resulting structural shift in the output mix of the economy is a natural response to changing prices according to the law of comparative advantage. If the economy is allowed to shift into its low cost product (in this case resource production), the entrepreneurs' short-run losses are minimized.

My study suggests that society benefits from an abundant resource sector through the broader welfare measures suggested by Davis (1995). Comparing these to corporate dividends, I demonstrate that society benefits both through economic growth and through receiving dividends attributed to the resource windfall. In the long-run, if society is careful to maximize the benefit of these dividends while the resource sector is the low cost product, society is better able to shift into its next low cost product when prices

change. However, shifting according to comparative advantage is not possible if governments persist in supporting non-competitive sectors. The entrepreneurs are seen as best able to identify society's competitive advantage.

Table 5.1 contains the raw output from the general equilibrium model. The model is run eight times corresponding to the eight scenarios described in chapter 4. The first four runs represent a resource-booming economy. The last four represent a consistent or stable resource endowment. Scenarios 1 and 5 combine investment with efficient firms following a 20% privatization. Scenarios 2 and 6 combine investment with continued firm-level inefficiency following a 20% privatization. Scenarios 4 and 8 combine welfare with inefficient firms following a 20% privatization. Scenarios 3 and 7 combine welfare with efficient firms following a 20% privatization.

Each of these scenarios is to be interpreted based on the two decision problems developed in chapter 4. These scenarios and the decision problem interpretation are summarized in table 5.2. Table 5.2 contains a brief description of the mechanics active within the model. These correspond to the switch set developed in chapter 4. The model is then used to draw inferences relevant to real-world economies. The decision problem interpretations in table 5.2 are therefore designed to reflect actual economic outcomes faced by transitional economies in choosing reform policy as developed in chapter 4.

Table 5.1. Uzbekistan Model Results

	Benchmark	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
R	1	1.246	1.259	1.253	1.265	1.021	1.026	1.027	1.032
S	1	1.053	1.043	1.023	1.013	1.008	1.005	0.984	0.981
X	1	0.293	0.173	0.326	0.208	0.938	0.911	0.943	0.915
SX	1	0.204	0.132	0.235	0.165	0.794	0.792	0.795	0.794
OX	1	0.446	0.291	0.476	0.347	0.994	1.649	1.001	1.667
EX	1	0.761	0.336	0.803	0.366	1.866	0.986	1.887	0.997
WT	1	2.698	2.67	2.754	2.727	1.027	1.018	1.051	1.042
WE	1	0.424	0.165	0.458	0.187	1.364	0.952	1.382	0.969
WG	1	1.386	1.421	1.345	1.38	1.036	1.044	1.014	1.022
E	1	34.635	36.66	34.422	36.397	2.334	2.721	2.393	2.775
M	1	14.679	15.503	14.593	15.396	1.543	1.7	1.567	1.722
INV	1	1.512	1.548	1.439	1.473	1.059	1.067	1.012	1.02
QX	1	0.204	0.132	0.235	0.165	0.794	0.792	0.795	0.794
PR	1	1	1	1	1	1	1	1	1
PS	1	1.646	1.612	1.605	1.573	0.985	0.979	0.969	0.964
PX	1	1	1	1	1	1	1	1	1
PSX	1	1.037	1.027	1.033	1.024	1.017	1.014	1.017	1.014
POX	1	0.959	0.949	0.963	0.95	0.994	0.942	0.994	0.942
PEX	1	0.909	0.936	0.914	0.945	0.934	0.992	0.933	0.991
PL	1	2.031	1.99	2.011	1.971	0.968	0.96	0.959	0.952
PKR	1	3.448	3.52	3.489	3.559	1.043	1.054	1.056	1.067
PKS	1	2.272	2.17	2.075	1.981	0.99	0.975	0.921	0.906
PKSX	1	0.34	0.309	0.351	0.319	1.155	1.141	1.173	1.158
PKOX	1	0.19	0.01	0.218	0.015	0.983	0.332	0.996	0.34
PKEX	1	0.249	0.315	0.264	0.346	0.628	0.978	0.634	0.989
FX	1	1	1	1	1	1	1	1	1
VQX	1	1.037	1.027	1.033	1.024	1.017	1.014	1.017	1.014
PWT	1	1	1	0.965	0.965	1	1	0.965	0.965
PWE	1	1.041	1.039	1.039	1.037	0.999	0.998	0.997	0.997
PWG	1	1.524	1.496	1.547	1.519	0.956	0.951	0.976	0.971
PSAV	1	1.397	1.373	1.447	1.423	0.935	0.931	0.977	0.973
HT	240.244	648.154	641.417	638.631	632.271	246.629	244.492	243.736	241.652
HE	12.785	5.637	2.196	6.085	2.474	17.418	12.153	17.623	12.351
GOVT	286.655	605.398	609.354	596.635	601.007	283.949	284.648	283.619	284.434

Scenario 1 = BIF = Resource-Boom, Investment, Flexible Firms
Scenario 2 = BIH = Resource-Boom, Investment, Inflexible and High Cost Firms
Scenario 3 = BWF = Resource-Boom, Welfare, Flexible Firms
Scenario 4 = BWH = Resource-Boom, Welfare, Inflexible and High Cost Firms
Scenario 5 = NIF = Benchmark Resources, Investment, Flexible Firms
Scenario 6 = NIH = Benchmark Resources, Investment, Inflexible and High Cost Firms
Scenario 7 = NWF = Benchmark Resources, Welfare, Flexible Firms
Scenario 8 = NWH = Benchmark Resources, Welfare, Inflexible and High Cost Firms

(continued)

Table 5.1 (Continued)

WHERE

SECTORS:

R	Activity level of resource sector
S	Activity level of service sector
X	Activity level of tradable sector
SX	Activity level of state tradable sector
OX	Activity level of privatized tradable sector
EX	Activity level of entrepreneurial tradable sector
WT	Hisksian welfare of traditional representative agent
WE	Hicksian welfare of entrepreneurial representative agent
WG	Hicksian welfare of government agent
E	Activity level of export sector
M	Activity level of import sector
INV	Investment activity
QX	Rent-seeking queuing activity

COMMODITIES:

PR	Price index for commodity R (natural resources)
PS	Price index for commodity S (services -- non-tradable)
PX	Price index for commodity X (tradable)
PSX	Price index for commodity SX (state produced tradable)
POX	Price index for commodity OX (privatized tradable)
PEX	Price index for commodity EX (entrepreneurial produced tradable)
PL	Price index for primary factor L (Labor)
PKR	Price index for resource specific primary factor K (capital)
PKS	Price index for service specific primary factor K (capital)
PKSX	Price index for state tradable specific primary factor K (capital)
PKOX	Price index for newly privatized specific primary factor K (capital)
PKEX	Price index for entrepreneurial specific primary factor K (capital)
FX	Price index for foreign exchange -- numeraire
VQX	Price index for commodity VQX (rent-seeking delivery)
PWT	Price index for traditional households welfare
PWE	Price index for entrepreneurial households welfare
PWG	Price index for government welfare
PSAV	Price index savings activity

CONSUMER:

HT	Traditional households representative agent (labor)
HE	Entrepreneurial households representative agent (capital owners)
GOVT	Government

Table 5.2. Scenario Summary and Decision Problem Interpretation

Scenarios 1 and 5:
Model: Investment in capital and flexible substitution possibilities.
Decision problem 1 interpretation: Successful investment policies.
Decision problem 2 interpretation: Rapid reform policies (shock therapy) and a controlling investment regime.
Scenarios 2 and 6:
Model: Investment in capital, inflexible substitution possibilities, and high cost production.
Decision problem 1 interpretation: Unsuccessful investment policies.
Decision problem 2 interpretation: Delayed reform policies (gradualism) and a controlling investment regime.
Scenarios 3 and 7:
Model: Welfare and flexible substitution possibilities.
Decision problem 1 interpretation: A priori efficient economy.
Decision problem 2 interpretation: Rapid reform policies (shock therapy) and a controlling welfare regime.
Scenarios 4 and 8:
Model: Welfare, inflexible substitution possibilities, and high cost production.
Decision problem 1 interpretation: An inefficient welfare state.
Decision problem 2 interpretation: Delayed reform policies (gradualism) and a controlling welfare regime.

The welfare states associated with the eight equilibrium payoffs are shown in table 5.3. In this table the WT and WE rows (the welfare of traditional and entrepreneurial households respectively) are taken from table 5.1 and displayed as percentage change. The table shows the percentage change in Hicksian welfare (income) of labor-endowed traditional households (WT), and capital-endowed entrepreneurial households (WE), from the eight counterfactual scenarios.

Table 5.3. Economic Agents' Change in Welfare

		BIF	BIH	BWF	BWH	NIF	NIH	NWF	NWH
	Benchmark	Scenario1	Scenario2	Scenario3	Scenario4	Scenario5	Scenario6	Scenario7	Scenario8
WT	1	170%	167%	175%	173%	3%	2%	5%	4%
WE	1	-58%	-84%	-54%	-81%	36%	-5%	38%	-3%

Where:

Scenario 1 = BIF = Resource-Boom, Investment, Flexible Firms
Scenario 2 = BIH = Resource-Boom, Investment, Inflexible and High Cost Firms
Scenario 3 = BWF = Resource-Boom, Welfare, Flexible Firms
Scenario 4 = BWH = Resource-Boom, Welfare, Inflexible and High Cost Firms
Scenario 5 = NIF = Benchmark Resources, Investment, Flexible Firms
Scenario 6 = NIH = Benchmark Resources, Investment, Inflexible and High Cost Firms
Scenario 7 = NWF = Benchmark Resources, Welfare, Flexible Firms
Scenario 8 = NWH = Benchmark Resources, Welfare, Inflexible and High Cost Firms

Figures 5.1 and 5.2 correspond to the decision trees first presented in figures 4.8 and 4.9. The data in table 5.3, contained in figures 5.1 and 5.2, represent the payoffs facing the two decision problems defined in chapter 4. From these figures, the dominantly preferred outcome is easily identified. In figure 5.1, society's best case

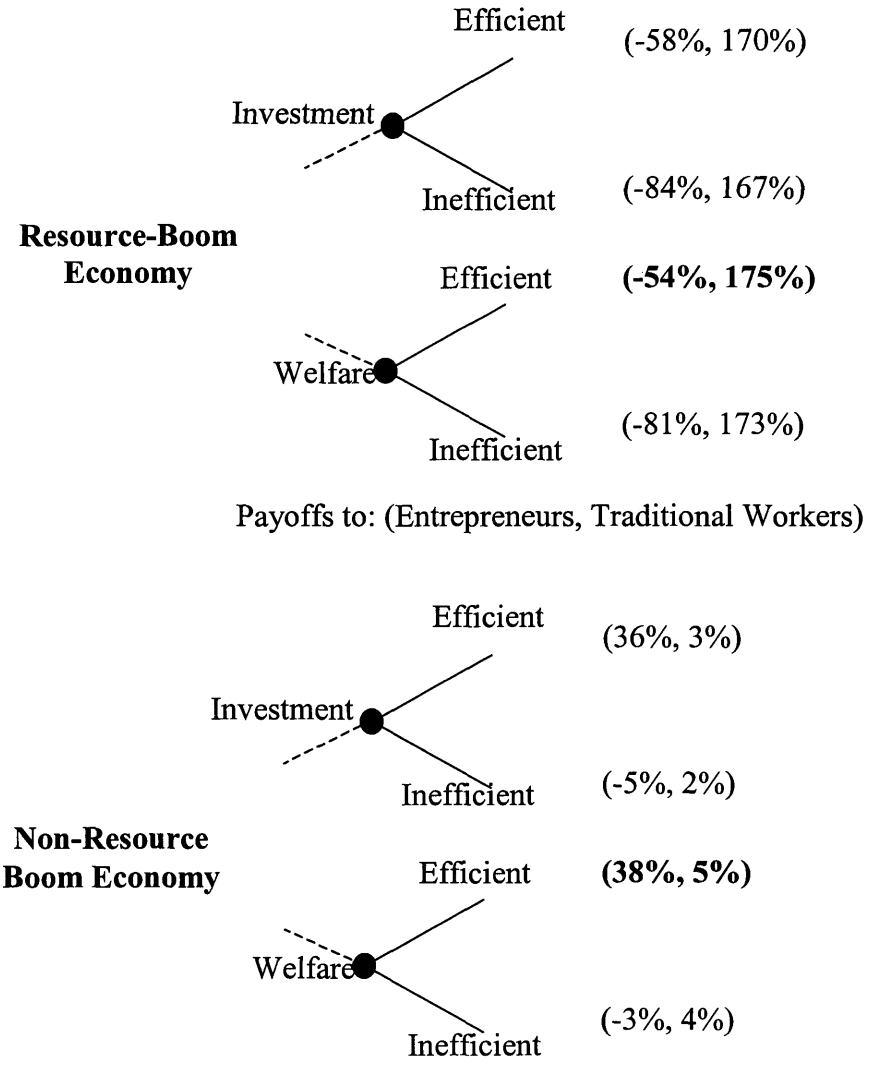

Figure 5.1. The Investment Regime vs. Welfare Regime Decision Tree

(Dominate outcomes are shown in bold)

