The Dynamic Response to Trade Policy:

Evidence from the
U.S. Textile and Clothing Industries

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Abstract

I study the behavior of textile and clothing makers in the U.S. as they were exposed to a large, anticipated increase in foreign competition through the removal of import quotas. I find a strong decline in capital investment in the industries that are likely to be the most vulnerable to such competition. The decline appears just after announcement of the policy, which is as many as nine years before the scheduled liberalization date. I present models of optimal industry investment in the presence of capital adjustment costs, and I establish their predictions regarding these industries when trade liberalization is to be introduced. Using industry panel data, I examine developments in the output and capital markets for these industries, and I find that they are broadly consistent with the models' predictions. A simulation using plausible parameter values produces a path for investment that closely matches the observed path. These findings suggest that capital adjustment costs played a central role in driving the dynamics that were precipitated by this episode of trade liberalization.

1 Introduction[1]

When an industry faces new competition due to a trade policy change, how does it respond? Does it make a transition that is swift and sudden, so that the effects of the policy can be effectively summarized with a simple before-and-after comparison? If not, why not? What forces drive the process of transition, and how long might the transition take? In this paper, I address these questions by examining the industry dynamics associated with an important episode of trade liberalization, including the period between announcement and implementation of the policy. I find strong evidence that, even though the policy change was effectively instantaneous, the transition for several industries took many years; that in many cases, a significant share of the transition occurred before the policy was implemented; and that costly adjustment of the capital stock was a primary driver of the dynamic response to this trade policy.

The episode I study here comprises the liberalization in the U.S. of international trade in textiles and clothing (T&C), and the contemporaneous accession of China to the WTO. Figures 1a and 1b give a first clue as to the nature of the dynamics that these policy changes induced. Figure 1a shows a time series of average real investment, relative to national nonresidential fixed investment, by the industries that faced direct competition from newly liberalized importation of the products they produced. Each of the main elements of liberalization occurred all-at-once on the first day of a calendar year, and those dates are also shown in the figure. The liberalization occurred in four phases

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(although the first phase will not concern us here[2]), the last of which was followed by a period of extended protection by so-called 'safeguards', and China gained trade concessions during this period when it acceded to the WTO. Based only on this figure, it appears that capital investment began to decline after phase 2 of the liberalization, continued its decline as liberalization proceeded, and bottomed out around the time of the fourth phase of liberalization.

Figure 1b, however, tells a different story. Here, I split the affected T&C industries into three groups–one each for liberalization phases 2 through 4–with each NAICS six-digit industry assigned to the group that corresponds to the phase of liberalization that exposed it to direct import competition. I then calculated average real investment within each of these groups, again relative to national nonresidential fixed investment. The resulting time series, plotted on the same scale as figure 1a, show considerable variation across industry groups in investment behavior. While investment declined for each industry group, the figure is dominated by the decline in investment by industries belonging to the phase 4 group. Further, the decline in investment by industries belonging to the phase 4 group (henceforth 'phase 4 industries') is prominent beginning around 2001, even though phase 4 products were not scheduled for liberalization until 2005. The observed decline in investment before 2005 by phase 4 industries suggests that anticipation of the policy may be inducing an important dynamic response years before implementation. I will show below that such behavior is predicted by models of investment with capital adjustment costs when an industry is faced with a trade liberalization episode such as this one, as are other features of the observed time series for investment, output, and trade. I will further show that the magnitude of decline in investment across this period is consistent, given plausible parameter values, with the numerical projections of the model with internal adjustment costs.

[2] A detailed account of the nature of the policy changes is given in section 2.

This finding is important for a few reasons. First, it informs ongoing efforts to model dynamic responses to trade policy changes. For instance, the literature inspired by Melitz (2003) has developed and extended models of trade with heterogeneous producers facing various fixed costs. Early versions of these models are well suited to comparative static analysis, but for various reasons are silent about transition dynamics. More recently, researchers have taken up the challenge of analyzing and amending these earlier models to explore dynamics of various kinds. A relatively early example is Ghironi and Melitz (2004), which added dynamics driven by a stream of stochastic aggregate productivity shocks. Alessandria and Choi (2007) consider productivity shocks and capital accumulation together to construct a dynamic model to match certain features of the U.S. manufacturing sector. Atkeson and Burstein (2010) introduce endogenous, durable, firm-level innovation to drive dynamics. Both of the latter conclude that taking account of dynamics can be very important both in accurately predicting short- and medium-run outcomes and in properly evaluating the welfare effects of a given policy experiment. However, this class of models typically abstracts from the presence of capital altogether.[3] Thus, its inclusion in future efforts may appreciably increase their capacity to reproduce observed responses to trade policy, and to accurately predict those responses and their welfare implications.

This paper also touches on the extensive literature on optimal industry investment behavior in the face of capital adjustment costs. For my purposes, I consider adjustment costs of two general types: *internal* and *external*. Conceptually, an internal adjustment cost is a cost that a firm faces, in addition to the purchase price of its capital, when it changes the size of its capital stock. An

[3] Alessandria and Choi (2007) do include physical capital in their model, but it is supplied perfectly elastically at each instant, and thereby does not itself drive any of the dynamics that they model. Atkeson and Burstein (2010) do not consider physical capital as such, although what might be called the 'knowledge capital' of their firms induces some dynamics akin to those I find here.

external adjustment cost, on the other hand, is a cost that arises outside of a given firm that affects the purchase price of its capital whenever there is a change in the size of the aggregate capital stock owned by the firm's industry. For example, Poterba (1984) finds evidence of an external adjustment cost in the form of an upward-sloping schedule for the supply of capital to the housing industry, as do Topel and Rosen (1988), who use a model that allows short- and long-run supply elasticities to differ. Goolsbee (1998) examines the effects of variation in the tax treatment of investment in physical capital, and finds evidence for an upward-sloping supply of capital to the manufacturing sector as a whole. The literature treating internal adjustment costs is equally rich. Doms and Dunne (1998) give an early overview of evidence regarding firm-level adjustment costs. More recently, Cooper and Haltiwanger (2006) test empirically for evidence of a variety of such costs, again at the firm level.

One implication that frequently arises in this class of models is that when it is costly to adjust the capital stock, it is optimal to smooth the adjustment over time. In particular, if it were known when and how market conditions would change *ex ante*, it would usually be optimal to begin adjusting the capital stock before the change occurred. The events studied by Goolsbee (1998), for instance, are arguably foreseeable in this way.[4] Other authors are able to uncover an anticipatory response to future shocks using models that contain either what might be called 'addiction capital' (Becker, Grossman, and Murphy (1994)), or possibly 'loyalty capital' (Goolsbee and Syverson (2008)). The present study, however, adds to this literature a case in which anticipation by forward-looking agents appears to have resulted in reactions that are quite large in magnitude, and which take place over a considerably longer period of time. Goolsbee's (1998) price effects last perhaps two to three

[4]Bloom, et al. (2010) is another study of a potentially foreseeable policy change. In neither case do the authors detect any anticipation effects, but they argue that such effects might be difficult to detect given uncertainty about the policy change. This highlights an advantage of the case I study–that the nature of the policy uncertainty that does exist is both known and easily modeled.

years after the policy change, and are not perceptible at all before the fact. Most of the short-run response in Topel and Rosen (1988) disappears after about one year. In contrast, I find significant deviations in investment behavior for the most-affected industries over a period of nine years before the scheduled implementation of the policy, and ultimately over the thirteen years before the policy is fully implemented. And while the magnitude of the effects picked up by Goolsbee are small, induced as they are by tax rate changes of a few percentage points, the response I observe includes an average decline in real investment, relative to trend, across the set of affected industries of about 85% over eight years, which was interrupted by a one-year surge in which real investment nearly doubled.

Finally, an episode of this type presents an opportunity to characterize the firm-level behavior that gives rise to the observed aggregate investment dynamics. Because of the magnitude and direction of the observed deviation in aggregate investment, this episode is likely to be especially suited to exploring the types of adjustment costs faced by shrinking firms, and by firms in a shrinking industry. In ongoing work, I am studying the establishment-level dynamics associated with the industry behavior observed during this period, although I do not present any of those results here.

The rest of this paper is organized as follows. In the next section, I give an overview of the relevant history and details of the industries and trade policies in question. In section 3, I lay out two models of investment, one with internal capital adjustment costs, the other with external. I describe how the policy environment that obtained during this period can be rendered as a reasonably straightforward shock to demand, and derive some testable predictions of the models. In section 4, I discuss the various industry and product data sources used, as well as data defining the relevant policies. In section 5, I present and discuss my results regarding industry and market responses to the policy, and I conclude with section 6.