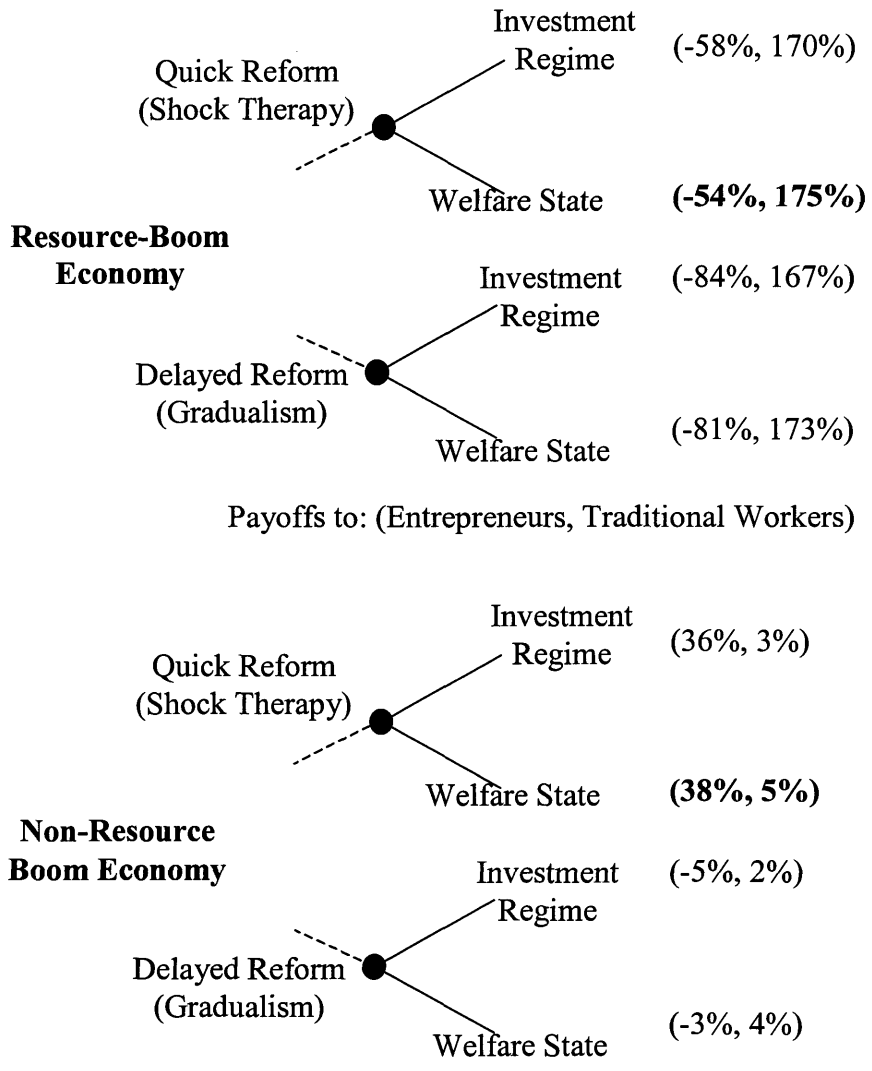

Figure 5.2. The Rapid Reform vs. Delayed Reform Decision Tree

(Dominate outcomes are shown in bold)

occurs where both welfare and efficient firms are possible. Additionally, society's worst case occurs where the government chooses invest policies, yet firms remain inefficient. In figure 5.2, society's best case occurs where policy makers choose quick-reform policies and a pro-welfare regime ends up with the majority vote. Additionally, society's worst case occurs where policy makers choose policies of delayed privatization, and a pro-investment regime ends up with the majority vote.

As mentioned in chapter 4, these best case scenarios reflect the policy makers' preferred outcome given normative expectations. The choices analyzed in the decision problems represent strategies based on the positive perceptions about the current or future state of the world and expected utility maximization. For example, in the investment vs. welfare decision problem, policy makers recognize that an economy characterized by efficient firms is preferable to an economy with inefficient firms. However, the choice in the decision problem considers the probability of obtaining efficient firms when faced with the cost of obtaining inefficient firms. The ultimate policy choice is then based on the expected outcome rather than the preferred outcome. The results of the two decision problems are presented in the following two sections.

The Investment vs. Welfare Decision Problem

As previously developed, there are four relevant players in our economy: two principals (entrepreneurs, and traditional workers), and two agents (politicians, reformers). In seeking to maintain political control, politicians and reformers promote policies designed to maximize the welfare of their respective constituents. In the first decision problem, the political agents choose between policies of capital investment or welfare. The uncertainty concerns the relative efficiency of firms immediately following privatization.

Politician's Dominant Welfare Choice

Politicians can either choose to invest or spend. The cost to the politician of adopting policies of capital investment is the loss of the more direct benefit to their constituents of welfare subsidies. Spending on welfare is a less risky method of achieving their objective. Subsides have an immediate short-term benefit on the well-being of society. For example, they may be used to provide an adequate social safety net in anticipation of layoffs. The benefits from investment, on the other hand, become apparent in future generations. Additionally, investment may altogether fail and realize society zero benefit if, for example, the investment is misdirected. The classical response would be to suggest that it is unrealistic to expect the same government that created the inefficient cost structure to correct it.

The benefit of welfare over investment for labor-endowed households is shown in table 5.3 by comparing investment scenarios (1 and 2) to the welfare scenarios (3 and 4) respectively. As the recipients of the subsidy, the results indicate that welfare is always better than investment for traditional workers in that the value of welfare exceeds the burden of inefficient firms. Traditional workers will choose welfare and inefficient firms (worst case for the reformer) over investment and efficient firms (the reformer's best case) as appears when comparing scenario 4 to scenario 1 and scenario 8 to scenario 5. Therefore, the traditional worker class prefers welfare regardless of the cost to the economy in terms of efficiency gains or losses.

Since the politician's constituents are traditional workers, the politician's dominant strategy is to choose welfare over investment regardless of whether this is perceived to result in efficient or inefficient firms.

The Reformer's Choice of Investment or Welfare

The reformer's choice is captured by using a Von Neumann-Morgenstern maximization of expected utility as previously defined in chapter 4. From equation 4.28, the results of the analysis are summarized in figure 5.3. Figure 5.3 contains the reformer's indifference curve. The line represents combinations of parameters γ and ε from which the reformer is indifferent to either policies of investment or welfare.

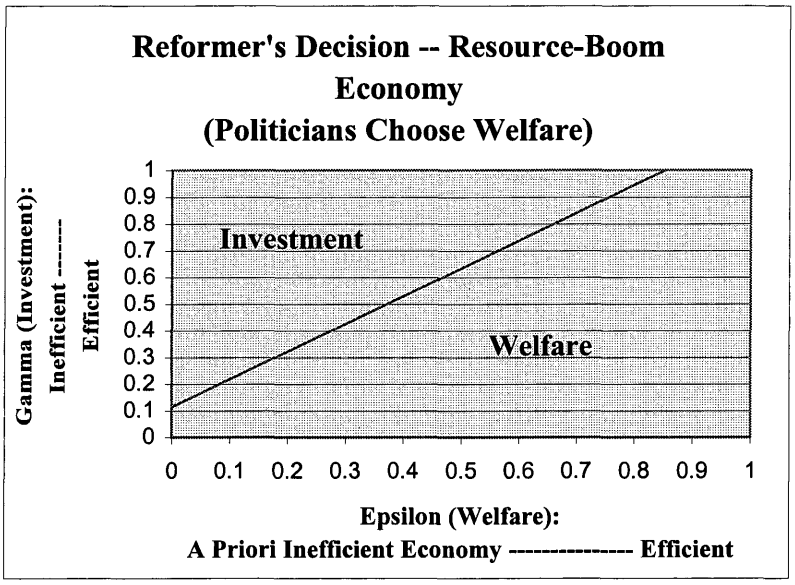

Figure 5.3. The Reformer's Choice in a Resource-boom Economy

The graph clearly indicates regions in which the reformer will choose between investment and welfare. Given high values of γ and low values of ε, the reformer will choose investment policies. Given low values of γ and high values of ε, the reformer will choose welfare policies. The parameter γ measures the expected outcome (efficient or inefficient firms) given the reformer's choice of investment. The parameter ε measures the expected outcome given the reformer's choice of welfare.

If the reformers choose investment, their concern is whether or not the investment funds will be effective in transforming firm level inefficiencies. The parameter γ is, therefore, measuring expectations about the effectiveness of investment funds. Low

values of γ indicate the reformer's expectation that investment will not be effective. High values of γ indicate the reformer's expectation that investment will be effective.

If the reformers choose welfare, their concern is whether or not the economy will end up burdened with inefficient firms following privatization. The parameter ε, therefore, measures the reformer's expectations about the efficiency of the economy prior to privatization. Low values of ε indicate the reformer's expectations of an inefficient economy prior to privatization. High values of ε indicate the reformer's expectations of an efficient economy prior to privatization.

Figure 5.3 can be updated with a priori information regarding the expected values of parameters γ and ε. If the intuitive outcome is considered, then:

$\gamma > 0.5$, and $\varepsilon < 0.5$,

where high values of γ indicates that investment is expected to result in efficient firms, and low values of ε indicates that choosing welfare is expected to result in inefficient firms. Given this a priori information, it is apparent that reformers will most likely choose investment, although the choice is not certain.

The Rapid Reform vs. Delayed Reform Decision Problem

As discussed in chapter 4, the GEM counterfactual results contain two interpretations of policy choice and policy outcome. In the second decision problem, policy makers are faced with deciding reform policy. They choose to either continue

privatization or delay privatization. The policy choice is synonymous with choosing between shock therapy or gradualism. The uncertainty facing policy makers concerns the eventual regime controlling government policy—an investment regime or a welfare regime.

Reformer's Dominantly Benefit from Efficient Firms

A key effect of privatization is the increase in the relative price of labor compared to capital—wage inflation. Privatization eliminates labor subsidies and transfers capital to capital-endowed households. Labor is therefore relatively more expensive and labor-endowed households receive more income. Additionally, as the relative price of capital falls, capital becomes relatively more productive. There is effectively more capital available to the economy. However, if an economy is unable to effectively reallocate factors because of a low capacity to transform, the extra capital will not be beneficially employed. When labor is the constraining factor, firms faced with an inefficient cost structure and an inability to transform face a dislocation of capital – entrepreneurs loose. The tight labor markets found in this study confirm Gelb (1988) who, in referring to resource-based windfalls, states, "In most countries, labor seems to have shared in the windfalls to a considerable extent. The spending effect tightened labor markets and raised employment" (p. 138).

The real burden of inefficient firms, therefore, falls on the entrepreneurs. In this model, efficiency is modeled as the ability of firms to respond to prices by substituting to low-cost factors. Inefficient firms are burdened by low capital-to-labor ratios, yet they are unable to shift away from more expensive labor. The result is wasted capital as full capital employment is constrained by available labor (note that in the actual model this is an underemployment of capital). Investment in this case exasperates the problem as the price of capital is driven down, yet the economy is unable to employ the low-cost factor. This effect can be best seen in the price for state capital (PKSX) as this sector is burdened by a Lenotiff technology structure. The relative price of capital is lower for the case of investment compared with the case of welfare for all cases as demand is unable to shift into the low-cost factor (compare scenarios 1 with 3; 2 with 4; 5 with 7; and 6 with 8). Inefficiencies in the economy, therefore, naturally benefit labor and harm capital.

Entrepreneurs and their political agents—the reformers—are therefore highly adverse to the possibility of obtaining inefficient firms. With inefficient firms, capital agents are burdened by capital that they cannot employ, and excess labor that has to be paid. Notice that the problem is not so much the extra labor, but the fact that there is not enough labor to fully employ capital.

The Politician's Choice of Rapid Reform or Delayed Reform

The politician's choice is captured by using a Von Neumann-Morgenstern maximization of expected utility as previously defined in chapter 4. From equation 4.30, the results of the analysis are summarized in figure 5.4. Figure 5.4 contains the politician's indifference curve. The line represents combinations of parameters δ and α from which the politician is indifferent to either policies of shock therapy or gradualism.

However, as with the reformer's choice in the previous decision problem, the graph clearly indicates regions in which the politician will choose between shock therapy and gradualism. Given high values of δ and low values of α, the politician will choose gradualist policies. Given low values of δ and high values of α, the politician will choose

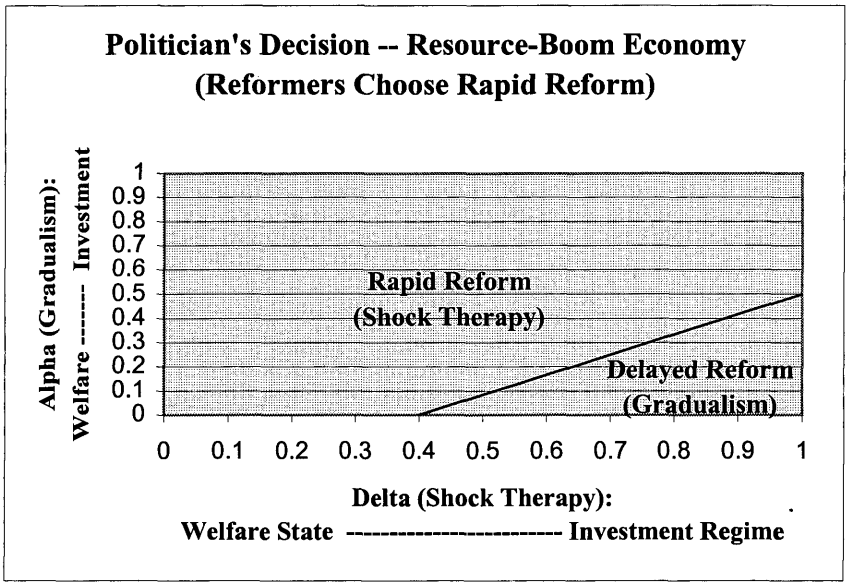

Figure 5.4. The Politician's Choice in a Resource-boom Economy

shock therapy policies. Both of the parameters δ and α measure expectations about the type of regime likely given the choice of reform strategy.

As with the previous decision problem, figure 5.4 can be updated with a priori information regarding the expected values of parameters δ and α. If the intuitive outcome is considered, then:

$\delta > 0.5$, and $\alpha < 0.5$,

where high values of δ indicate that choosing shock therapy policy is expected to result in an investment regime, and low values of α indicate that choosing gradualist policy is expected to result in a welfare regime. Given this a priori information, politicians are much less likely to choose policies of shock therapy. However, the choice between shock therapy and gradualism is indeterminate. Politicians will support continued privatization up to the point where it is apparent that supporting shock therapy will result in an investment regime dictating future government policy. Additionally, if the politicians perceive that the best chance of obtaining a welfare state is by promoting gradualist reform policies, they will choose to delay privatization.

The Decision Problem Summary

The results from the two decision problems indicate that the reformers will always prefer policies of quick reform consistent with shock therapy. However, reformers may

prefer policies of either investment or welfare depending on their expectations regarding the effectiveness and need of investment expenditures. If the reformers perceive that government investment policies will likely fail, or if they perceive that government investment policies are not necessary, they will prefer welfare policies to investment policies. When updated with a priori expectations the results indicate that the reformers are more likely to prefer investment policies to welfare policies. Reformers, therefore, dominantly prefer shock therapy and are likely to prefer investment policy.

Politicians, however, will always prefer policies of continued social welfare. Additionally, politicians may promote continued privatization, consistent with shock therapy, or promote delayed privatization, characterizing gradualism, based on their expectation about the likely regime resulting from reform policy. The politicians will support continued privatization up to the point where it is apparent that a shock therapy policy will result in an investment regime. Additionally, if the politicians perceive that the best chance of obtaining a welfare state is by promoting gradualist reform policies, they will choose to delay privatization. When updated with priori information, the results indicate that the politicians are more likely to prefer gradualist reform policies. Politicians, therefore, dominantly prefer welfare and are likely to prefer gradualist reform policy.

The results indicate, therefore, that the reformers and politicians are likely to promote conflicting objectives. However, the results are dependent on the expectations measured by the decision problem parameters.

Comparing Resource-Boom and Non-Boom Economies

When the strategies of politicians and reformers conflict, the dominant political party wins. As argued in chapter 4, ordinal welfare measures cannot be translated into popular vote. However, the relative magnitude of political strength is apparent. Clearly, given parameters γ and ε equal to 0.5, table 5.4 and the corresponding decision tree in figure 5.5 show that politicians are more likely to win in a resource-boom economy and reformers are more likely to win in a non-boom economy. The result is found in comparing the difference between the change in welfare of the reformer's constituents, and the politician's constituents. Recall from chapter 4 that reductions in the income of

Table 5.4. Von Neumann-Morgenstern Maximization of Expected Utility

(From parameters γ and ε equal to 0.5)

	Resource-Boom	Non-Resource Boom
Invest	-63%, 169%	28%, 3%
Welfare	-76%, 173%	5%, 4%
Payoffs to: (Entrepreneurs, Traditional Workers)		

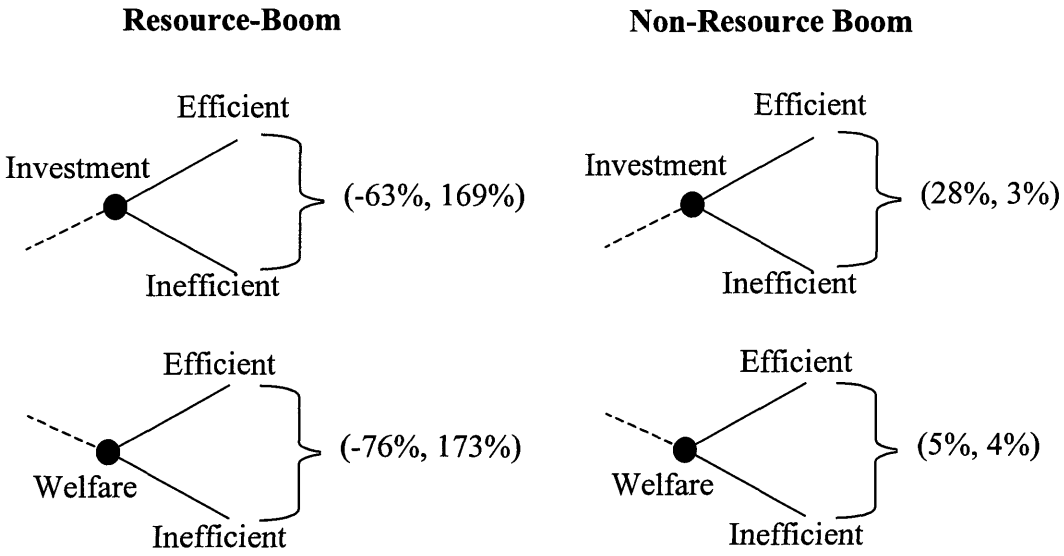

Figure 5.5. A Von Neumann-Morgenstern Aggregation Given Parameters γ and $\varepsilon = 0.5$

entrepreneurs effectively reduce the political strength of that constituent base through bankruptcies and loss or transfer of assets. In an investment regime, the entrepreneurs go from a 63% loss of income in a resource-boom economy to a 28% gain in a non-boom economy. In the resource-boom economy, the traditional workers are big winners when compared with the non-boom economy. In fact, the result is reversed in the non-boom economy—the gains to entrepreneurs exceed the gains to traditional workers.

When comparing the two outcomes, the reformer's position is clearly stronger in the non-boom economy. Countries without a booming resource-sector are more likely to choose to invest in capital replacement rather than welfare. They will choose a more

reformist approach as the political strength of the reformer is relatively stronger than that of politicians.

Table 5.4 and figure 5.5 represent a specific example where γ and ε are set equal to 0.5 indicating neutral expectations. The result is extended to the general case in figures 5.6 and 5.7. In these figures the resource-boom and non-boom results are plotted together. From figure 5.6, it is clear that reformers are more likely to favor policies of welfare in a resource-boom economy relative to a non-boom economy. Likewise, from figure 5.7, politicians are more likely to favor gradualist reform policies in a resource-boom economy relative to a non-boom economy.

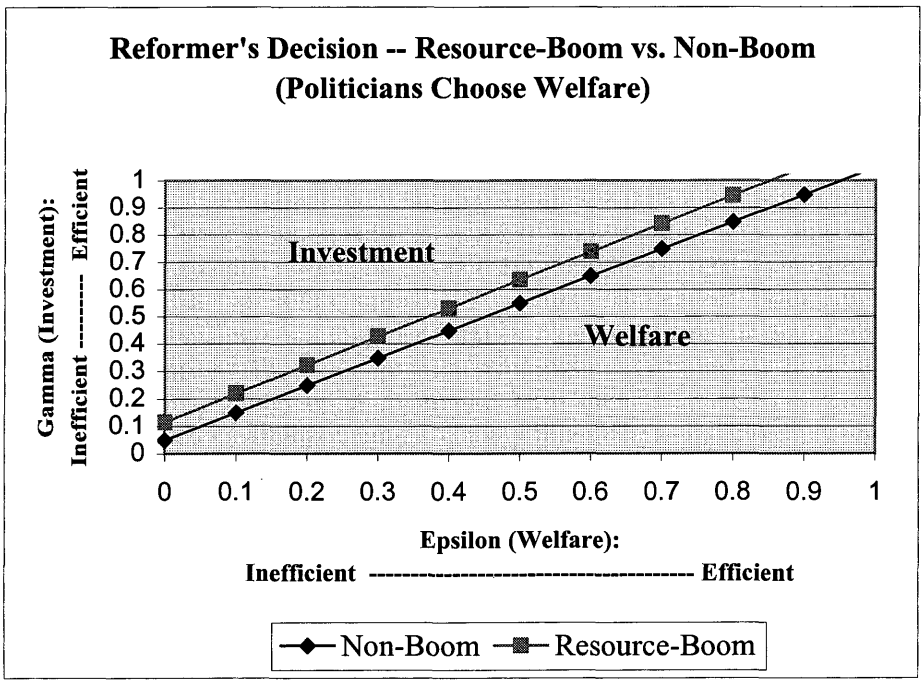

Figure 5.6. The Investment vs. Welfare Decision Relative to the Resource-State

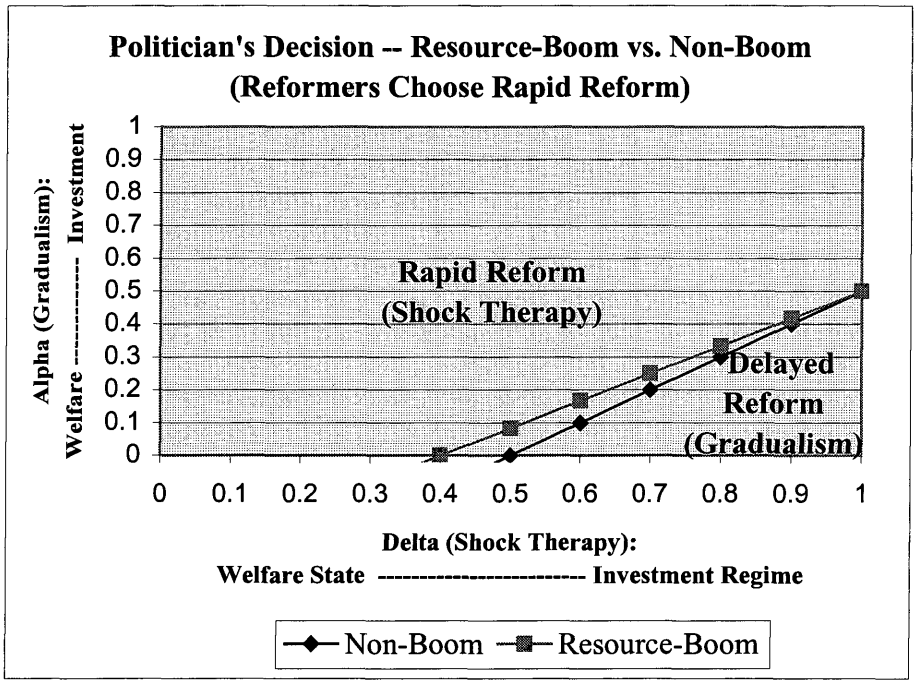

Figure 5.7. The Rate-of-Reform Decision Relative to the Resource-State

Inefficiencies of the State Controlled Tradable-Sector Are Naturally Mitigated

Clearly, the differing results between the resource-boom and the non-boom economies can be attributed to the Dutch disease. Dutch disease changes the political strength of reform-minded policy makers by reducing the strength of their constituent base—the entrepreneurs. In a resource abundant country such as Uzbekistan, the strength of the reformer's position is greatly reduced due to the natural, Dutch disease driven, reduction of the tradable-sector. This reduction will more likely result in policies of absorption and slow rates of privatization.

On the other hand, given an open economy, the inefficiencies of the state-controlled tradable-sectors are reduced as imports, which reflect the world efficiency, replace the inefficient state sector. Society's welfare remains strong due to the resource windfall as inefficiencies and price distortions are naturally mitigated through increased imports. Countries with fewer resource windfalls, conversely, are more likely to choose investment and rapid reform due to the relative strength of the reformers vs. politicians.

Reforming Countries will Experience a Collapse in Output

One further observation is the reduction in the economy's tradable output in the non-resource-boom scenarios. Notice from table 5.1 (see also figure 5.11) that the tradable-sector output dropped from 5.7% (in scenario 7) to 8.9% (in scenario 6) following a 20% privatization. Subsidies effectively lower the input costs faced by firms. Eliminating these subsidies effectively raises costs. Firms are required to raise prices to the extent of the magnitude of lost subsidies – price inflation. However, marginal firms are no longer competitive when faced with world imports. Furthermore, income and substitution effects captured in a general equilibrium framework change relative demand – both intermediate and final demand. A country without a booming resource sector will naturally see a collapse in the output due to loss of subsidies and resulting higher cost. The result can be stated as a theorem: Privatization results in a reduced GDP to the extent

of the pre-reform distortion of costs and the openness of the economy to import competition. The result should not be surprising. The failure of non-competitive enterprise is a natural characteristic of a free-market economy. Schumpeter (1934) notes that, "Because [entrepreneurial success] proceeds by competitively destroying old businesses and hence the existences dependent upon them, there always corresponds to it a process of decline, of loss of caste, of elimination."

The results additionally indicate that an economy such as the Czech Republic, characterized by a relatively small resource endowment and by what Balcerowicz (1997) identifies as "hidden treasures," or the numerous inherited conditions enabling them to "produce relatively more economic gain and less economic pain during the economic transition" (p. 162), is more likely to choose a rapid rate of reform then, for example, Russia, characterized by higher resource endowments and highly inefficient firms. Additionally, economies characterized by "hidden treasures" will experience a relatively smaller drop in domestic output than economies characterized by high price distortions. These economies "do well" by choosing their respective paths in that their choice is based on maximizing expected utility—be it through shock therapy or gradualism.

Capacity to Transform

This study clearly demonstrates the validity of neoclassical economics and the supremacy of market forces. Of course, such a result is not surprising considering the

nature of general equilibrium modeling. After all, the model is based on the foundational microeconomic variables of price and quantity, and the understanding that markets clear according to supply and demand. Yet, perhaps such a view of the world is exactly what is required to separate normative utopian ideals from positive economic principles. It is not surprising, therefore, that the most important contribution in determining government policy is related to how effectively the economy can respond to price signals.

Sensitivity analysis demonstrates that perhaps the single most important parameter impacting welfare is the substitution elasticities among competing products—what I have identified as input transformation elasticities. The parameter represents an environment that promotes quick and efficient free market movement of productive factors based on price signals. Government policies that prevent the free movement of factors will slow transition. For example, policies that disrupt ownership, property rights, and the ability to sell, transfer, and utilize private property, limit transition.

Recall from chapter 4 that two features were introduced to depict the difference between state, newly privatized, and entrepreneurial firms. These are 1) an inefficient cost structure whereby newly privatized firms inherit the state input factor ratios less subsidies and 2) a limited ability to substitute away from high cost inputs. Privatized firms are burdened by relatively high production costs and are limited in what they can do about it; and therein lies the key to successful transformation—what they can do about it. The ability to respond to price signals is captured by the input elasticity of

transformation. This variable demonstrates that regardless of the initial state of efficiency, if firms can quickly and effectively respond to price signals, the initial inefficiencies are quickly and effectively eliminated. The implication for quick reform strategies (shock therapy) for example, is that effectiveness is limited by the ease in which factors can be re-deployed to their marginally most efficient use.

Shock therapy suggests that by freeing all factors, society will reorganize itself in an efficient manner. This is true to the extent that society is able to respond to the price motive. In fact, industries, firms, or managers unable to transform may re-employ factors in the identical inefficient manner as prior to the disruption. If this were to happen, society would be burdened with the full cost of reform without any of the benefits. In considering the cost to society of disruptive factor reallocation, society's ability to transform will determine the magnitude of loss following shock therapy.