2 Industry and Policy Details

The policy changes that I study here are the unwinding of the Multifibre Arrangement (MFA) in the U.S. that was negotiated as part of the creation of the WTO in 1995, and the accession of China to the WTO in 2002. Liberalization by the U.S. of trade in textiles and clothing is suitable as an object of study for several reasons. First, the T&C trade liberalization did not coincide with other important trade policy changes, which allows me to abstract from general equilibrium effects that might be of concern under a broader liberalization regime. Second, T&C liberalization was unusual in that trade in a given product was basically liberalized fully on a single day, rather than gradually over time as is typically done in such agreements. This allows me to model the shock in a way that is both realistic and relatively simple. Third, the trade restrictions that were liberalized were economically important, even on the scale of a whole U.S. industry, which enables me to identify changes arising from the policy change amid noise in the data. These industries had generally been protected by import quotas since the 1970s, with some protections dating back to the 1950s. Finally, although trade was liberalized all-at-once for any given product, not all product trade was liberalized on the same date. One reason that this is useful is that, for the products in any given phase of liberalization, I have a set of reasonably comparable industries in the set of T&C products not being contemporaneously liberalized with which to make comparisons. A second reason is that industries are likely to have been assigned among the phases of liberalization in a way that concentrated the most affected industries in the later phases, making it easier for me to pick up the effects of the policy announcement in the industry data.

Beginning in the 1950s, world trade in textiles and clothing stood outside the GATT, which governed nearly all other goods trade internationally among the vast majority of countries. Instead, trade in these products was limited by bilateral agreements, each of which typically limited exports from a particular developing country to a developed country. The typical bilateral agreement imposed annual quotas separately on the quantities of imports of each of several textile and clothing products. The number of such agreements grew with time and, in 1974, this web of bilateral agreements was codified in the Multifibre Arrangement, which was conceived as an attempt to impose on textile and clothing trade some of the multilateral discipline embodied in the GATT, and to eventually phase out the quotas altogether. Instead, the system became more complex and expansive, with several "temporary" renewals of the quota system over the following two decades, although the quantity restrictions on imports were allowed to increase slightly each year.[5] Finally, as part of the negotiations that led to the creation of the WTO, the MFA was replaced with the Agreement on Textiles and Clothing (ATC), which took effect with the creation of the WTO on January 1, 1995. The ATC required a phased removal of all bilateral quotas on textile and clothing trade, to be completed on January 1, 2005.

Textile and clothing production in the U.S. is predictably more capital-intensive than is production of the same goods in a developing country, but these industries are not especially capital-intensive with respect to U.S. manufacturing as a whole, which is perhaps part of the legacy of having received decades-long protection from imports. Textile production is the more capital intensive of the two sectors, but even here, capital intensity (as measured by capital stock per production worker) is below the average for all manufacturing throughout the time period covered by my dataset (1958-2005), though it more or less tracks the rate of increase in capital intensity of U.S. manufacturing over time. Clothing production is quite labor-intensive for a U.S. manufacturing industry, although its capital intensity also increased at about the same rate as did manufacturing from the

[5] See, for example, Brandis (1982) or Zheng (1988) for more details about the history of international trade in textiles and clothing.

late 1950s through 1990. However, beginning in the early 1990s, the rate of capital deepening in clothing manufacturing in the U.S. accelerated considerably, so that much of the gap in capital intensity between the textile and clothing manufacturing sectors had been closed by 2005.

Despite the protection they received, the U.S. textile and clothing industries have, by many measures, been in gradual decline since the 1970s. Production employment in both sectors declined relative to manufacturing as a whole,[6] net imports have increased over time, and prices have fallen. Thus, any effects of the recent trade liberalization must be measured relative to these trends. My approach to this is detailed in section 5.

As alluded to earlier, the peculiar structure of the ATC's liberalization schedule makes it a useful episode to study. Countries with quota restrictions on imports were required to implement a phase of liberalization on January 1 in each of four years: 1995, 1998, 2002, and 2005 (phases 1 through 4, respectively). Each phase of liberalization required that quotas be lifted in their entirety on textile and clothing products representing a certain share of all T&C imports. The lines of goods liberalized in the first three phases had to represent at least 16%, 17%, and 18%, respectively, of the quantity of 1990 imports of textiles and clothing by that country, with the remainder (at most 49%) liberalized in the fourth phase. However, it was up to each importing country to decide which products would be liberalized in which phase, subject to some mild constraints that need not concern us here, and the full schedule of product line liberalizations had to be set in 1995.[7] Note that phases could be

[6]An exception is the textile product industry, which has retained workers to a slightly greater extent than has manufacturing as a whole. Textile products are finished products that are made out of textiles but which are not worn, such as curtains and carpets.

[7]Take, as a simplified example, a country had quotas on imports of "hats", "shirts", "pants", and "shoes". It would first choose an order in which it would like to liberalize imports in those products. Assume it chose to liberalize them in the order listed. It would then have lifted all restrictions on hat imports in 1995; all restrictions on shirt imports in 1998; and so forth. This all-at-once approach differs from the more common type of trade liberalization schedule

partially or entirely filled by textile and clothing lines that the importing country did not have any restriction on at the outset, so long as the universe of textile and clothing goods, as defined at the negotiations, was ultimately accounted for by the end of the fourth phase. For example, the United States filled its entire first phase with textile products on which it did not have quota restrictions, which is why phase 1 is discussed nowhere else in this paper.[8] Note also that, while there were other minor aspects to liberalization, such as an incremental easing over time of the import quantities allowed, the wholesale removal of the quotas will certainly have had the largest effects.

The second policy change that occurred during this period is China's accession to the WTO, which effectively coincided with the implementation of phase 3 of ATC liberalization.[9] Because it was not a WTO member until that time, China did not qualify for phase 1 or 2 concessions, which were granted to other countries in 1995 and 1998, respectively, until it acceded. Thus, China was granted concessions for the first 3 phases of liberalization just after the date of its accession. Because of China's large role as an exporter to the U.S., particularly in many textile and clothing lines, I will consider China's accession as a T&C trade liberalization event *per se*.

One further wrinkle is that, as part of its accession agreement, China agreed to a "safeguard clause" which could be used by importing countries to limit imports of Chinese goods for a period of time if certain conditions were met. Beginning in 2003, trade associations representing the U.S. textile and apparel industries lobbied to invoke this clause with respect to certain product lines. Three requests for protection appeared in the Federal Register during 2003; the next year, as phase 4 of liberalization approached, twelve more notices appeared. When Chinese imports poured into the

in which import restrictions on any given product are eased gradually over time.

[8] Some illustrative examples of phase 1 goods: silk trunks and suitcases, fishing nets, cloth adhesive tape, lamp wicks, ice hockey gloves, garden umbrellas, watch bands, parachutes, and doll clothing.

[9] China acceded on December 11, 2001; phase 3 was implemented on January 1, 2002.

U.S. in 2005, lobbying intensified still further, so that thirty requests for protection had already been published that year by the time the U.S. and China announced that they had signed a 'Memorandum of Understanding' with respect to T&C trade. As a result, safeguards were applied to Chinese imports in several lines of T&C goods beginning in late 2005, and extending through 2008. The process for invoking this clause likely involved uncertainty with respect to the outcome from the textile industries' points of view. I will try to capture this uncertainty and its implications in the models presented in the next section.

3 Models of Industry Investment

In this section, I present a framework to evaluate and interpret the dynamics observed in the data. I do not take a stand at the outset on the type of capital adjustment costs present (if any). Rather, I consider two models, each of which features a type of capital adjustment cost–one *internal*, the other *external*. Each model will deliver a set of predictions about industry investment behavior in the presence of a trade policy change, which I model as a demand shock that is anticipated with uncertainty. In both models, perfectly competitive firms produce a textile or clothing product using capital.[10] This product is sold domestically, and must compete with an identical imported product so that the demand curve faced by the industry is a residual demand–domestic demand net of a supply of imports.[11] Imports are initially restricted in quantity by a quota, and when this quota is relaxed, the residual demand shifts inward.

[10] The models can be easily extended to include a variable input–call it 'labor'–which is combined with capital using a Leontief production technology. The results are not qualitatively affected.