The results of the input transformation elasticity sensitivity analysis is presented in table 5.5. Table 5.5 focuses on the change in welfare in the traditional and entrepreneurial households (WT and WE) for the eight scenarios previously discussed. In this analysis, sigma represents the substitution elasticity of the newly privatized tradable activity sector (OX). The base-case value of sigma(OX) is 0.5 corresponding to the values of table 4.5—Tradable Sector Input Transformation Elasticities. The sensitivity analysis tests values for sigma(OX) of 0, 0.5 and 1. In table 4.5, state firms (SX) are characterized by sigma(SX) = 0, and entrepreneurial firms (EX) are characterized by

Table 5.5. The Impact of Input Transformation Elasticity on Welfare

		Sigma=0	Sigma=0.5	Sigma=1
Benchmark	WT	1	1	1
	WE	1	1	1
Scenaro 1	WT	2.689	2.698	2.692
	WE	0.311	0.424	0.512
Scenario 2	WT	2.651	2.67	2.68
	WE	0.113	0.165	0.419
Scenario 3	WT	2.748	2.754	2.748
	WE	0.337	0.458	0.545
Scenario 4	WT	2.705	2.727	2.736
	WE	0.126	0.187	0.449
Scenario 5	WT	1.027	1.027	1.027
	WE	1.362	1.364	1.365
Scenario 6	WT	1.034	1.018	1.005
	WE	0.491	0.952	1.183
Scenario 7	WT	1.051	1.051	1.052
	WE	1.382	1.382	1.381
Scenario 8	WT	1.06	1.042	1.029
	WE	0.497	0.969	1.197

sigma(EX) = 1. A sigma(OX) of 0 implies that newly privatized firms retain the state firms' lack of price responsive behavior. A sigma(OX) of 1 implies that newly privatized firms are as responsive as entrepreneurial firms.

Welfare increases as sigma increases in all cases except for the traditional worker class in scenarios 6 and 8. In scenarios 6 and 8, traditional workers benefit from the inefficient cost structure because firms are unable to substitute away from the high cost factor (i.e. there are no layoffs). As capacity to transform improves, firms demand less labor and employ capital. Non-resource-boom scenarios 6 and 8 correspond to the resource-boom scenarios 2 and 4. However, although the same structural movement is working in scenarios 2 and 4, firm level substitution does not reduce the welfare of traditional workers as shown in scenarios 6 and 8. In the resource-boom scenarios, labor markets are very tight due to the strength of the resource and service sectors. The improved efficiency of the labor market in the resource-boom scenarios increases the overall demand for labor, whereas the overall demand decreases in the non-boom scenarios.

The most dramatic change is that of capital welfare shown in scenarios 6 and 8. Improved efficiency modeled by the sensitivity analysis allows employment of capital factors that would otherwise remain unemployed. At some point, privatization becomes welfare-improving for entrepreneurs. Privatizing inefficient firms results in a dramatic welfare loss for the owners of the newly privatized firms. However, although both are

equally price responsive, entrepreneurs would still prefer entrepreneurial firms to equally efficient newly privatized firms as shown by comparing scenarios 1 and 2, 3 and 4, 5 and 6, and 7 and 8. Although newly privatized firms are equally price responsive in this case, recall that they still face a high cost structure due to the loss of labor subsidy. However, these firms are better able to compensate for the loss of the subsidy through price responsive substitution.

Entrepreneurial firms are inherently characterized by relatively high input transformation elasticities. Governments can take advantage of this inherent feature by designing policies to promote growth of the entrepreneurial class. Other policies should be designed to assure factors find their most effective employment regardless of ownership issues. From the results suggested here, it seems that an economy's capacity to transform is a major key in achieving successful economic performance. Unfortunately, very little literature is available to guide transforming economies in achieving high capacity to transform.

Karl (1997) for example, is one of the few studies to use a political-economic approach in accounting for the interaction between political institutions and economic development. Unfortunately, in Karl's "great structural determinist" view of the world, resource-boom economies are a priori doomed to "economic deterioration and political decay" (p. 5). Although she considers the interrelated parameters facing socio-political systems, by focusing on determinism, she fails to recognize the dynamic nature inherent

in a systems view of the world and fails to identify the parameters defining efficient and inefficient systems.[13] In her view, apart from changing the leading sector industry, economies have little say in their ability to establish self-sustaining, equitable, and stable development paths. By definition, open systems dynamically interact and respond to their environment. A country's ability to dynamically respond to a changing environment can be measured in its capacity to transform.

Although economists have yet to fully address the issue of capacity to transform at the country level, the huge management consulting industry has been developing the idea at a firm level for several decades. In management consultant lingo, the idea of capacity to transform has been called such things as high performance systems, learning organizations, the fifth discipline, and systems thinking. In fact, management consultants have become so adamant about the issue that management guru Tom Peters (1987) has suggested the need for a revolution of innovation. I would suggest a need for a transformation revolution. In the spirit of the 1998 revolutionary Taco Bell advertising campaign, I ask "Yo Quiero transformacion?"

Peters (1987) was one of the first authors to connect firm level efficiency principles to macroeconomic policy issues. In his book *Thriving on Chaos: A Handbook*

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[13] A systems view of the world simply suggests that all (economic) activity is interdependent, and that efficient subsystems effectively respond to and interact with other subsystems and the larger systems as a whole. A systems view of the economics is consistent with general equilibrium analysis, especially when, in an open economy model, world activity is included in the equilibrium conditions.

for a Management Revolution, Peters outlines five keys to competitive resurgence—policies for "speeding the necessary transformation" (p. 32). He suggests, 1) Promoting more, not less, competition; 2) Retooling and involving the work force; 3) Stopping the mindless offshore job drift; 4) Pushing internationalism, and 5) Supporting expanded research and development. I don't think Peters should ever claim to be an economist since his first, second, and fourth recommendations directly contradict his third.

Although his policy recommendations need work, the firm-level principles he identifies are valid at the macro policy level as well. I would suggest that capacity to transform can be measured by how well countries reflect Peters's firm level "prescriptions." For firms to remain competitive, Peters recommends, 1) Creating total customer responsiveness by specializing, creating niches, and through product differentiation; 2) Pursuing fast-paced innovation by investing in applications (customer)-oriented small starts; 3) Achieving flexibility by empowering people by involving everyone and using self-managing teams; 4) Learning to love change through a new view of leadership at all levels; and 5) Building systems for a world turned upside down.

To map government policies onto these ideas requires only a few basic economic principles. First, in a market economy, Peters's "customer responsiveness" is economically equivalent to price responsiveness, as prices capture the tastes and preferences embodied in utility functions. "Fast-paced innovation" is equivalent to what I have identified as input transformation elasticity. This would include well-defined

property rights, full disclosure, and means of transferring property rights. "Flexibility by empowering people" refers to the tools necessary for private sector investment and development. In the case of resource-boom transitional economies, this includes all of the benefits accruing from the resource rents, including education, health, and welfare. "Learning to love change through a new view of leadership" refers to reducing government interference in market driven transactions. "Building systems" maps to a general equilibrium view of the economy whereby all of the individual pieces of the economy are interrelated, interdependent, and responsive to the economic environment. Taken together these ideas provide an overarching mantra guiding government policy.

An interesting corollary is the mapping of information onto the idea of input transformation elasticity. As mentioned in chapter 2, if a country has inefficient firms, a learning curve is required for these industries to respond to price signals. This learning curve, or process of learning by doing, has also been studied in organizational development literature. Senge (1994), in describing his idea of the fifth discipline, suggests that becoming a learning organization "helps us to see how to change systems more effectively, and to act more in tune with the larger process of the natural and economic world" (pp. 6, 7). He further states, "In the long run, the only sustainable source of competitive advantage is your organization's ability to learn faster than its competition. No outside force can take the momentum of that advantage away from you" (p. 11). This ability to learn is a "deep learning cycle" whereby,

> Team members develop new skills and capabilities which alter what they can do and understand. As new capabilities develop, so do new awareness and sensibilities. Over time, as people start to see and experience the world differently, new beliefs and assumptions begin to form, which enables further development of skills and capabilities. This deep learning cycle constitutes the essence of a learning organization—the development not just of new capabilities, but of fundamental shifts of mind, individually and collectively (p. 18).

So with transitional economies, a certain synergy is possible if government policies are focused on creating an environment of learning and adapting to competitive markets. This idea is further developed in the next section.

Specialization According to Comparative Advantage

A third result of this study is found in observing society's costs from the perspective of world prices. The model exogenously establishes world prices as the numeraire, and all prices are interpreted relative to world prices. Notice from table 5.1 that, consistent with choosing world prices as the numeraire, the price of foreign exchange (FX), the price of tradable commodities (PX), and the price of resources (PR) remain equal to one in the counterfactual studies. Traditionally, when economists have described Dutch disease, they have pointed to the effect the resource-boom has on the exchange rate as the reason for the collapse of the tradable-sector. As the local currency appreciates, domestic goods become more expensive relative to foreign goods. The suggestions that follow from these studies are intended to insulate the economy from

exchange rate appreciation as a method of protecting the tradable-sector (see, for example, the studies reviewed in chapter 3).

My study suggests that independent of exchange rate appreciation, the economy will face shifting relative costs between sectors that effectively change the optimal domestic production mix. Traditionally, economists assume homogeneity of degree zero in prices and income when describing the neutral effects of price changes. In a closed economy, as income and prices change, supply and demand remain unchanged. However, given a ceterus paribus constant exchange rate, in an open economy the tradable sector is constrained in raising prices because of competing imports. In figure 5.1, PX (the price of tradable output) is fixed at 1 in the counterfactual scenarios. While the price of tradable goods remain equal to 1, the price of services increase. From figure 5.1 PS (the price of services) increase by over 50% in the counterfactual scenarios.

Further, because of the open economy output-price constraint, the costs faced by the tradable-sector increase relative to the service and resource sectors. As seen from table 5.1, a resource-boom economy experiences a shift in relative prices compared to a non-boom economy. The resulting structural shift away from the tradable sector into the resource sector is the result of specialization into comparative advantage. From table 5.1, as the booming-resource sector expands, wages (PL) increase 100% relative to foreign exchange. In the non-resource-boom case, wage rates fall as the economy contracts following privatization. Consistent with increased demand resulting from wage inflation,

the aggregate service prices increase around 60%. The price of imports is reflected in the price of foreign exchange—the numeraire. Imports become less expensive and increase dramatically. However, because of the resource-boom exports also increase dramatically. In fact, the increase in exports is over twice the increase in imports.

Additionally, from figure 5.1, consistent with shifting relative costs, imports dramatically increase. The economy is specializing according to comparative advantage. The low-cost resource sector is expanding and supplying foreign markets, and the high-cost tradable manufacturing sector is contracting as lower cost foreign markets are supplying domestic demand. And all the while this is happening, society's welfare is increasing as consumption moves beyond the domestic production possibility frontier.

Understanding the implications of changing relative costs is critical in order to understand the implications of Dutch disease. In a resource-booming economy, the costs of the tradable-sector increase relative to the costs faced by the service and resource sectors. Therefore, *the observed structural shift resulting from a booming resource sector is consistent with what would be expected when an economy specializes according to comparative advantage.*

The economic law of comparative advantage originated with the work of David Ricardo in 1817. In his book *On the Principles of Political Economy and Taxation*, Ricardo described the potential gains from specialization and trade,

> Two men can both make shoes and hats, and one is superior to the other in both employments; but in making hats he can only exceed his competitor

> by one-fifth or twenty percent, and in making shoes he can excel him by one-third or over thirty percent; will it not be for the interest of both, that the superior man should employ himself exclusively in making shoes, and the inferior man in making hats?

In other words, mutually beneficial exchanges are possible whenever relative production costs differ prior to trade. Factor mobility, both domestically and internationally, reduces the opportunity costs that result from these differences in production costs. Byrns and Stone (1993) point out, "Opportunity cost guides us to comparative advantage: *Individuals and nations gain by producing goods at relatively low cost and exchanging their outputs for different goods produced by others at relatively low cost* [italics added]. All potential trading partners can gain enormously through appropriate specialization and exchange" (p. 36).

For the same reason that trade according to comparative advantage is welfare improving, so unconstrained exploitation of resource endowments is also welfare improving. Being the low-cost producer of resources, any action other than production of these would be welfare reducing. If, for example, a country were to proceed with trade barriers designed to protect its tradable-sector, resources that should specialize according to comparative advantage by being best utilized in the resource or service sectors are forced to remain in an artificially supported high-cost sector.

Attempts to Protect the Tradable-Sector Are Always Welfare Reducing

Attempts to protect the tradable sector are always welfare reducing as productive factors are moved away from the low-cost activities. In a general equilibrium model, a solution by definition is Pareto-optimal given the constraints embedded in the model. Movement away from the optimal is welfare reducing. Recall from figures 4.5 and 4.6 that artificially reallocating factors into marginally less productive use causes a reduction in the society's production possibilities frontier.

Bhagwati (1988) links optimal employment of productive factors to private sector initiative. Bhagwati uses the terms "prescriptions" and "proscriptions" to identify countries that encourage or stifle private sector initiative. In his study, proscriptive governments will "tend to stifle technical change and entrepreneurial activity and hence hurt growth" (p. 99). "Prescriptive governments, in contrast, appear to work in a symbiotic relationship with private entrepreneurs" (p. 100).

Bhagwati makes a significant contribution to the anti-projectionist arguments by introducing the concept of directly unproductive profit-seeking (DUP) activities. DUP activities are those that, "use resources and produce income but zero output" (p. 104). These activities produce a positive shadow or social cost of productive factors withdrawn from productive use—conventional deadweight loss. This same idea applies directly to arguments for adopting policies to "protect" the lagging sector in a resource-booming economy. Bhagwati demonstrates that proscriptive governments will induce more

directly unproductive rent-seeking (DUP) activities than prescriptive ones, causing production possibilities to shrink (or expand less rapidly) because of the wasteful use of resources.