[11] In reality, a small and relatively stable amount of output from these industries is exported. This can simply be thought of as part of the residual demand that an industry faces.

In the first model, firms purchase capital whose aggregate supply is not perfectly elastic (though each firm takes its price as given).[12] Thus, an increase (decrease) in industry-wide demand for capital results in an increase (decrease) in the equilibrium price of that capital. I refer to this price change as an 'external adjustment cost'–once a firm pays the purchase price for this capital, it may produce costlessly with it.

In the second model, firms purchase capital that is supplied perfectly elastically, but pay a penalty when they adjust their net capital stock. I use an adjustment cost that is convex in the magnitude of the percent change in the capital stock. I refer to this cost as an 'internal adjustment cost'–a firm/industry may purchase any amount of capital at a fixed price, but after doing so it must pay an additional cost in order to change the size of its capital stock.

The literature on firm-level capital adjustment costs is a rich one that has considered the presence of many types of adjustment costs, both convex and nonconvex. Cooper and Haltiwanger (2006) test for the presence at the firm level of convex adjustment costs, along with two types of nonconvex adjustment costs, and conclude that the cross-sectional patterns of investment they observe in the firm-level data are best captured by admitting the presence of all three types of costs. When they run the same tests on industry-level data, however, they find that most of the observed investment behavior can be explained by allowing for only for convex adjustment costs. This implication–that the presence of a variety of types of adjustment costs at the firm level gives rise to aggregate behavior that largely mimics that of an industry facing convex adjustment costs–colors the interpretation of the model I present here. Should I find industry investment behavior that is consistent with this model, it cannot be concluded that the adjustment costs faced by firms in the industry are primarily convex. On the other hand, such a finding can be viewed as evidence that firms in the industry do

[12] The model presented here is roughly equivalent to that used in Poterba (1984).

face important capital adjustment costs of some kind.

3.1 A Model with External Adjustment Costs

U.S. consumers demand a given textile or clothing product that is produced domestically and abroad. Their demand for the product net of its supply by foreign producers is given by the function $D(P(t), A)$ where $P(t)$ is the unit price at time t and $D_P < 0$. A is a variable whose value is 0 prior to liberalization, and is 1 after liberalization, with $D(P, 0) > D(P, 1)$ for all values of P. Assume for now that the firm knows with certainty the date on which liberalization will occur. Domestic firms make this product using industry-specific physical capital with the technology $F(K) = K$. Each solves the problem

$$max_{i(t),k(t)} \int_0^\infty e^{-rt} \left(P(t)k(t) - P_k(t)i(t)\right) dt$$

by selecting time paths for i and k, where at time t, $P(t)$ is the sale price of output, $P_k(t)$ is the purchase price of capital, $i(t)$ is gross real investment, $k(t)$ is the firm's industry-specific capital stock, and r is the (constant) real interest rate. Each firm takes P and P_k as given at all times, and its capital stock evolves as

$$\dot{k}(t) = i(t) - \delta k(t)$$

where δ is the instantaneous rate of depreciation. The firm's problem is linear in i and k, so that a firm with twice as much capital as another firm will select an investment level that is twice as large as that smaller firm's. More generally, we can think of the industry as being composed of a single firm that owns all of the capital and takes prices as given, so that the solution at the industry level can be found by solving the problem for a single, representative, price-taking firm. Using uppercase letters for industry investment and capital stock, the price of output and capital at each instant will be given respectively by the pair of equations

$$D(P(t), A) = K(t)$$

$$S(P_k(t)) = I(t)$$

where $S(\cdot)$ is the supply of capital to the industry. This supply is not perfectly elastic, so that $S' > 0$.

The solution to this problem can be represented by a pair of differential equations in P_k and K, along with an initial condition for the capital stock, $K(0) = K_0$, and the transversality condition. Using the notation $\dot{X}(t) = \frac{dX(t)}{dt}$,

$$\dot{P}_k(t) = (r + \delta)P_k(t) - D^{-1}(K(t), A) \quad (1)$$

$$\dot{K}(t) = S(P_k(t)) - \delta K(t) \quad (2)$$

Here I abuse notation slightly by defining D^{-1} implicitly as the function that solves $D\left(D^{-1}(x, A), A\right) = x$. The phase diagram associated with this system is shown in figure 2. The upward-sloping schedule is the $\dot{K}(t) = 0$ locus, and the downward-sloping red schedule is the $\dot{P}_k(t) = 0$ locus. The stable manifold (the thin black line) in $P_k - K$ space slopes downward. The steady-state is represented by the pair $\{P_{k,ss}, K_{ss}\}$ that solve $S(P_{k,ss}) = \delta K_{ss}$ and $D((r + \delta)P_{k,ss}, \cdot) = K_{ss}$, which imply unique values for steady state investment quantity, and for output price and quantity as well.

If the representative firm in this model owns a capital stock that is different than the steady state capital stock, it will not immediately adjust to that level because of the upward-sloping supply of the capital good–that is, because of the external adjustment cost. Take the case when the industry suddenly finds that its capital stock is too high (that is, it exceeds its steady state value). In this case, the firm is producing more output than it would in steady state, and thus faces a price for output that is below its steady state value. It will thus not be willing to pay the steady state price for capital because that additional capital has a low marginal revenue product. However, as the firm chooses to lower its level of investment, the purchase price of capital falls. At some point, this lower price for capital will induce the firm to make some positive investment despite the fact that its output price is low.[13] However, this investment level will certainly be below its steady state value, and because the capital stock is above its steady state value, depreciation will be high. The result will be a shrinking capital stock.

As the capital stock shrinks, the output price for the firm will begin to rise, which in turn will make it willing to pay a higher price for capital. Investment quantity and price will both rise toward their steady state values as the capital stock settles down to its steady state value. These dynamics can also be traced out on the phase diagram. For high levels of capital, P_k and K will follow the downward-sloping stable manifold back toward the steady state, implying that P_k is low and increasing. Although I does not appear explicitly here, it follows P_k monotonically because a higher price of capital induces a higher output of capital. Formally, $\dot{P}_k S'(P_k) = \dot{I}$ and $S' > 0$.

I am interested first in analyzing the case when the industry learns beforehand that a negative shock to demand for output will occur at a future date certain. This shock, induced by the trade policy, will shift the $\dot{P}(t) = 0$ locus inward, but not until the time of the policy change. The $\dot{K}(t) = 0$ locus, which does not depend on the $D()$ function, will remain unchanged. A perfectly anticipated demand shock will have two discrete effects–one on announcement, and the other on realization–with a dynamic response in the interim. In terms of the phase diagram, the capital stock and investment price will follow the dynamics of the pre-shock system until the shock arrives. The investment price

[13] I ignore here the case when the firm would like to have zero or negative gross investment. I do not observe such a case in the data at the industry level.

will fall discretely when the industry learns of the forthcoming shock, then will continue to fall gradually along with the capital stock. Again, the quantity of investment will track the price of investment. These trends will continue until the shock hits, at which time the price and quantity of investment will begin to *rise*, although the capital stock will continue to fall. These capital market dynamics are shown in figure 3. In the output market, the quantity produced will begin to fall at announcement because output capacity is declining. However, because this will happen before demand shifts, the price of output will increase until the demand shock arrives. Figures 4a and 4b show qualitative times series for the prices and output quantities predicted by this model in relation to an instantaneous, anticipated demand shock. Figure 4a shows the quantity of investment (I) and price of the investment good (P) relative to announcement and implementation dates of the policy. Figure 4b shows the quantity (Q) and price (P) of the good that is produced by the industry, relative to the same events.

Economically, the firm faces a tradeoff during the period between announcement and implementation of the policy. It understands that its capital will fall in value when the policy is implemented–in the sense that it will generate a lower revenue stream–because demand for its output will fall. This puts downward pressure on the amount of capital that the firm would like to hold at that time. However, when it begins to reduce its capital stock in anticipation of the change, the price of its output begins to rise. Thus, although its capital will produce less revenue after the shock, it will generate higher-than-normal revenue in the meantime. As this period of higher-than-normal revenue becomes ever shorter, the firm is willing to pay an ever lower price for capital. When the shock arrives, the price of the firm's output falls discretely, but because its capital stock continues to fall, the price of output continues to rise, although from this lower level. Now, the firm faces a period of lower-than-normal output prices. As the price of its output rises toward its steady state level, the firm will be willing to pay an ever-increasing price for capital. Output prices and investment prices and quantities will approach their steady state values from below, while output quantity and the capital stock approach their steady state values from above.