Bhagwati's ideas map directly onto the concepts of capacity to transform, and the deadweight loss associated with an incapacity to transform. An economy's capacity to transform is a measure of the ease in which the economy adjusts to price signals and optimally uses its factors in productive activity. Optimally, factors are allocated up to the point where factor marginal productivities are equal across the economy—the point identified in a general equilibrium framework. Arguments that suggest the possibility of welfare-improving government intervention must account for the very real deadweight loss such intervention produces. Arguments that suggest policies of lagging sector protection fail to address the issue of deadweight loss, let alone attempt to measure it. Clearly, the magnitude of loss depends on the difference between the marginal factor productivity of the market equilibrium and the artificially distorted equilibrium.

I am suggesting that governments should not attempt to protect tradable-sector firms from the ravages of comparative advantage. This is difficult for many to accept. However, note what I am not saying. I am not suggesting that countries intentionally fall behind the world leaders in value-added production. I am suggesting that the government provide every means available to help their economy find their low-cost comparative

advantage industries. Such policies are consistent with the idea of a high capacity to transform. Note, however, that the timing of transformation is also market driven.

As an illustration for example, here in Golden, Colorado, our city prides itself in its mineral boom heritage. In the late 1800s, labor and capital flowed into the region to support the mineral extraction effort. Today, the town boasts a lovely quilt museum. During the boom years, economists would not have suggested policies to shift labor from mining to quilt production simply because of some foresight of the sustainable value of quilts (for the quilt museum) and the eventual exhaustion of the mineral reserves. Yet this is exactly the approach taken today by those who would suggest transferring factors from the low-cost resource sector to artificially support a high-cost tradable sector.

Here in Golden, most of the miners have long gone, and today several world-class tradable products are produced. Furthermore, these firms have developed according to the price signals of Smith's invisible hand, without the assistance of substitution policies or protective government intervention. Simple economics lets us know when factors should shift. When the marginal factor productivity of producing quilts exceeds that of producing gold, factors will naturally shift from gold to quilts.

One conclusion is to let the market take its turn. Competitive industries will naturally develop according to prices, marginal productivities, and costs over time. Another conclusion is that regardless of measuring the absolute magnitude, any action that moves factors away from the competitive equilibrium is welfare reducing. Any

argument that suggests sustainability requires moving resources must account for the resulting dead weight loss in demonstrating long-term gain.

Kindleberger (1962) links sustainable development with a country's capacity to transform. He identifies a pattern whereby traditional societies, characterized by an historical and cultural predisposition against change, eventually adopt "once-and-for-all" technical change. These societies move from one traditional society to another, "but one in which a world of change would ultimately turn against." Kindleberger (p. 103) goes on to explain the need for a price responsive pattern of investment. Resources are invested, "*so that they earn the same at the margin in all industries; and an increment of resources should be invested in export, import-competing, or domestic industry depending upon the relative rates of return in each*" [italics added]. A non-transforming society, however, will go on investing the incremental resources in the traditional sector—even when that sector becomes comparatively unprofitable. Kindleberger (p. 103) further states,

> Incapacity to transform may lead to disaster at an earlier stage as a consequence of trade. When trade begins, cheap imports may impinge on a domestic sector engaged, as in early India, in the production of cloth. The price of cloth falls. According to the free-trade model, the factors engaged in cloth production should shift into other more remunerative occupations, with the country as a whole faring better as a result of trade. But they may know no other possibilities. For a time they go on producing at a loss, and finally they are wiped out.

My results clearly demonstrate that natural resource exporting countries can gain from the exploitation of their resource sector. According to the theory of comparative

advantage, the economy should incrementally move toward its low-cost sector—in this case the natural resource sector. The economy can do no better, and any policies that would prevent factors from moving to this sector reduce society's best. The theory of comparative advantage would again suggest that following resource exhaustion, factors would then naturally migrate to the next low-cost sector. The efficiency by which a society can exploit comparative advantage is directly related to Kindlberger's concept of capacity to transform.

How is it then that economists can make suggestions such as Askari, et al. (1997) who state, "The clear policy indication of a depletable resource-based economy is to attain growing export diversification from oil" (p. 24), and further suggest that these countries stop real exchange rate appreciation (to protect exports) through reduced domestic expenditures, or through the introduction of tradable-sector subsidies (p.26)! Krugman (1987) suggests diversification into competitive non-mining tradables, "thus protecting non-mining sector from once-for-all closures." Auty (1988) has noted such diversification as being consistent with sustainable long-term development (p. 23). What I have identified as specialization according to comparative advantage, structuralists have labeled the "negative" affects of Dutch disease, and the mineral sector's potential to inflict "structural damage."

These studies have purported to find a negative link between an economy's performance and its leading sector industry. Traditionally they have relied on GDP

growth as a proxy for economic performance. The explanatory variable is some variation of the leading sector industry, and the dependent variable is GDP growth. *This is a mis-specification*. When comparing a mineral or resource-based economy's performance with the performance of an export-based economy, *GDP growth cannot be used as a proxy for welfare.* As suggested in chapter 2 in discussing Davis (1995), the correct specification would account for welfare effects associated with the booming-sector. The benefits of a natural resource sector include wages, intermediate demand, infrastructure directly supporting the natural resource industries, multiplier benefits related to wealth generation including consumer demand and related intermediate industries and taxes as well as windfall rents accruing to the government via royalties. These royalties are ultimately passed on to society in the form of dividends.

Sachs and Warner (1995), mentioned in chapter 2, is an example of this type of misspecification. It is clear from their study that the growth rates between resource-based economies and value-added export economies will differ. Resource-based economies grow at a slower rate—a result that Sachs and Warner conclude validates the resource curse thesis. However, they fail to include broader measures of welfare that may demonstrate the benefit of resource abundance. Here is a simple illustration of the fallacy of this approach. As an investor in securities, I am interested in receiving the highest return on my investment. If I have two stocks that I am considering purchasing, say for example, Texaco Corporation and Microsoft Corporation, I will naturally account for the

differences in how these two stocks will provide a return on my investment—one being a growth stock and the other returning a dividend. Why does Texaco return a dividend instead of retaining its earnings in an attempt to become a growth stock? Technically, companies choose to pay a dividend when the net present value of their investments by retaining the earnings will not exceed the private return that can be obtained by shareholders investing the dividends themselves. Practically, Texaco is limited in its ability to grow by the very nature of the industry. In real terms, they are limited by the size of proven reserves and the capacity by which they can extract the reserves. Microsoft, on the other hand, can always grow by adding additional product lines, expanding markets, or value-added product differentiation. Microsoft does well by retaining its earnings and reinvesting in growth.

Applying this idea to economies, it becomes apparent that comparing the growth rate of resource economies to the growth rate of export-based economies is like comparing apples to oranges. Like utilities and oil companies, resource-based economies face growth constraints. In fact, some countries, specifically OPEC countries, contractually limit their leading sector growth. And like Microsoft Corporation, export-based countries face numerous opportunities for leading sector growth. Comparing simple GDP growth rates of these two types of economies does not account for the dividends a resource-based economy obtains because of the limited growth potential of a

resource-based leading sector. Leading sector benefits are best accounted for by considering:

leading sector return = dividends + capital gains,

where dividends are synonymous with changes to the Hicks and Streeten (1979) basic needs indicators, and capital gains are synonymous with traditional changes in GDP.

This type of anti-resource bias is common in resource-boom studies. For example, Askari, et al. (1997) examine the low sustained growth of the group of states known as the Gulf Cooperation Counsel, consisting of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. Askari, et al. admit that these countries have maintained a huge per capita GDP. Because of oil revenue, the average per capita GDP went from $1,000 in 1970 to $12,742 in 1976. They further admit that, "Oil has financed a total transformation of economic life for the citizens of these countries and this at an unparalleled pace. Economic growth has been accompanied by a dramatic improvement in the welfare of the general population as indicated by almost any social indicator" (p. 2). These benefits, of course, include improved health, higher life expectancy at birth, and better education.

However, at a 1993 per capita GDP of $12,012, the authors' focus remains on the lack of GDP growth. They state that, "None of the GCC countries have been able to diversify their economies away from a preponderant dependence on oil. Wealth in the form of oil reserves has been run down with only a limited conversion into other forms of

wealth, such as productive economic assets necessary to guarantee future incomes and to create the basis for future growth" (pp. 1, 2). Askari, et al. assume governments are motivated by some need to make productive investments or to achieve some normative sustainable value for future generations. Political agents are motivated by the self-serving objective of maintaining political control. Unless Adam Smith's invisible hand is working in the actions of government officials that will achieve these "politically correct" objectives—it will not happen. However, the lack of growth is exactly the Pareto-optimal behavior that classical economics would predict. The self-serving actions of politicians that allow the economy to specialize according to comparative advantage result in society accruing its maximum benefit from the resource endowment.

By focusing on the resource-boom effects, my results parallel the early gains experienced by the Gulf Cooperation Counsel. As pointed out by Askari, et al. (1997), the average per capita GDP of these countries went from $1,000 in 1970 to $12,742 in 1976. The following three figures, 5.8 through 5.10, compare the total welfare effects of privatization for both the resource-boom economy and non-boom economy. These represent increasing percentage privatization over time (from left to right on the graph). Figure 5.8 plots the total welfare of the resource-boom economy together with the non-boom economy, and assumes that the rate of privatization is the same in both. Figure 5.9 plots the total welfare of the resource-boom economy, and figure 5.10 plots the total

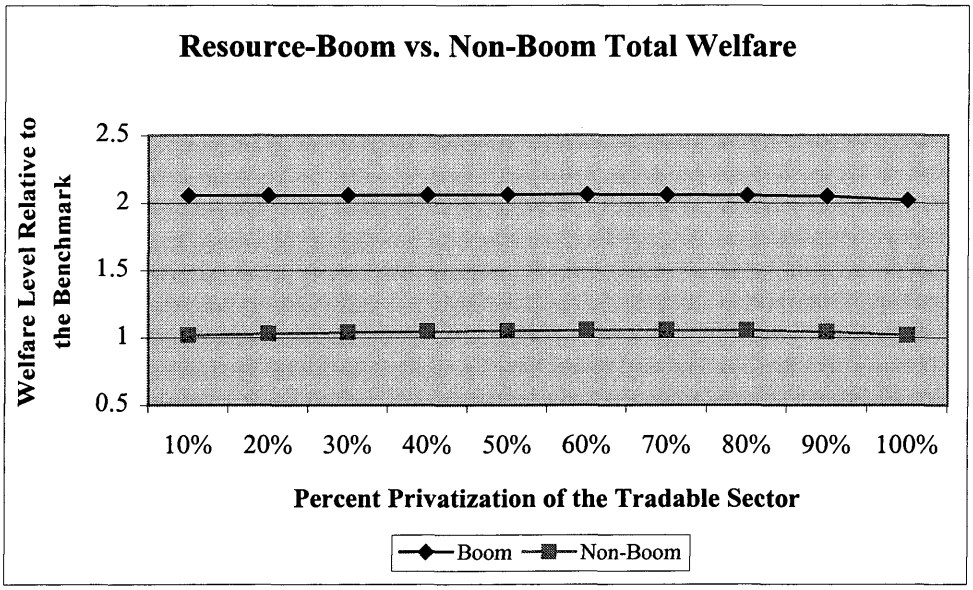

Figure 5.8. A Comparison of the Total Welfare Gains

welfare of the non-boom economy.[14] These three figures are based on scenarios 1 and 5, which assumes successful investment in firm-level restructuring. The figures indicate that the resource-boom translates directly into increased welfare. In this case, the 100% productivity growth experienced by the resource sector contributes to a greater than 100% increase in total welfare. As previously noted, Askari, et al., in referring to the Gulf States, comments that, "Oil has financed a total transformation of economic life for the citizens of these countries and this at an unparalleled pace."

[14] Total welfare is the sum of the weighted consumer welfare. The consumers, in this case, are traditional and entrepreneurial households, and government. Each is weighted by the percentage of society's total income each receives.

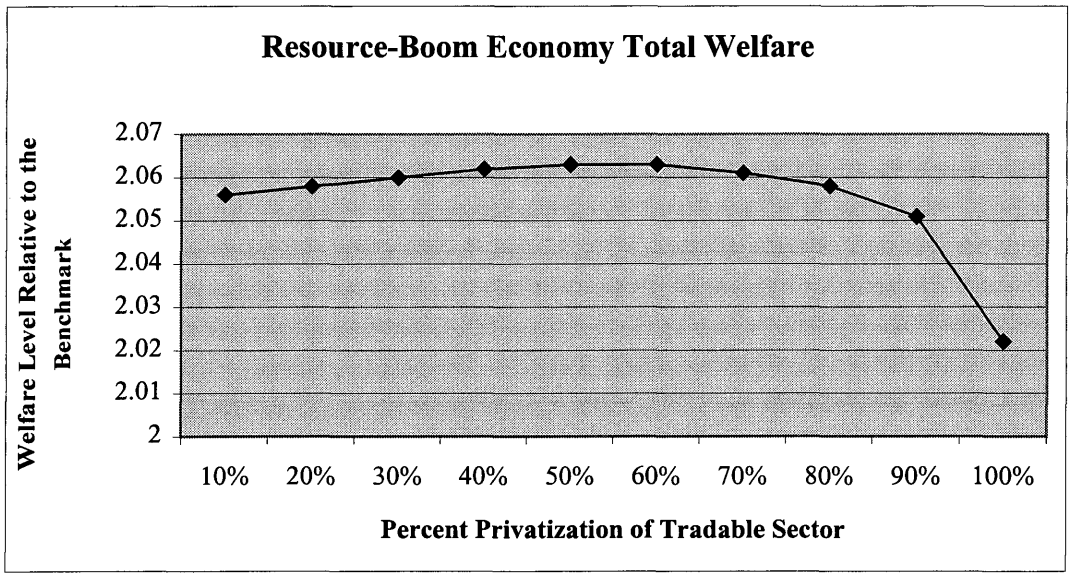

Figure 5.9. The Total Welfare Gains from a Privatizing Resource-boom Economy

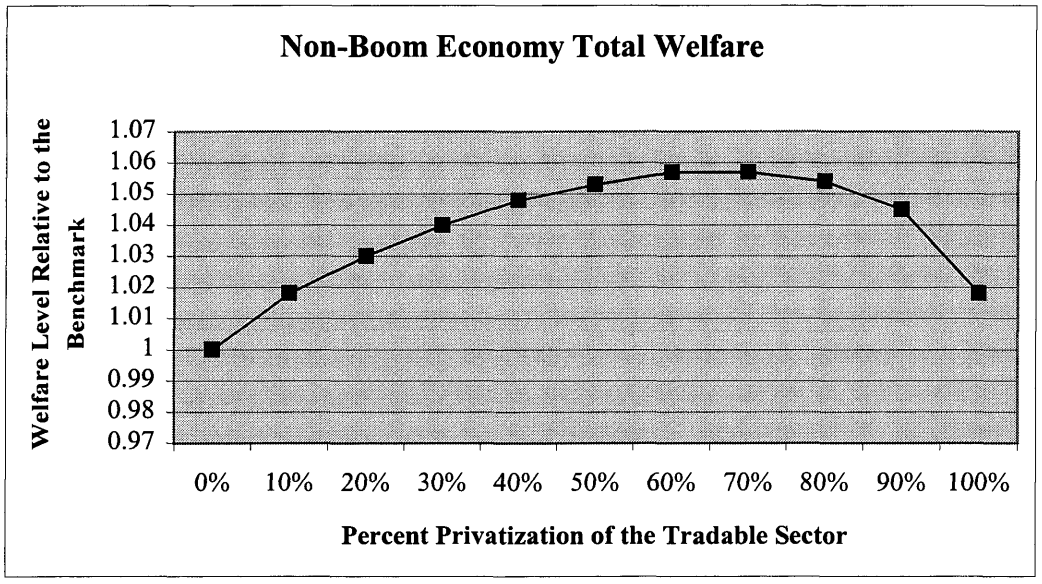

Figure 5.10. The Total Welfare Gains from a Privatizing Non-boom Economy

By considering the welfare gains, the same can be said for the resource-boom country in my study.