Finally, I will consider the same model with uncertainty over the date of liberalization. Recall that, as the date for phase 4 of liberalization approached, the textile industry lobbied to have the China safeguard clause invoked to delay liberalization for certain products.[14] The terms of the safeguard clause included language that effectively limited the duration of any safeguard protection to three years.[15] Thus, the affected industries were more or less faced with two possible dates for liberalization, with uncertainty over which would be the actual date of implementation. Further, it was clear that this uncertainty would be resolved effectively on the earlier of these dates.

This type of uncertainty can straightforwardly be incorporated into the model. Consider a representative firm that believes that, at some future date T_1, trade liberalization will be delayed until $T_2 > T_1$ with probability $\pi > 0$, and will otherwise be implemented immediately. The optimal path for investment up to time T_1 will entail a price for capital just before T_1 that is equal to the expected price for capital just after T_1–otherwise there would be an opportunity for (expected) gains through arbitrage by reallocating some investment around this time. That is, we will have

$$P^- = \pi P_2^+ + (1-\pi)P_1^+$$

where P^- is the price of capital just before the uncertainty is resolved at T_1, $P_2^+ > P^-$ is the price

[14] Protection was sought mostly for phase 4 products, but included a few product lines from the other phases as well.

[15] In the case when safeguards were implemented due to an absolute increase in imports, China could withhold trade concessions if those safeguards remained in place for more than three years. In practice, the agreement reached by the U.S. and China extending quotas for textiles and clothing was scheduled to last three years, and quotas were in fact lifted at the end of that period.

of capital just after T_1 if the liberalization was delayed, and $P_1^+ < P^-$ is the price just after T_1 otherwise. The system's dynamics after resolution of the uncertainty would follow one of two paths. These dynamics are illustrated in figure 5.

The dynamics for investment will again track the price of capital. Take the case when liberalization is delayed, which is the case that most closely resembles the policy environment that was actually faced by phase 4 industries. In this case, the model predicts that real investment should decline leading up to T_1 (2005 in this case), jump up upon announcement of the delay in liberalization, and thereafter continue to decline until liberalization occurred. It should then begin to rise, although the capital stock should continue to shrink. These dynamics for investment are depicted qualitatively in figure 6.

3.2 A Model with Internal Adjustment Costs

In this model, U.S. consumers once again demand a given textile or clothing product that is produced domestically and abroad. As before, their demand for the product net of its supply by foreign producers is given by the function $D(P(t), A)$ where $P(t)$ is the unit price at time t and $D' < 0$. A is a variable whose value is 0 prior to liberalization, and is 1 after liberalization, with $D(P, 0) > D(P, 1)$ for all values of P. Domestic firms make this product using industry-specific physical capital with the technology $F(K) = K$. Each now solves the problem

$$max_{i(t),k(t)} \int_0^\infty e^{-rt} \left\{ P(t)k(t) - P_k \left[i(t) + k(t)c\left(\frac{i(t)}{k(t)}\right)\right]\right\} dt$$

subject to the law of motion for capital, by selecting time paths for i and k, where at time t, $P(t)$ is the sale price of output, P_k is the purchase price of capital, $i(t)$ is gross real investment, $k(t)$ is the firm's industry-specific capital stock, and r is the (constant) real interest rate. The function $c(\cdot)$ represents a cost that the firm bears for adjusting its capital stock in addition to the purchase price it pays for capital–that is, an internal adjustment cost. I will here consider symmetric convex adjustment costs so that $c'' > 0$, with $c(\delta) = 0$ and $c(x) > 0$ for all $x \neq \delta$. Thus, the firm pays an amount equal to a share of its capital stock when it adjusts the size of its net capital stock, and that amount increases in the magnitude of the capital stock adjustment, as does its first derivative. Note here also that capital is supplied perfectly elastically so that the price of capital is fixed. Now, it is not a variable external price for capital that causes firms to smooth their capital adjustment over time, but rather a penalty that causes the cost of adjustment to increase with the magnitude of adjustment.

Each firm takes P and P_k as given at all times, and the capital stock evolves as

$$\dot{k}(t) = i(t) - \delta k(t)$$

The firm's problem is again linear in i and k, so that the solution at the industry level can be found by solving the problem for a single representative firm that takes both output and capital prices as given. Using uppercase letters for industry investment and capital stock, the price of output at each instant will be given by $D(P(t), A) = K(t)$.

To illustrate the dynamics of this system, I will use a standard functional form for $c()$, namely $c(x) = \frac{b}{2}(x - \delta)^2$ with $b > 0$, so that the problem can be easily solved analytically. The solution to this problem can be represented (suppressing the time variable) by a pair of differential equations in I and K,

$$\dot{I} = K \left[\frac{r + \delta - \frac{D^{-1}(K,A)}{P_k}}{b} + \left(\frac{I}{K} + r\right)\left(\frac{I}{K} - \delta\right) - \frac{\left(\frac{I}{K} - \delta\right)^2}{2} \right] \quad (3)$$

$$\dot{K} = I - \delta K \quad (4)$$

along with an initial condition for the capital stock, $K(0) = K_0$, and the transversality condition. The phase diagram associated with this system is shown in figure 7. The upward-sloping schedule is the $\dot{K}(t) = 0$ locus. The $\dot{I}(t) = 0$ locus, shown in red, is a skewed parabola in $I - K$ space. It can be shown that the parabola is downward-sloping around and below the $\dot{K}(t) = 0$ locus, which is the region that concerns us here. The stable manifold (the thin line) in $I - K$ space slopes downward. The steady-state is represented by the pair $\{I_{ss}, K_{ss}\}$ that solve $I_{ss} = \delta K_{ss}$ and $D((r+\delta)P_k, \cdot) = K_{ss}$, which imply unique values for steady state output price and quantity as well.

The demand shock that arises from the trade policy change can again be represented by a shift inward, this time in the$\dot{I}(t) = 0$ schedule. In the case of a perfectly anticipated negative shock to demand, investment will drop discretely upon announcement of the policy, and will decline until the policy is implemented. It will then rise after the policy is implemented, eventually reaching its steady state level. The capital stock will shrink, beginning at announcement of the policy, until it reaches its new steady state level. In the output market, the quantity of output will fall with the capital stock. The price of output will rise as the capital stock shrinks, both before and after the policy change, although it will jump down discretely upon implementation of the policy. In fact, these dynamics for each variable are qualitatively identical to those that arise in the case with external adjustment costs, with the exception of the price of capital, P_k, which is fixed in the internal adjustment cost case. Thus, with this exception, the qualitative dynamics for this system can be seen by again inspecting figures 4a and 4b.

Finally, consider the case when the representative firm is uncertain about the date of liberalization in the same way that was specified in section 3.1. As in that previous case, the price of investment just before resolution of the uncertainty must equal the expected price of investment just after resolution of the uncertainty, but this time the relevant price is the price *inclusive of the internal adjustment cost*. It can be shown that the relevant condition in this case is

$$\frac{(x^- - \delta)^2}{x^-} = \pi \frac{(x_2^+ - \delta)^2}{x_2^+} + (1-\pi)\frac{(x_1^+ - \delta)^2}{x_1^+}$$

where $x \equiv \frac{I}{K}$, and π and the sub- and super-scripts retain their meanings from the external adjustment cost case. This condition, together with the differential equations already derived, imply a unique level of investment at the moment before resolution of the uncertainty. As with the previous model, if liberalization actually occurs at T_1, investment will jump down discretely and rise thereafter; and if liberalization is delayed, investment will jump up at T_1, fall from that level over time until T_2, and rise thereafter. In fact, the dynamics for all variables in the case with uncertainty are once again qualitatively the same as those predicted by the model with external adjustment costs, with the exception once more of the price of capital, which is fixed here.

3.3 Summary of Implications

Each of the models delivers qualitative predictions–for the time paths for the price and quantity of industry investment, the price and quantity of output, and the size of the industry capital stock–when an industry foresees a negative shock to demand, the time of arrival of which is uncertain, and faces capital adjustment costs. Both models predict that investment will decrease discretely upon announcement of the policy change, and will fall further from that level over time until the uncertainty is resolved. If it is learned that the demand shock will be delayed, then investment will jump up at that moment, but will fall over time from that new level until the shock finally arrives. Thereafter, it will rise to its new steady state level. Over the entire period, the capital stock will be declining. The price of investment is fixed in the model with internal adjustment costs, but is predicted to move in parallel with investment in the model with external adjustment costs.

The models also make like predictions for the output market. Both predict that the quantity of industry output will fall along with the capital stock, but that the price of output will rise over time, both before and after the policy shock. However, this rise will be interrupted by a discrete jump down in the price level at the moment that the shock arrives. It is this common set of implications that I will look for in the data.

I have complete price and quantity data by industry for the period between announcement and scheduled implementation of phase 4 of the policy in 2005, so I am able to perform several tests to compare observed with predicted trends during this period. In the period after 2005, I have less-detailed industry data, but I will still be able to get some insights into the qualitative behavior of the variables of interest. I will also examine trade data over both periods. Finally, I will consider alternative explanations for the observed investment behavior, and I will examine related data from a few other sources for further evidence.

Note, however, that I may not directly observe the import-competing industry that I have modeled above. Even within narrowly-defined industries like those I observe–six digit NAICS categories in this case–there can exist a considerable dispersion of product qualities. To highlight the issues this raises, consider the stark example of an industry that produces two products–one high-quality and one low-quality. The low-quality product is subject to competition from an identical imported product, whereas the high-quality product faces no import competition. However, I only observe data reflecting the aggregate output, investment, and so forth of these two types of producers.

In general, the models' predictions regarding quantities will be unaffected. The real investment and output that we observe are the sums, respectively, of the investment and output of these two types of producers. If the high-quality segment of the industry is unaffected by the policy change, then we have simply added a constant to the investment and output quantities of the low-quality producers to arrive at the industry aggregates. In percentage terms, all of the quantity changes we observe will be smaller in magnitude because they are a weighted average of the change in the high-quality segment (zero) and the change in the low-quality segment. In this case, even the large changes in real investment we have already seen would be underestimates of the actual shifts in real investment by the low-quality segment.

The models' predictions for prices, on the other hand, may be entirely confounded because the price series are an average rather than a sum. In particular, because the quantities of investment and output from the low-quality segment are likely to decline over time, the low-quality segment's weight in any given price index will also be declining. The upshot is that each price index will tend toward the relevant price for the high-quality segment. In the case of output, where we might assume that the price of the high-quality good is higher than the price of the low-quality good, we would tend to see the composite price index rise over time toward the price of the high-quality good simply because the cheaper, low-quality segment is shrinking. This effect could offset any decline in output price for the low-quality segment. The implications of this effect on the price series for investment are even less clear because, although the series will once again tend toward the capital price of the high-quality segment, it is not obvious which segment pays a higher price for capital.

Finally, note that if these models do indeed explain a good deal of the observed investment behavior, then they also help to explain why it is that investment by phase 4 industries should react more strongly than that of other textile and clothing industries around the time of trade liberalization. Recall that under the ATC, each importing country was free to choose which products would be represented in which phase of liberalization, with the only serious constraint being that some share of products had to be represented in each of the first three phases. The allocation of products across phases was effectively a political task, and U.S. producers (rather than consumers) would have exerted the bulk of the lobbying force. If adjustment costs were an important consideration, then the industries that would have the highest willingness-to-pay to have their products put into a late phase of liberalization would be (1) those industries that had to make the largest adjustments, perhaps rolling up a large share of existing capacity and; (2) industries which, for a given amount of adjustment, faced the highest adjustment costs. This is true for two reasons. First, for a given amount of capital adjustment, the cost of that adjustment is decreasing in the amount of time available to perform the adjustment. Second, for a given adjustment path, the present value of the total adjustment cost is reduced by pushing those costs further into the future. Thus, if the likelihood of an industry getting assigned to a later phase of liberalization was positively correlated with its willingness-to-pay to have its liberalization delayed, then we would expect to find those industries for which capital adjustment costs are most important overrepresented in the last phase of liberalization. I show in section 5 that, indeed, the observed severity of decline in investment prior to implementation can be used to rationalize almost exactly which industries were allocated to phase 4.

4 Data

Annual data on U.S. manufacturing, by six-digit NAICS industry, come from the NBER Manufacturing Productivity Database.[16] These data are taken from the Census of Manufactures (CMF) and the Annual Survey of Manufactures (ASM) conducted by the U.S. Department of Commerce, or estimated using other public data from these sources where needed; and from price series from the BEA and BLS. From this dataset, I take quantity and price series for investment, quantity series for real capital stock, as well as plant and equipment stock separately, and quantity and price series for shipments. The dataset also provides series for production employees, hours, and wages. The database is available on the NBER website, the most recent version including data through 2005. Investment and shipment data for the period after 2006-2009 come directly from the ASM and CMF,

[16] See Bartelsman and Gray (1996).

which are available on the Census Bureau website.

Economy-wide investment quantity and price data, which I use as controls, are from the U.S. National Income and Product Accounts from the BEA. I test my results using various series for quantity, the primary being real nonresidential investment. I use a variety of price series as well, which I specify in the analysis section. These come either from the BLS or from sources already named.

Historical data relating to the quota policies come from various sources. The products included in each phase of the liberalization are from the Federal Register, which also contains the preliminary allocations (printed for public comment and revision in 1994 before the final versions were announced in 1995). For those who are curious, industry requests for relief from import competition by way of the China safeguard are also published in the Federal Register, the first such case appearing in 2004. The U.S. Department of Commerce Office of Textiles and Apparel's (OTEXA) website has time series for imports and production for each product, and provided historical information in personal correspondence. Information about the quota levels comes from from Brambilla, et al. (2010), from the OTEXA website, and from Peter Schott's website.

In order to determine which industries' products belonged to each of the phases of liberalization, I used a concordance between HTS categories on the one hand and NAICS categories on the other. For the majority of product codes, Pierce and Schott (2009) contained the necessary concordance; the remainder were gathered manually from the USITC website. The USITC website is also the source for most of the trade data, both price and quantity, used at various places in the analysis.

5 Analysis and Estimation

In this section, I will examine the data to determine whether and which of the predictions of the capital adjustment models presented earlier are borne out. Although I will consider phase 2 and 3 industries occasionally, I will focus primarily on phase 4 industries. My statistical tests will concentrate on the period for which I have full data–namely the years through 2005–and I will judge the qualitative behavior of variables in the post-2005 period using what data I have at my disposal for that period, less detailed though it is. I begin by documenting the crash in capital investment, particularly among phase 4 industries, in the years immediately preceding the scheduled liberalization in the U.S. of trade in the products produced by those industries. I show that membership of an industry in phase 4 of liberalization can be almost perfectly predicted by the magnitude of the estimated decline in investment. Next, I examine the capital and output markets for those industries to see whether the predictions for those markets obtain. Using parameter values that reflect these estimates, I then generate a numerical estimate of the predicted path of real investment by phase 4 industries over the pre-implementation period. The predicted path falls within the band of significance of the observed investment path in every year beginning in 1996. Finally, I consider relevant data regarding contemporaneous developments in the domestic sector that produces much of the capital used by textile and clothing producers, along with related U.S. trade data, to see whether movements in these series accord with my other findings in a way that is consistent with the models.

The NBER Manufacturing Productivity Database contains 49 six-digit NAICS industries that make products affected by phases 2-4 of the quota liberalization.[17] I will ignore those industries

[17] Recall that the U.S. did not actually have quota restrictions on any of the phase 1 product lines.

that include some textile products, but which do not primarily make textiles or clothing.[18] In particular, I will only consider those industries falling within NAICS categories 313-316,[19] leaving me with 38 industries. For most of these, I have annual data for the years 1958-2005, giving me 48 observations for most six-digit industries, and 1746 observations in total. However, products were assigned among the liberalization phases at the HS product level, not at the NAICS industry level. NAICS industries typically comprise dozens of HS-level products, each of which could belong to any of the four phases of liberalization, so there is generally no one-to-one mapping between NAICS industries and liberalization dates. To proceed, I assign each NAICS industry to a liberalization phase based on the 1990 product import intensity. Specifically, I disaggregate the total quantity of T&C imports[20] in 1990 for each NAICS industry into its constituent HS product lines. Using the one-to-one relationship between HS products and liberalization phases, I then determine the percent of product lines in each NAICS category, weighted by the quantity of 1990 imports, that belongs to each phase of liberalization and assign each NAICS industry to the phase to which the largest share of its HS lines belongs.