Notice in figures 5.9 and 5.10 that, although both economies grow from the efficiency gains due to privatization, clearly, given the same continuous rate of privatization, the non-boom economy grows at a higher rate relative to the resource-boom economy. This result further demonstrates the growth limits faced by resource-rich economies compared to non-resource economies. In this case, the magnitude of gains from increased tradable sector efficiency in the resource-boom economy is mitigated due to natural reduction of that sector. However, the resource-boom welfare is twice that of the non-boom economy. Clearly, growth considerations alone cannot be used as the sole determinant of social welfare. The absolute magnitude of gains attributed to the resource-booming sector must also be considered.

Deterministic sectoral development studies also break down by focusing on growth measures. These studies define capacity to transform as the ability to diversify away from a resource-based leading sector. Karl (1997), for example, takes a snapshot view of the world, finds that resource-based economies are not growing and concludes that resource-based economies have an inherent incapacity to transform. In fact, capacity to transform cannot be measured through a static view of the world. Capacity to transform can only be measured when an economy is faced with a change in its

comparative advantage from, for example, changes in world demand, trade distortions, or world supply. Capacity to transform is a measure of the economy's ability to respond to the change in marginal factor productivity. By setting up artificial markets, it may actually be the case that resource-based economies attempting to diversify away from leading sector activity are in fact inhibiting their capacity to transform. Such a result directly contradicts the sectoral conclusion. Further, resource-based countries that exhibit complete dependence on the leading sector, may be exhibiting a high capacity to transform, consistent with society's Pareto-optimal equilibrium according to comparative advantage.

One further point should be considered when comparing figures 5.9 and 5.10. Notice that in both figures the total welfare peaks and then drops as privatization approaches 100%. The result indicates that the initial efficiency gains from privatization are beneficial to society and that there is an optimal rate of privatization that less that 100%. The reason for this is that as the subsidies are systematically removed from the tradable sector, the sector's output declines. The relative decline in the tradable-sector output is shown in figure 5.11. The outputs of the resource sector (R), the services sector (S), and the tradable sector (X) are plotted together through increasing levels of privatization—from 0% to 100%. Losing the subsidy subjects the tradable sector to increased relative costs. As pointed out earlier, this result demonstrates that artificially

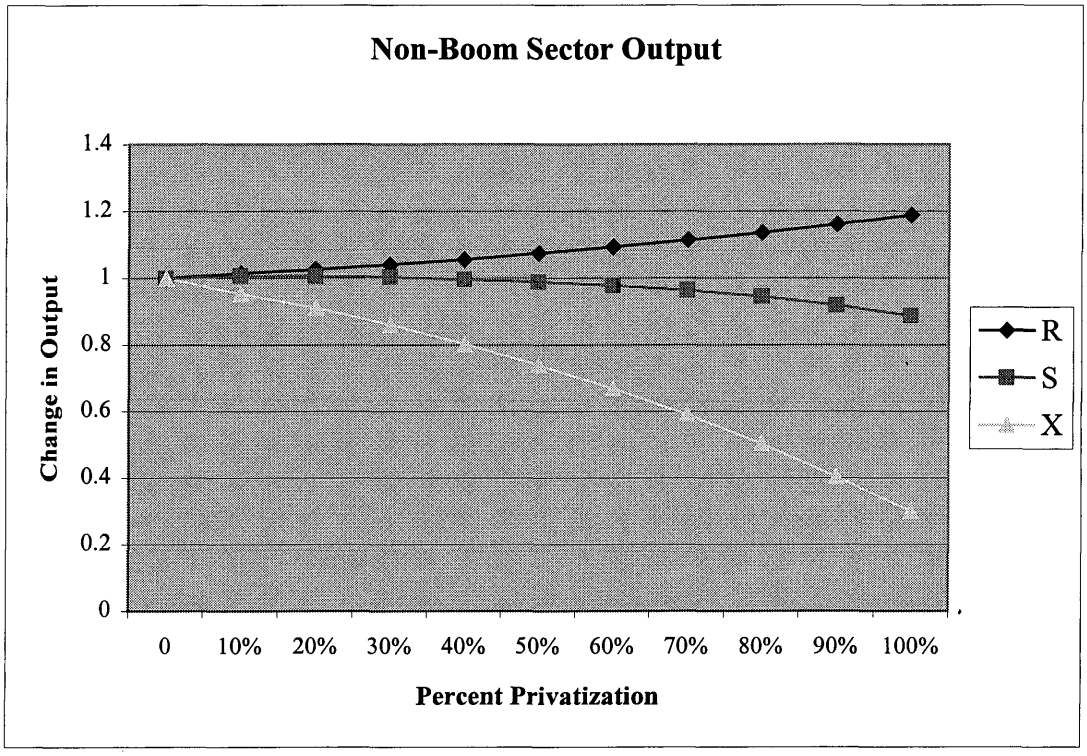

Figure 5.11. Sector Output through 100% Privatization of the Tradable Sector

supported industries will face a reduction in output when relative costs change through privatization. The result parallels the collapse in GDP faced by the former Soviet States at the beginning of the reform efforts. Eventually, the income loss associated with the collapsing tradable-sector can exceed the welfare gains associated with the privatization effort. At that point, the society's total welfare begins to fall.

The result clearly indicates that static gains are possible through privatization. However, it also seems that unabated privatization efforts characterizing radical shock therapy are to be avoided, in that the cost in lost output may exceed the benefits of

efficient industries. Rather, society's optimal welfare exists through measured reform and partial privatization characterizing the gradualist reform approach.[15]

Sustainable Resource Depletion

The term "sustainability" has been used widely in environmental circles to describe the need for wise use of natural resources. Pearce and Turner (1990) define sustainable development as "maximizing the net benefits of economic development, subject to maintaining the services and quality of natural resources over time" (p. 24).

This study contributes to the understanding of the mechanisms by which society's net present value of benefits is maximized. By structuring the problem as a principal-agent problem, and better identifying the motivations of agents, those agents who will maximize the resource value are clearly identified. Ultimately, it's the entrepreneurs who will determine the country's comparative advantage and create jobs in accordance with the best use of factors. Productive investment is best left to the agents motivated by profits rather than those motivated by political control.

Clearly, a proper amount of savings and effective investment is important for long-term economic growth. The next question is who is best able to invest the earnings

[15] The result is predicated on the unique characteristics of the 1991 Uzbekistan economy and the relative size of the tradable to the rest of the economy. If the tradable sector output were shown to increase with privatization, it is clearly possible that 100% privatization would be welfare maximizing.

associated with the booming resource sector. Returning to the stock analogy, we know that companies will choose to retain earnings or issue dividends based on the opportunity costs associated with investing the earnings. If a company can receive a net present value return on investment that exceeds the return associated with alternative uses by shareholders, the company will retain the earnings and forego paying dividends.

Now let's extend this idea to government policies. Let's say that a resource-boom economy's government can choose to either take an active role in investment policy (consistent with the advice of Sachs, Warner, Karl, and others) or they can return the resource rents to the people in the form of dividends. By recognizing the actions of government officials through a principal-agent motive, rather than through the profit motive, we understand that governments will invest without considering specialization according to comparative advantage or price signals and end up promoting rent-seeking development projects. For example, between 1945 and 1980, England heavily invested in nationalized industries in which England had lost its comparative advantage. The result of course was economic stagnation relative to the U.S. economy despite England's relatively higher savings rates. Politicians respond to the needs of their principals—the voting electorate. A government may choose to build a high-cost automotive factory in a region characterized by political unrest in order to gain political stability and encourage nationalistic pride rather than to earn profits.

Entrepreneurs, on the other hand are characterized by the profit motive. Operating under Smith's invisible hand, entrepreneurs, through self-interest, will find the most profitable application of factor resources—if the economic environment is characterized by a high capacity to transform. Furthermore, countries cannot determine a priori the most profitable application of factor resources until the time comes when relative factor productivities change. Attempts at doing so will most likely result in promotion of non-competitive industries that will require government protection for the life of the industry.

Furthermore, by maximizing the value of dividends entrepreneurial agents receive while the resource sector is the economy's low-cost activity, society is maximizing its ability to exploit the economy's next low-cost industry. The general equilibrium approach employed in this study demonstrates this ability through the efficiency realized by price responsive entrepreneurial activity when household endowments are maximized and factors are employed in their marginally most productive sector. By transferring resource rents to the private sector, the populace is more educated, healthier, wealthier, and generally more capable of finding the country's next comparative advantage industry, be it computer technology, heavy equipment, shipbuilding, TVs, wine, or cheese. The point is that governments cannot determine beforehand what the next comparative advantage industry will be, and attempts to promote industries via projectionist policies

will ultimately reduce the countries ability to respond to the next low-cost opportunity when comparative advantage eventually changes.

Porter (1990), after demonstrating the failure of government policies intended to promote domestic industries through export subsidies and import tariffs, suggests that, "Government policy should be directed toward a) encouraging domestic rivalry (which rewards success in lowering costs and improving quality), b) investing in human resources skills that enhance productivity, and c) emphasizing quality as a national priority" (pp. 36 and 37, in Byrns and Stone, 1993). These policies are consistent with creating an economy conducive to change, responsive to the (economic) environment, and adaptive to comparative advantage. Byrns and Stone (1993) further suggest that, "Government's major role in a capitalist economy is to establish who owns what and how ownership rights can be transferred" (p. 49). Governments should focus policies on encouraging an environment conducive to the free movement of land, capital, and labor through clearly defined property rights and transparent financial activity, so that the economy is given every opportunity to exploit comparative advantage. However, governments should not direct investment. Governments, no matter how well intentioned, will set up rent-seeking activities that create deadweight loss (Bhagwati's DUP activities) and ultimately prevent the most efficient use of productive factors.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

This study examines the role of natural resources in countries moving from a former Soviet planned economy to a market economy. Specifically, the study examines the effect of natural resource abundance in the privatization process through a computable general equilibrium model (GEM) of the 1991 Uzbekistan economy. By using a political-economic paradigm, the actions of transitional economy policy makers are better understood. Rather than traditional profit motives, reflecting the actions of firms minimizing costs, or consumers maximizing utility, this study utilizes a principal-agent explanation for actions of politicians. The actions of governments are better understood as the need to maximize political control (Downs, 1957).

Furthermore, when characterizing a transitional economy it is helpful to distinguish between those government agents who are pro-reform and those who are pro-status quo. Boycko et al. (1996), for example, divide policy makers in transitional economies into different classes. In building on Boycko my study divides policy makers into two categories—reformers and politicians. Both seek to maintain political control through appeasing their respective constituents. Reformers seek to appease entrepreneurs (shareholders), and politicians seek to appease traditional workers. The strength of each

voting class is observed through exogenous privatization modeled as the free movement of productive factors to entrepreneurial agents. The GEM counterfactual results are presented as eight payoffs in two decision problems between reformers and politicians.

While much can be learned by examining the interplay between reform-minded and politically-motivated policy makers, this study is specific in examining how a country's natural resource endowment affects the final outcome between reformers vs. politicians in the privatization process. The relative strength of these two voting classes is compared based on nature's endowment of natural resources—a country with few resources vs. a country with plentiful resources. Although the effect of resource abundance has been studied in relation to developing and least developed economies, my study is the first to examine how resource abundance affects transitional economies.

The input for the decision problems comes directly from the GEM output. The GEM output represents society's most desirable outcome. However, the best case may not be attainable because of the unique economic and political conditions active in a given transitional economy. Through varying the perceptions about the likelihood of attaining a given outcome, the decision analysis is used to capture these economic and political conditions.

Previous studies related to this theme broadly fall into three categories—literature related to privatization and reform, political-economic studies, and studies related to natural resources and growth. The literature that I reference related to privatization and

reform primarily focuses on the rate of reform, the role of the entrepreneurial agents in reform, or stylized facts used to model reform. Sachs (1993) argues on behalf of shock therapy, whereas Roland (1997) argues the virtues of gradualism. Pogodzinski and Antes (1992), and Patterson (1994) develop computable general equilibrium models to examine economic reform. Their work helps to identify structural features characteristic of a reforming economy.