5.1 Real Investment

Both adjustment cost models predict that industry should anticipate the policy change by reducing investment before the event, and graphical evidence of a decline in investment for at least one set of

[18] To take one example, trade in 'electric blankets' was liberalized in phase 3 of the ATC. This product belongs to NAICS industry 335211: 'Electric Housewares and Household Fan Manufacturing '. I ignore this industry, which I assume was not likely to have been greatly affected as a whole by liberalization in textile and clothing trade.

[19] These respectively comprise 'Textile Mills', 'Textile Product Mills', 'Apparel Manufacturing', and 'Leather and Allied Product Manufacturing'.

[20] Quantities are measured in square meter equivalents (SME), a unit that was devised under the quota system for the purpose of meaningfully adding together quantities of different products.

industries has already been presented. In order to test formally for statistically significant changes in real investment due to proximity to a policy change, I examine data for the years immediately preceding liberalization, using the reduced-form specification

$$\log(I_{it}) = \alpha_i + \beta_i t + \gamma_i \log(GNRI_t) + \lambda_p' \nabla_{pt} + \varepsilon_{it}$$

where i indexes a six-digit NAICS industry, p is the liberalization phase to which that industry belongs, t indexes time in years, I is real investment, and $GNRI$ is national real gross nonresidential fixed investment. This specification allows for industry fixed effects and industry-specific linear time trends in log investment, as well as industry-specific correlation between industry investment and national investment. I include the measure of national investment to attempt to control for factors that depress all investment, such as tight financial conditions, and in particular I do not want to causally ascribe the dip in investment that accompanied the 2001-02 recession to simultaneous or forthcoming trade policy changes.

The models predict a particular pattern for the vector of coefficients on ∇_{pt}, which is a vector of indicator dummies. For each liberalization event, I include a separate dummy for affected industries for each year, beginning a few years prior to implementation of the event. Each dummy is assigned a value of zero except for observations in the year represented by that dummy for industries in the phase that were affected by the associated liberalization event. For example, one of the dummy variables corresponds to the year two years before phase 3 industries faced import competition. The value of this dummy is always zero, except for observations for phase 3 industries in the year 2000 (two years before the third phase of ATC liberalization in 2002). The coefficient on this dummy can be interpreted as the average difference (in log points) between observed investment by phase 3 industries in 2000, on one hand, and expected investment by phase 3 industries, given trends and national investment level, on the other. Similarly, there is a dummy for phase 3 industries for 1999, another for 2001, and so on for each year through the end of the data set in 2005. If adjustment costs are important enough to lead to an reduction in investment in a given year, then the models predict that the coefficient on the dummy for that year will be negative, and that the coefficients on dummies for the following years will follow a particular pattern with respect to the timing of the liberalization event, as described in section 3.

Some results from this regression for the years leading up to liberalization are given in table 1. Each column in the table contains the coefficients on the year dummies for a given liberalization event. The top row contains the coefficients for the dummies that represent the year four years prior to liberalization, and each subsequent row contains the coefficients for the dummies for the subsequent year, with the bottom row giving the coefficients on the dummies for the year of liberalization. For example, the cell in column 'Phase 2', row 'Three years' (before liberalization) shows that real investment by phase 2 industries in 1995 (three years before phase 2 liberalization occurred in 1998) was about 12 log points below the expected level, on average, and that this deviation was not statistically significant.

In general, phase 2 and phase 3 industries show some of the anticipatory investment behavior predicted by the models. None of the coefficients on the year-event dummies is significant for the initial liberalization of phase 2 products, although investment is low and the point estimate is falling for phase 2 industries in the two years immediately preceding China's WTO accession. Likewise, investment by phase 3 industries was low in the year before phase 3 of liberalization. In both cases, the point estimate for investment increases in the year of liberalization, another prediction of the models.

On the other hand, the dummies for phase 4 industries are negative and significant in each of the 4 years prior to liberalization. Investment by phase 4 industries was below its predicted level by

2001, even after accounting for the general drop in investment that accompanied the 2001 recession. The point estimates of the coefficients representing each subsequent year leading up to liberalization show an average decrease of about 0.35 log points per year, indicating that investment declined still further over this period. Investment (temporarily) bottomed out the year before liberalization was scheduled to occur, when the estimated coefficient reached -1.51 log points, an exceptionally low level. In comparison, this point estimate–representing the average level of investment across 16 industries for that year–is lower than the estimated residuals for all but three industry-years in the rest of the dataset. The 'year of liberalization' dummy for phase 4 industries shows that while investment remained low that year, it increased significantly from its previous level, both in economic and statistical terms, to -1.14 log points. The qualitative trends in these coefficients are robust to using other controls for national economic conditions.

Figures 8a-c show the full series of phase-year dummies, still in log points, along with the associated bands of 95% certainty around the point estimates. Figure 8a shows the series of dummies for phase 2 industries, which begins in 1995, three years before scheduled phase 2 liberalization. The point estimates begin to decline in 1998, although they do not become statistically significantly negative until 2000, two years before these industries were exposed to competition from China. The point estimate declines in 2001 and increases in 2002, both of which movements are consistent with the models, and remains low and stable thereafter. Figure 8b shows the corresponding series for phase 3 industries, which begins in 1999, three years before phase 3 of liberalization. The point estimates are declining from the beginning, although none is statistically significantly negative until 2001, the year before liberalization. The point estimate increases in 2002, declines in 2003 and 2003, and increases again in 2005, though again none of these point estimates is statistically distinguishable from the point estimates in the adjacent years. The 2005 increase may have been in part due to the fact that a few phase 3 goods received extended import protection beginning in that year. Further, recalling that the assignment of NAICS categories across phases was imperfect, some of the phase 3 industries contain a few phase 4 products.

Figure 8c shows the dummies for phase 4 industries. Note here that the deviation in investment is significantly negative beginning all the way back in 1996, the first full year after the liberalization schedule was announced.[21] This makes the beginning of the investment response a near-match with the discrete drop in investment that the models predict should occur at announcement.[22] Although most estimates are statistically indistinguishable from year to year, note that the point estimates decline in every year after 1996, as predicted by the models, with the lone exception of 1997. A series of four or more consecutive yearly declines in the point estimate is itself unlikely if investment is not declining during that period. The estimate for the 2002 coefficient is statistically distinguishable from all coefficients more than two years prior, as are each of the next two. In fact, investment falls significantly from 2003 to 2004, and it then increases significantly in 2005. The point estimates behave exactly as predicted by the models beginning in 1996, except for a slight increase in 1997, and the year-to-year investment changes correspond to the models' predictions in the years immediately around scheduled liberalization with a high degree of certainty.

Although I do not have a consistent data series that spans 2005, I can construct a series for investment by these industries for the period 2005-2009. To do this, I use the investment series from the ASM and CMF. The ASM contains data at only the 5-digit NAICS level for many industries, so this investment series is somewhat coarser than the one I constructed from the NBER database. Further, neither the ASM nor the CMF lists investment prices, so I use the national nonresidential

[21] The final allocation of products across phases 2 through 4 was published on April 26, 1995.

[22] The phase 2-4 liberalization schedule was announced near the end of April, 1995, so that it can be argued that 1995 was the first year after announcement. On the other hand, 1996 was the first full calendar year after announcement.

fixed investment price index, which is again a compromise, to deflate this series. Finally, I normalize these series so that the observation for 2005 matches the 2005 level of real investment from the NBER series. The resulting series, which we have already seen in figure 1a, shows that investment behavior by phase 4 industries after 2005 matches the qualitative predictions of the models. Investment jumped up at the time that the delay in liberalization was announced, although not by enough to arrest the decline in the size of the capital stock (not pictured). Investment declined thereafter until liberalization occurred. After liberalization, investment began to rise (although there is only one year of investment data for the post-liberalization period).

Using a related procedure, I can return to the issue of industry assignment across the phases of liberalization. If costly adjustment of the physical capital stock was an important issue in the assignment process, one implication would be that those industries that faced large capital stock adjustments should be more likely to have been placed in the late stages of liberalization. In order to examine the issue, I run the above specification, but this time I allow the coefficients on the year dummies to vary by industry. I then order six-digit industries according to the magnitude of decline in investment that they display in the year immediately preceding liberalization–that is, the year during which capital investment should bottom out according to the models. Table 2 lists, in order, the 20 industries (out of 37[23]) that showed the largest negative deviation from trend in real investment in the year before liberalization, along with the phase to which each industry was assigned. The list includes all 15 phase 4 industries. Only two of the top 17 industries belong instead to phase 3, while the remaining non-phase-4 industries are ranked 18-20. Recall that, in the presence of capital adjustment costs, it is those industries which have the largest adjustments to make that

[23]NAICS 315999, a phase 4 industry, was excluded because data for it are available for only a limited range of dates.

stand to gain the most by delaying liberalization. Thus, the fact that phase 4 was packed with industries that underwent large declines in real investment, even before liberalization, reinforces the notion that the cost of adjustment of the physical capital stock was an important consideration in assignment of industries among phases.