Political-economic literature focuses on capturing the incentives of agents operating within the economy. Much of this literature seeks to better understand the incentives of politicians so as to model policy choice. Kay & Thompson (1986) and Boycko et al. (1996) focus on the agents active in a reforming economy and their incentives. Kennedy (1995) and Johnson and Loveman (1995) study the role of entrepreneurs in reforming economies. Kindleberger (1962) suggests that the ability to quickly and effectively respond to price signals determines an economies success. Downs (1957) introduces the incentives driving the actions of politicians.

Third, literature related to natural resources and growth primarily seeks to demonstrate the negative value of leading sector resource production. However, a few authors take the opposing view—that resource abundance is beneficial to an economy. Gelb (1988), Auty and Evans (1994), and Sachs and Warner (1995) build on the theme that abundant resources are detrimental to economic growth. Davis (1995), on the other hand, demonstrates the benefits of resource abundance.

My contribution lies in combining these three areas of study. Using a structuralist computable general equilibrium model my approach adopts a *political-economic paradigm*, identifies the various agents' incentives, and demonstrates that given these incentives, *the (Pareto optimal) rate of reform* will likely vary depending on *the amount of resource endowment*. The political-economic paradigm provides a more realistic scenario of reform than studies that have simply recommended normative corrective action is disregard of positive political realities. By understanding the political implications of free-market recommendations, the methods, timing, and sequence of reform can be better managed. Additionally, by understanding the affect of a country's resource endowment on the reform process, an optimism exists that regardless of the methods, timing, or sequences attempted, the many constraints facing policy makers are eased.

The results indicate that in a resource-abundant country such as Uzbekistan, the strength of the reformer's position is greatly reduced due to the natural, Dutch disease driven, reduction of the tradable sector because their constituents, the entrepreneurs, experience severe losses in the value of their endowments. This reduction will more likely result in policies of absorption and slow rates of privatization. On the other hand, traditional households' (workers) welfare improves because of the resource windfall as income rises and inefficiencies and price distortions are naturally mitigated through increased imports. Conversely, countries with fewer resource windfalls are more likely to

choose investment and rapid reform owing to the relative strength of the reformers vs. politicians.

By examining the sensitivity of the results to changes in structural variables, capacity to transform was identified as perhaps the single most important characteristic of a transitional economy in determining the success or failure of reform policies as measured by change in overall welfare. Capacity to transform measures an economy's ability to respond to market-driven price signals in allocating its factors of production to their marginally most productive employment. In my study, the entrepreneurs, who are highly price responsive, are characterized by high capacity to transform. The strength of the entrepreneurial class, therefore, is shown to be instrumental in directing a successful reform effort.

Pearce and Turner (1990) describe the role of government in welfare economics. They state that,

> The 'basic theorem of welfare economics' seeks to legitimize rational behavior as being socially desirable and also to justify some government intervention *to improve the conditions under which individuals make choices* [italics added]. Intervention would be especially justified whenever so-called market failures exist, i.e., when it is clear that markets are not maximizing collective welfare (p. 11).

Adam Smith (1723 -1790) argued that self-interested rational behavior by individuals operating in competitive markets could serve the interests of society as a whole. Governments, he argued, were important in providing "night watchman" services such as law and order, national defense, and education.

This study is in agreement with both of these interpretations of the role of government. Because they are motivated by profit maximization rather that political control, entrepreneurial agents, rather than government, are best suited to identify society's next low-cost product when comparative advantages changes from resource-based to export-based. This study therefore suggests that resource-boom governments should maximize the potential of entrepreneurs to identify comparative advantage by maximizing the social dividends of resource endowments and encouraging an economy characterized by a high capacity to transform.

Entrepreneurial firms are inherently characterized by relatively high input transformation elasticities (Kennedy, 1995; Johnson and Loveman, 1995). Governments can take advantage of this inherent feature by designing policies to promote growth of the entrepreneurial class. Other policies should be designed to assure factors of production find their most effective employment regardless of ownership issues. From the results suggested here, it seems that an economy's capacity to transform is a major key in achieving successful economic performance. Unfortunately, very little literature is available to guide transforming economies in achieving high capacity to transform.

Although economists have yet to fully address the issue of capacity to transform at the country level, the huge management consulting industry has been developing the idea at a firm level for several decades. In management consultant lingo, the idea of capacity to transform has been called such things as high performance systems, learning

organizations, the fifth discipline, and systems thinking. Research in firm level organizational development methods can provide guidance to reform minded governments in designing policies to promote capacity to transform. I have demonstrated that governments should promote policies that increase capacity to transform and exploit comparative advantage rather than promote policies that disregard comparative advantage.

Finally, consistent with capacity to transform, resource-boom economies experiencing the natural structural shifts attributed to Dutch disease, are better understood as specializing according to comparative advantage. Traditional recommendations designed to protect the tradable sector from shrinking are seen as socially detrimental, as these recommendations require factors of production to be artificially removed from their most productive employment.

Suggestions for Further Research

First, although I have suggested that countries can take advantage of the firm-level principles promoted by organizational development theorists in designing policies to promote an economy characterized by high capacity to transform, additional research is required to map these firm level principals onto policies available to governments. Organizational development theorists have developed programs designed to help firms improve their ability to respond to customer preferences and changing market

opportunities. In my study I have identified the need for countries to exhibit many of these same characteristics. At a country level the idea is captured in the phrase capacity to transform. Firm level organizational development theory can be used to help countries achieve a high capacity to transform.

Second, I have suggested that previous studies comparing economic performance of resource-boom economies with non-boom economies based on GDP growth, such as Sachs and Warner (1995), are misspecified. Because resource-boom economies are constrained in their leading sector growth, sometimes by capacity and reserve limits, sometimes, as with OPEC, by contract, and sometimes by the unique characteristics of the resource market, resource-based leading sector economies will naturally exhibit slower growth when compared with export-based leading sector economies.

Furthermore, I have suggested that a correct specification would account for the dividends resource-based economies accrue in welfare measures identified by Davis (1995). Further study is required to model these "basic needs indicators" in a computable equilibrium framework. The problem is in valuing these indicators because welfare derived from these is of normative value. Lal and Myint (1996, p.31) suggests:

> The "basic needs" advocates are right, in our view, in setting up an objective of poverty redressal in contrast with the distributivist objective [underlying other studies]. However, it is difficult to provide a rationale for the concern with the commodities and services included in the basic-needs bundles as ends in themselves. They are better looked at as being "instrumentally (rather than intrinsically) important." One way of looking at them is in utilitarian terms – as in Pigou's phrase "a national minimum standard of real income."

They argue that the basic needs are, therefore, a proxy for wealth. This argument is used to justify the use classical measures of wealth. Lal and Myint go on to conclude that "positive classical measures of wealth retain a primacy, general acceptance, and applicability across a diverse set of countries that normative neoclassical measures of welfare can never attain" (p. 34). However, discounting these dividends has led to research such as the Sachs and Warner study that inaccurately propagate an anti-resource bias. Further study is required to fully capture the value of these resource-dividends for comparing resource-boom economies with non-boom economies.

Further studies are required to determine whether a dynamic estimation of investment will alter my results. A dynamic estimation of investment is required to capture the benefit to future generations. In a dynamic model, the net present value of future gains in welfare from investment may offset the immediate gains from welfare. However, given the principal-agent motivation of politicians, future gains periods would be highly discounted in the dynamic model. Clearly, politicians benefit most from immediate welfare gains, and may not benefit at all from future gains if, for example, they lose power prior to realizing the gains. A dynamic estimation, therefore, should not alter my conclusions. However, this is yet to be verified.

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Appendix A

MPS/GE Syntax for the Example Model
M1-1S: Closed 2x2 Economy—A Quick Introduction to the Basics

```
$TITLE Model M1_1S: Closed 2x2 Economy -- A Quick Introduction to the
Basics

By Jim Markuson and Tom Rutherford (1995)

$ontext

November, 1995 (revised)

The Social Accounting Matrix

The starting point for many models is a balanced input social
accounting matrix (SAM).  Traditionally, SAMs are presented as square
matrices in which row i and column i refer to a single account.  In
the traditional SAM, rows correspond to receipts and columns are
expenditures.  A 9x9 SAM describes the benchmark equilibrium for the
first model we consider:
```

	PX	PY	PW	PL	PK	X	Y	W	CONS
PX								100	
PY								100	
PW									200
PL						40	60		
PK						60	40		
X	100								
Y		100							
W			200						
CONS				100	100				

```
Reading rows as receipts, we see from the first row of the SAM that
100 is spent on good X in sector W.  Likewise, reading across row 4
we see that 40 units of labor enter sector X and 60 units enter
sector Y.  SAMS can be quite detailed in their representation of an
economy, and they are also quite flexible.  All sorts of
inter-account taxes, subsidies and transfers can be represented
through an appropriate definition of the accounts.  (For an
introduction, see Pyatt and Round, "Social Accounting Matrices: A
Basis for Planning", The World Bank, 1985.)

For simple MPSGE models, it is convenient to use a rectangular SAM
format.  This format emphasizes how the MPSGE program structure is
connected to the benchmark data.  In the rectangular SAM, we have one
row for every market (traded commodity).  In the present model, there
are five markets, for goods X, Y and W and factors L and K.

There are two types of columns in the rectangular SAM, corresponding
to production sectors and consumers.  In the present model, there are
three production sectors (X, Y and W) and a single consumer (CONS).
```

The numbers which appear in a conventional SAM are typically positive, apart from very special circumstances. In the MPSGE SAM, there are both positive and negative entries. A positive entry signifies a receipt (sale) in a particular market. A negative entry signifies an expenditure (purchase) in a particular market. Reading down a production column, we then observe a complete list of the transactions associated with that activity.

The following rectangular SAM conveys the same information as the traditional square SAM presented above:

	Production Sectors			Consumers
Markets	X	Y	W	CONS
PX	100		-100	
PY		100	-100	
PW			200	-200
PL	-40	-60		100
PK	-60	-40		100

A square SAM is "balanced" when the vector of row sums equals the vector of column sums. A rectangular SAM is "balanced" when row and column sums are zeros.

Positive numbers represent the value of commodity flows into the economy (sales or factor supplies), while negative numbers represent the value of commodity flows out of the economy (factor demands or final demands). With this interpretation, a row sum is zero if the total amount of commodity flowing into the economy equals the total amount of commodity flowing out of the economy. This is market clearance, and one such condition applies for each commodity in the model.

Columns in this matrix correspond to production sectors or consumers. A production sector column sum is zero if the value of outputs equals the cost of inputs. A consumer column is balanced if the sum of primary factor sales equals the value of final demands.