5.2 The Markets for Output

Critical to the dynamics predicted in the model is downward sloping demand for the output produced by the capital-owning industry. If demand were perfectly elastic, then the price of output would be fixed irrespective of industry capacity and output, and also of imports. The response of changes in any of these would be strictly through quantity, and the value of capital would be unchanged, barring other changes on the supply side.

The models make two main predictions for the output market during a contraction in supply in the presence of downward sloping demand. The first is that industry output should fall; the second is that, during this decline, the price of the output should be rising. These implications are clearly at odds with most explanations for the investment crash that involve a contemporaneous decrease in demand for output. Such explanations would tend to imply that quantities and prices in the output market should be moving in the same direction.

To test for these effects, I examine shipment data for phase 4 industries. I construct a quantity shipments index in two parts. For the pre-2005 period, I create an index of real shipments for each phase 4 industry using the NBER database. I then divide this series by real goods production in the U.S., take logs, normalize 1990 shipments to 100, and average across phase 4 industries. For 2005-09, I gather ASM shipments data, using BLS production price indices to arrive at real shipments. I divide each point in this series by national real goods production for the corresponding year, take logs, and normalize the 2005 value to match the 2005 value from the first series. I then detrend the resulting series for the period 1990-2000.

The resulting series appears in figure 9. Indeed, there appears to be a decline in shipments by these industries that begins around the time of the decline in investment. By 2004, the year before liberalization was scheduled to occur, shipments were 0.61 log-points below trend on average. Shipments continued to decline thereafter, as predicted.

To test for this formally, I use the specification

$$\log(S_{it}) = \alpha_i + \beta_i t + \gamma_i \log(GDGP_t) + \lambda' \nabla_t + \varepsilon_{it}$$

where S_{it} is the quantity of shipments by industry i in year t, $GDGP$ is real gross domestic product of goods, and ∇ is again a vector of dummies, one each for the 4 years immediately preceding phase 4 liberalization and one for the post-liberalization period. I run this specification using the full data set for phase 4 industries, with the results given in table 2.

Each of the dummies is negative and highly statistically significant, and the dummies as a group become more negative as time passes, indicating that real shipments by phase 4 industries in the years preceding phase 4 liberalization fell ever further below trend.

Next, I turn to the price data. Figure 10 shows a chained shipment price index for phase 4 industries, relative to the US consumer price index (CPI) from 1982-2010. As with the real shipment data, I have detrended this series, this time for the period 1982-2001. Also, I have extended the series past 2005 by using producer price indices from the BLS. This figure shows that, during the period 2001-2010, when both real investment and real shipments are declining, prices are rising.

To test this formally, I use the specification

$$\log\left(\frac{P}{CPI}\right)_{it} = \alpha_i + \beta_i t + \gamma \nabla_t + \varepsilon_{it}$$

where P_{it} is price of shipments by industry i in year t, and CPI is the urban consumer price index (less energy and food). Again, ∇ is once again a vector of dummies, one each for the years 2001-2005. The value of the coefficient on this dummy represents a break in the price trend during this period. A positive (negative) coefficient value would represent an increase (decrease) in prices relative to trend during this time, while a value around zero would suggest no significant deviation from trend. I run this specification using data on all phase 4 industries from 1982-2005, and the results are shown in table 3. The coefficients are significantly positive, and the point estimates increase each year after 2002, as predicted by the models. Figure 10 shows that this trend continued subsequently. However, no evidence of the predicted price decline upon final liberalization in 2009 appears. In fact, the price continues to rise, highlighting the possibility that the observed price increase may be driven by the compositional effects discussed at the end of section 3.3.

The trade data may shed some light on the likely underlying price movements. Consider again the case of a single industry that produces a high-quality product and a low-quality, import-competing product. In such a situation, the price of the low-quality product should positively covary with the price of imports, in which case we could get some useful evidence by examining the behavior of the import price index. The models would here predict that the prices of imports should decline upon liberalization.

Figure 11 shows import prices for phase 4 goods from 1997-2009, the full period for which NAICS-based trade data are available. Import prices are trending downward from 1997-2001, a period during which domestic prices were also declining for these goods. This trend appears to stop in 2002, around the beginning of the decline in domestic shipments and increase in domestic prices. However, we see two notable subsequent yearly declines in the price of imports, and these declines happen to coincide with the initial surge in imports in 2005 and the ultimate removal of the remaining import restrictions in 2009. Thus, what evidence is available in the import price data accords with the predictions of the models.

5.3 Investment Prices

With respect to the price of investment, the models differ in their predictions. The external adjustment cost model predicts that, during an investment decrease spurred by a decrease in future demand, the price of investment should be falling, and that it should begin rising once the demand shock arrives. Meanwhile, the internal adjustment cost model assumes a constant investment price at all times.

In addition to the issue raised at the end of section 3.3, analysis of the price data is hindered by two additional difficulties. First, the results are sensitive to which control for trends in national investment prices is used. This is shown in figure 12, where I have plotted detrended time series for the average price for phase 4 investment goods relative to three likely controls–the price index for national gross domestic nonresidential investment; for national gross domestic investment in nonresidential structures; and for national gross domestic investment in equipment in software. Figure 12 shows that in the period leading up to 2005, investment prices (relative to trend) are low and falling relative to the corresponding series for structures; are high and rising relative to that for equipment and software; and that they decline relative to nonresidential investment prices as a whole around the time of the crash in phase 4 investment, and remain low during thereafter. The first of these–national gross domestic nonresidential investment–is the sum of the other two, so it is likely that the best control is some weighted average of these two.

Second, the industry that produces equipment for the textile and clothing manufacturers may itself be in a position similar to those manufacturers. It experienced a decrease in demand for its output, a decrease which it may have foreseen, and therefore it may have begun to decrease its capacity. This would have the effect of shifting the *supply* curve in our model inward over time, which would tend to amplify the quantity decrease in investment, but to simultaneously mute any price decrease.

To begin, I present the results from running the following specification:

$$\log(P_{it}) = \alpha_i + \beta_i t + \gamma_i \log(PNFI_t) + \lambda D_t + \varepsilon_{it}$$

where P_{it} is the price of investment for industry i in year t, $PNFI$ is the price index for gross domestic nonresidential fixed investment, and D is once again a dummy, here indicating whether the year in question is one of the four years immediately preceding phase 4 of the ATC liberalization.

The results appear in table 4. These coefficients are negative, as predicted by the theory, and are statistically significant. However, because price coefficients of either sign can be generated for many of these years depending upon which price index is selected to control for national economic conditions, as discussed above, I will examine some related data for further evidence.

Further evidence can be found by examining data for NAICS industry 333292–producers of textile machinery. These data are less tightly linked to the investment behavior of phase 4 industries because this industry serves all textile makers. On the other hand, it is just this type of equipment that is most likely to be a trapped factor subject to the dynamic forces in the model–that is, textile machinery is not likely to be useful to producers of anything but textiles. Figure 13 shows time series for the values of shipments by textile machinery manufacturers, imports of textile machinery, and exports of textile machinery. We see a notable decline in both shipments and imports that largely overlaps with the decline in phase 4 investment, and little movement in exports during the same period.

Figure 14 shows time series for real shipments by U.S. textile machinery manufacturers relative to real U.S. industrial equipment output; and a price index for shipments by the industry, relative to industrial equipment prices nationwide.[24] We see that during the period of declining phase 4 investment, textile equipment prices in general are declining.