In this simple model there are really only two produced commodities (X and Y), two factors of production (L and K) and one consumer (CONS). An extra column (W) and extra row (PW) have been introduced to represente aggregate consumption index and the corresponding price index.

```
$OFFTEXT

*       Next, we specify a general equilibrium model based on
*       this data using MPSGE syntax.
```

```
*       First, declare GAMS parameters which we will use in model
*       specification.

SCALAR  TX      Ad-valorem tax rate for X sector inputs /0/,
        LENDOW  Labor endowment multiplier              /1/;

$ONTEXT

*       An MPSGE model is specified within an $ONTEXT / $OFFTEXT
*       block, and the first keyword must define the model name.
*       The model name must conform to the usual rules for GAMS
*       MODEL names (e.g., maximum 10 characters):

$MODEL:M1_1S

*       The declaration of variables for an MPSGE model immediately
*       follows the $MODEL statement.  There are three classes of
*       variables, $SECTORS, $COMMODITIES and $CONSUMERS.  A
*       variable definition may include a description in the trailing
*       comment (following a "!" -- Not that this is unlike the
*       ordinary GAMS syntax for variable and equation definitions,
*       in which any trailing text, up to a comma, is interpreted as
*       a description.).

$SECTORS:
        X       ! Activity level for sector X
        Y       ! Activity level for sector Y
        W       ! Activity level for sector W (Hicksian welfare index)

$COMMODITIES:
        PX      ! Price index for commodity X
        PY      ! Price index for commodity Y
        PL      ! Price index for primary factor L
        PK      ! Price index for primary factor K
        PW      ! Price index for welfare (expenditure function)

$CONSUMERS:
        CONS    ! Income level for consumer CONS

*       Cobb-Douglas technology is characterized by unitary elasticity
*       of substitution at the top level (s:1).  Taxes are always
*       applied on a value-added basis.  Here, the user cost of labor
*       inputs is then PL*(1+TX) and the user cost of capital inputs
*       is PK*(1+TX).  The A: field indicates that tax revenue should
*       accrue to CONS.

$PROD:X s:1
        O:PX  Q:100
        I:PL  Q:40 A:CONS T:TX
```

```
        I:PK  Q:60 A:CONS T:TX

$PROD:Y s:1
        O:PY  Q:100
        I:PL  Q:60
        I:PK  Q:40

$PROD:W s:1
        O:PW   Q:200
        I:PX   Q:100
        I:PY   Q:100

*       Here we represent final excess demand.  This function
*       represents preferences (using reference demands), and
*       initial factor endowments:

$DEMAND:CONS
        D:PW   Q:200
        E:PL   Q:(100*LENDOW)
        E:PK   Q:100

$OFFTEXT

*       Include a compiler directive instructing MPSGE to compile
*       the functions.  This statement must be issue, otherwise the
*       MPSGE functions are invisible to GAMS:

$SYSINCLUDE mpsgeset M1_1S

*       An equilibrium in this model determines only relative prices --
*       there is no "money illusion" and the absolute price level is
*       irrelevant.  This must be considered when reporting induced
*       changes in relative prices.  It is convenient to select one
*       good as numeraire and fix its price as unity.  Labor is
*       a traditional choice as numeraire, so we use it:

        PL.FX = 1;

*       N.B.  Fixing a price instructs MPSGE to omit the corresponding
*       equation -- In equilibrium, this equation will be satisfied
*       automatically through Walras' law.

*      It is not necessary to fix a numeraire, however if a numeraire
*      is not specified, the normalization of prices is arbitrary.
*     (When no price is exogenously fixed, the system uses one consumer
*      income as normalization, and this income level is determined
*      by the initial price vector).

*      Instruct GAMS to generate and evaluate the model.  The data
*      for this model is balanced, so this model should return
```

```
*       with "solved" status.  If it is not solved, the solution
*       listing can be used to identify the source of the inconsistency.

         M1_1S.ITERLIM = 0;
$INCLUDE M1_1S.GEN
         SOLVE M1_1S USING MCP;
         M1_1S.ITERLIM = 2000;

         Solve a counterfactual: 50% tax on inputs to X production.

         TX = 0.5;
         LENDOW = 1;

$INCLUDE M1_1S.GEN
         SOLVE M1_1S USING MCP;

*        Solve a counterfactual: 100% increase in labor endowment (TX=0)

         TX = 0;
         LENDOW = 2;

$INCLUDE M1_1S.GEN
         SOLVE M1_1S USING MCP;

*        Finally, to remove some of the mystery from the model
*        description, we provide an algebraic presentation of the
*        same equations which have been generated automatically by
*        MPSGE.

*        We write these equations using precisely the same variables
*        which have already been declared within the MPSGE model
*        (hence, they need not be declared a second time).

*        We need to give names to the equations, however, because the
*        MPSGE-generate equations are not named.

EQUATIONS
         PRF_X   Zero profit for sector X
         PRF_Y   Zero profit for sector Y
         PRF_W   Zero profit for sector W (Hicksian welfare index)

         MKT_X   Supply-demand balance for commodity X
         MKT_Y   Supply-demand balance for commodity Y
         MKT_L   Supply-demand balance for primary factor L
         MKT_K   Supply-demand balance for primary factor L
         MKT_W   Supply-demand balance for aggregate demand

         I_CONS  Income definition for CONS;

*        Zero profit conditions are produced for all of the production
```

```
*       sectors.  These are interpreted as:

*       Cost of Production Gross of Tax  =  Value of Output

PRF_X..         100 * PL**0.4 * PK**0.6 * (1+TX) =E= 100 * PX;

PRF_Y..         100 * PL**0.6 * PK**0.4 =E= 100 * PY;

PRF_W..         200 * PX**0.5 * PY**0.5 =E= 200 * PW;

*       Market clearance conditions for each of the final goods and
*       primary factors.  These are interpreted as:

*       Output plus Initial Endowment  = Intermediate + Final Demand

MKT_X..         100 * X =E= 100 * W * PX**0.5 * PY**0.5 / PX;

MKT_Y..         100 * Y =E= 100 * W * PX**0.5 * PY**0.5 / PY;

MKT_W..         200 * W =E= CONS / PW;

MKT_L..         100 * LENDOW =E= 40 * X * PL**0.4 * PK**0.6 / PL +
                                 60 * Y * PL**0.6 * PK**0.4 / PL;

MKT_K..         100 =E= 60 * X * PL**0.4 * PK**0.6 / PK +
                        40 * Y * PL**0.6 * PK**0.4 / PK;

*       Income balance states that the level of expenditure (CONS)
*       equals the value of factor income plus tax revenue:

I_CONS..        CONS =E= 100*LENDOW*PL + 100*PK +
                         TX*100*X*PL**0.4*PK**0.6;

*       We declare this model using the mixed complementarity syntax
*       in which equation identifiers are associated with variables.

*       One advantage of this syntax is that if a variable value is
*       fixed within an MCP model, the associated equation is
*       automatically omitted from the model:

MODEL ALGEBRAIC /PRF_X.X, PRF_Y.Y, PRF_W.W, MKT_X.PX, MKT_Y.PY,
MKT_L.PL, MKT_K.PK, MKT_W.PW, I_CONS.CONS /;

*       Check the benchmark (again):

        X.L=1; Y.L=1; W.L=1; PX.L=1; PY.L=1; PK.L=1; PW.L=1;
CONS.L=200;

        TX = 0;
        LENDOW=1;
```

```
        SOLVE ALGEBRAIC USING MCP;

*       Solve the same counterfactuals:

        TX = 0.5;
        LENDOW = 1;
        SOLVE ALGEBRAIC USING MCP;

        TX = 0;
        LENDOW = 2;
        SOLVE ALGEBRAIC USING MCP;

$ontext


Exercises for M1_1S:

(1) Remove the PL.FX = 1.  This will cause MPSGE to select use the
default normalization of prices. (Note that if the PL is not fixed,
the algebraic model may not solve because the Jacobian is singular at
the solution.)

Rerun the counter-factual simulations using the MPSGE model and the
default price normalization.  Verify that relative price in the new
solution are identical to the original solution.

(2) Introduce a "typo" in a sector X input, e.g. O:PX Q:101, and then
examine the benchmark replication listing to see how this error is
manifested in the output.

(3) Consult a microeconomics text book to verify that the algebraic
model is properly specified.  A close familiarity with CES algebra is
useful but not essential.  One motivation for the development of
MPSGE is that the algebraic approach is difficult and error prone.

$offtext
```

Appendix B

MPS/GE Syntax
The 1991 Uzbekistan Transitional Economy Model

```
$TITLE:uzbek


SCALAR
SW1   Switch one: 1=benchmark resource endowment 2=resource boom  /1/,
SW2   Switch two: 1=investment 0=consumption  /1/,
EFF   Newly privatized calibration subsidy:1=subsidized 0=no subsidy /1/,
SW3   Switch three:  1=Inefficient vs. 0=Efficient /1/,
PRIV  Exogenous privatization: 1=government owns capital
      0=entrepreneurs own capital  /1/,
PXBAR Price wedge: percent distortion /0.2/;


$ONTEXT

$MODEL:uzbek

$SECTORS:
R     !Activity level of resource sector
S     !Activity level of service sector
X     !Activity level of tradable sector
SX    !Activity level of state tradable sector
OX    !Activity level of privatized tradable sector
EX    !Activity level of entrepreneurial tradable sector
WT    !Hisksian welfare of traditional representative agent
WE    !Hicksian welfare of entrepreneurial representative agent
WG    !Hicksian welfare of government agent
E     !Activity level of export sector
M     !Activity level of import sector
INV   !Investment activity
QX    !Rent-seeking queuing activity

$COMMODITIES:
PR    !Price index for commodity R (natural resources)
PS    !Price index for commodity S (services -- non-tradable)
PX    !Price index for commodity X (tradable)
PSX   !Price index for commodity SX (state produced tradable)
POX   !Price index for commodity OX (privatized tradable)
PEX   !Price index for commodity EX (entrepreneurial produced tradable)
PL    !Price index for primary factor L (Labor)
PKR   !Price index for resource specific primary factor K (capital)
PKS   !Price index for service specific primary factor K (capital)
PKSX  !Price index for state tradable specific primary factor K (capital)
PKOX  !Price index for newly privatized specific primary factor K (capital)
PKEX  !Price index for entrepreneurial specific primary factor K (capital)
FX    !Price index for foreign exchange -- numeraire
VQX   !Price index for commodity VQX (rent-seeking delivery)
PWT   !Price index for traditional households welfare
PWE   !Price index for entrepreneurial households welfare
PWG   !Price index for government welfare
```

```
PSAV  !Price index savings activity

$CONSUMER:
HT    !Traditional households representative agent (labor)
HE    !Entrepreneurial households representative agent (capital owners)
GOVT  !Government


$PROD:R s:0 k(s):0.5 l(k):0.5 r(l):1
O:PR              Q:(394.43599*SW1)
I:PR        Q:65.055720  r:
I:PS        Q:16.510830
I:PX        Q:63.297710
I:PL        Q:134.944120 l: P:(1+(6.069910/(134.944120+108.557700)))
A:GOVT  T:(6.069910/(134.944120+108.557700))
I:PKR       Q:108.557700 k:   P:(1+(6.069910/(134.944120+108.557700)))
A:GOVT  T:(6.069910/(134.944120+108.557700))


$PROD:S s:0 k(s):0.5 l(k):0.5 r(l):1
O:PS              Q:201.747000
I:PR        Q:4.520380   r:
I:PS        Q:4.024160
I:PX        Q:76.086460
I:PL        Q:81.020670  l:   P:(1+(3.836000/(81.020670+32.259330)))
A:GOVT  T:(3.836000/(81.020670+32.259330))
I:PKS       Q:32.259330  k:   P:(1+(3.836000/(81.020670+32.259330)))
A:GOVT  T:(3.836000/(81.020670+32.259330))

$PROD:X S:10
O:PX        Q:574.138671
I:VQX       Q:440.074946
I:POX       Q:66.215366
I:PEX       Q:67.848359


$PROD:SX s:0 k(s):0 l(k):0 r(l):0
O:PSX       Q:528.089935
I:PR        Q:165.639200 r:
I:PS        Q:53.247472
I:PX        Q:210.485640
I:PL        Q:54.274319  l:   P:(1+(36.733672/(54.274319+51.140032))-
(43.4304/54.274319)) A:GOVT  T:((36.733672/(54.274319+51.140032))-
(43.4304/54.274319))
I:PKSX      Q:51.140032  k:   P:(1+(36.733672/(54.274319+51.140032)))
A:GOVT  T:(36.733672/(54.274319+51.140032))

$PROD:OX s:0.5 k(s):0.5 l(k):0.5 r(l):0.5
O:POX       Q:66.215366
I:PR        Q:20.704900  r:
```

```
I:PS        Q:6.655934
I:PX        Q:26.310705
I:PL        Q:6.385214   l:   P:(1+(4.591709/(6.385214+6.392504))-
(4.825600/6.385214))  A:GOVT T:((4.591709/(6.385214+6.392504))-
((4.825600/6.385214)*EFF))
I:PKOX      Q:6.392504   k:   P:(1+(4.591709/(6.385214+6.392504)))
A:GOVT T:(4.591709/(6.385214+6.392504))

$PROD:EX s:1 k(s):1 l(k):1 r(l):1
O:PEX       Q:67.848359
I:PR        Q:20.704900  r:
I:PS        Q:6.655934
I:PX        Q:26.310705
I:PL        Q:3.192607   l:   P:(1+(4.591709/(3.192607+6.392504)))
A:GOVT T:(4.591709/(3.192607+6.392504))
I:PKEX      Q:6.392504   k:   P:(1+(4.591709/(3.192607+6.392504)))
A:GOVT T:(4.591709/(3.192607+6.392504))

$PROD:E s:0
O:FX        Q:16.296980
I:PR        Q:16.296980

$PROD:M s:0
O:PX        Q:40.071980
I:FX        Q:40.071980

$PROD:INV
O:PSAV      Q:151.477000      A:GOVT      T:((-
43.430400/151.477000)*SW2*(1-PRIV))
I:PR        Q:28.156960
I:PS        Q:111.734960
I:PX        Q:11.585080

$PROD:QX
O:VQX       Q:440.074946      A:HT  T:-PXBAR
I:PSX       Q:528.089935

$PROD:WT s:1
O:PWT       Q:240.244011      A:GOVT      T:((-
43.430400/240.244011)*(1-SW2)*(1-PRIV))
I:PR        Q:67.836470
I:PS        Q:0
I:PX        Q:172.407541

$PROD:WE s:1
O:PWE       Q:12.785008
I:PR        Q:1.951594
I:PS        Q:1.031465
I:PX        Q:9.801949
```

```
$PROD:WG s:1
O:PWG        Q:286.654652
I:PR         Q:3.568886
I:PS         Q:1.886245
I:PX         Q:17.924861
I:PSAV       Q:151.477000
I:PL         Q:106.169290
I:PKSX       Q:5.628370

$DEMAND:HT
D:PWT        Q:240.244011
E:PL         Q:328.259000

$DEMAND:HE
D:PWE        Q:12.785008
E:PKOX       Q:(6.392504 + SW3*(1-PRIV)*56.768402)
E:PKEX       Q:(6.392504 + (1-SW3)*(1-PRIV)*56.768402)

$DEMAND:GOVT
D:PWG        Q:286.654652
E:PL         Q:57.727220
E:PKR        Q:108.557700
E:PKS        Q:32.259330
E:PKSX       Q:(56.768402*PRIV)
E:FX         Q:23.775000

$OFFTEXT

$SYSINCLUDE mpsgeset uzbek
FX.FX=1;

uzbek.iterlim=0;
$INCLUDE uzbek.GEN
SOLVE uzbek USING MCP;



* State 1 -- Resources, Investment, Continued Operation

PRIV=.8;
SW1=2;
SW2=1;
SW3=0;

uzbek.iterlim = 1000;
$include uzbek.gen
solve uzbek using mcp;
```

```
* State 2 -- Resources, Investment, Discontinue Operation

PRIV=.8;
SW1=2;
SW2=1;
EFF=0;
SW3=1;

uzbek.iterlim = 1000;
$include uzbek.gen
solve uzbek using mcp;

* State 3 -- Resources, Welfare, Continued Operation

PRIV=.8;
SW1=2;
SW2=0;
EFF=1;
SW3=0;

uzbek.iterlim = 1000;
$include uzbek.gen
solve uzbek using mcp;

* State 4 -- Resources, Welfare, Discontinued Operation

PRIV=.8;
SW1=2;
SW2=0;
EFF=0;
SW3=1;

uzbek.iterlim = 1000;
$include uzbek.gen
solve uzbek using mcp;

* State 5 -- No Resources, Investment, Continued Operation

PRIV=.8;
SW1=1;
SW2=1;
EFF=1;
SW3=0;


uzbek.iterlim = 1000;
$include uzbek.gen
solve uzbek using mcp;
```

```
* State 6 -- No Resources, Investment, Discontinue Operation

PRIV=.8;
SW1=1;
SW2=1;
EFF=0;
SW3=1;

uzbek.iterlim = 1000;
$include uzbek.gen
solve uzbek using mcp;

* State 7 -- No Resources, Welfare, Continued Operation

PRIV=.8;
SW1=1;
SW2=0;
EFF=1;
SW3=0;

uzbek.iterlim = 1000;
$include uzbek.gen
solve uzbek using mcp;

* State 8 -- No Resources, Welfare, Discontinued Operation

PRIV=.8;
SW1=1;
SW2=0;
EFF=0;
SW3=1;

uzbek.iterlim = 1000;
$include uzbek.gen
solve uzbek using mcp;
```