Finally, I return to the last point raised above–that producers of capital for textile and clothing manufacturers themselves faced a foreseeable decline in demand for their output, and so may have been contracting their capacity during this period as well. Figure 15 shows a time series for real investment by U.S. textile machinery manufacturers, relative to real U.S. nonresidential fixed investment; and a price series for investment by the industry, again relative to the prices for U.S. nonresidential fixed investment, in deviation from trend, with 1990=100. No clear trend in real investment appears in the first half of this period, but a decline is clear after 2000, and that decline is accompanied by a decline in the relative price of the investment good, suggesting that the decline is driven by decreasing demand by the industry for investment. These facts, together with the shipment data, suggest that this industry was indeed in the process of contracting its capacity. As stated above, such a contraction would tend to amplify the quantity response of investment by the downstream phase 4 industries while attenuating the effect on the price of that investment. Taken together, these factors make it difficult to judge whether or not there are important, but offsetting, effects on the price of investment for phase 4 industries during this period. In turn, it is difficult to distinguish which of the models of adjustment cost presented better captures the adjustment costs that drove investment behavior in these industries.

[24] The price series shows the deviation from the pre-2001 trend, with 1990=100.

5.4 Simulation

In this section, I simulate numerically the path of adjustment for an 'average' phase 4 industry using the model with internal adjustment costs. I then search the parameter space to find the best fit and compare those optimal parameter values to the parameter values that would be expected given the empirical findings already presented.

The dynamics of the internal adjustment cost model are pinned down by values for b, r, and δ, a demand curve for output, and an initial condition on I and K. I will constrain my search over these variables by adopting a value of $b = 0.195$ from Cooper and Haltiwanger (2006), using $r = \delta = 0.05$, assuming a demand curve with constant elasticity, and taking the initial value of K as its steady state value prior to announcement of the policy. This leaves me with two parameters: the elasticity of demand and the initial value of I (that is, the value of I in 1996, immediately after announcement of the policy).

I conduct the search over this two-dimensional parameter space as follows. For a given pair of values, I numerically estimate the continuous-time real investment path for nine years (i.e., from the beginning of 1996 to the end of 2004). I then collapse this continuous-time path into nine discrete values for annual investment. Finally, I compare these estimated values with the point estimates from my empirical estimates of real investment. I take as the best fit the pair of parameters which gives the lowest sum of squared errors in this comparison.

Figure 16 plots the best-fit simulated path for annualized real investment on top of the estimated path for real investment by phase 4 industries that was shown in figure 8c. Each of the nine simulated values for annual investment falls within the band of significance of the estimated investment for the corresponding year. Clearly, the optimal initial value of I closely matches the estimated value.

Using the estimates for changes in log shipments and log prices of output presented earlier (see

Tables 3 and 4), we can get an empirical estimate of demand elasticity. Taking the ratios of the values from the year before liberalization (that is, from 2004), we get an estimated demand elasticity of -21.9. The best-fit elasticity of demand from the simulation of -19.7 compares favorably with this value. Additionally, if I instead take the estimated demand elasticity and use it to simulate the path for investment, each of the simulated investment values still falls within the bands of significance of the estimates whether I take as given the initial value of investment, the final value of investment, or use the best-fit initial value of investment. These findings further reinforce the hypothesis that capital adjustment costs of the type described in the theory outlined earlier were the primary driver of the dynamics engendered by the announcement and implementation of the ATC in the U.S.

6 Conclusion

The investment patterns for all affected U.S. textile and clothing manufacturers around the time of important trade liberalization qualitatively matches the predictions of either of two models of investment with costly capital stock adjustment under uncertainty over the date of liberalization. The liberalization of textile and clothing imports scheduled for 2005 was preceded by an especially large episode of disinvestment by the directly competing U.S. industries–so called 'phase 4 industries'. Investment by these industries was low and declining beginning in 1996 and, after a one-year surge in 2005 during which investment by these industries nearly doubled, it continued to decline through 2008. Given the policy environment during this period, this investment behavior too matches the predictions of these models with capital adjustment costs.

I showed that, based only on the estimated decline in real investment across industries, I could predict very closely which industries would be assigned to the last phase of liberalization. In the presence of adjustment costs that are heterogeneous across industries, those industries with the largest adjustment costs would benefit most from having liberalization in their products delayed. In such a case, if the likelihood of being assigned to phase 4 of liberalization was positively correlated to the willingness to pay of the industry, the observed pattern is exactly the pattern that would be expected.

I found that the quantity of output produced by phase 4 industries moved qualitatively as predicted by the models. That quantity of output was decreasing while the relative price of that output was increasing suggests that these dynamics are being driven by supply- rather than demand-side factors. I estimated total domestic consumption to verify that increasing net imports were more than offset by decreasing shipments. Further, I examined import prices (relative to shipment prices) over this period and found that they generally mirrored the movements in the domestic shipment price series, but that they saw a notable decline in the years of liberalization events. This provides some evidence that the underlying output prices were moving in the manner predicted by the models, though those movements may have been affected by compositional effects in the industry data.

I further used the model with internal adjustment costs to generate a numerical simulation of investment over the nine years preceding liberalization for phase 4 industries. The results strongly support the hypothesis that the observed dynamics were driven by capital adjustment costs. Using only parameter values from the literature and the observed path of investment, the model generates a best-fit for the remaining parameters that closely matches the values derived from the empirical estimates. Conversely, a simulation using parameter values taken directly from the empirical estimates yields an investment path that closely matches the observed path over the entire nine-year period preceding liberalization.

Taken together, these findings suggest that this episode of disinvestment by phase 4 industries was driven by a decline in demand for investment associated with a policy change in the form of trade liberalization that was anticipated with uncertainty. This result suggests that accounting for capital dynamics, particularly driven by internal capital adjustment costs, may be an important element in modeling the response of markets to trade policy changes, and in estimating the welfare effects of those changes. It also provides a stark example of the anticipatory investment behavior arising from adjustment costs that is predicted in the theoretical literature. The fact that a disinvestment of this magnitude was not observed for phase 2 and 3 industries, both of which eventually faced strong import competition as well, suggests that the importance of the drivers of the dynamics observed in the behavior of phase 4 industries is heterogeneous across industries. It is likely that the peculiarities of the ATC policy itself served to highlight a set of industries for which these costs are particularly important.

Finally, this result can inform policy evaluation outside of the realm of trade policy. The fact that the policy in question pertained to international trade is in some ways incidental. If industries are prone to react to forthcoming policies, or to the uncertain prospect of policies, in the manner documented here, then a careful evaluation of the effects of those proposed policies would do well to account for such behavior.

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Tables and Figures

Table 1: Deviation in Log(Real Investment) by Proximity to Policy Change

Years before liberalization	Phase 2	Phase 2 (China)	Phase 3	Phase 4
Four years	-	-	-	-.637** (.114)
Three years	-.123 (.123)	-.256 (.131)	-.017 (.141)	-1.01** (.110)
Two years	-.062 (.123)	-.506** (.135)	-.163 (.147)	-1.24** (.111)
One year	.019 (.125)	-.661** (.1312)	-.353* (.141)	-1.69** (.112)
Year of liberalization	-.124 (.128)	-.458** (.127)	-.280* (.137)	-1.14** (.113)

* significant at the 5% level; ** significant at the 1% level

N = 1746; R^2 = .912

Notes: Values shown are average deviations by year, in log points, from predicted real investment by the specified industry group. Standard errors appear in parentheses.

Table 2: NAICS Industries by Magnitude of Deviation in Real Investment

NAICS Industry	Deviation in Log Investment	Phase	NAICS Industry	Deviation in Log Investment	Phase
315222	-2.54	4	313113	-1.60	4
315228	-2.53	4	313210	-1.54	4
315223	-2.45	4	316991	-1.45	3
315221	-2.25	4	315233	-1.44	4
315224	-2.06	4	315993	-1.32	4
315234	-1.89	4	315231	-1.32	4
313249	-1.72	3	315232	-1.13	4
313111	-1.70	4	316214	-0.96	2
315239	-1.69	4	316992	-0.89	3
315991	-1.60	4	316219	-0.75	2

Notes: Values shown are deviations, in log points, from predicted real investment levels in the year preceding liberalization.

Table 3: Deviation in Phase 4 Log(Real Shipments) by Proximity to Policy Change

Years before liberalization	Phase 4
Four years	-.367** (.047)
Three years	-.634** (.048)
Two years	-.741** (.048)
One year	-.943** (.048)
Year of liberalization	-1.03** (.048)

* significant at the 5% level; ** significant at the 1% level N = 729; R^2 = .972

Notes: Values shown are average deviations by year, in log points, from predicted real shipments. Standard errors appear in parentheses.

Table 4: Deviation in Phase 4 Shipment Prices by Proximity to Policy Change

Years before liberalization	Phase 4
Four years	.022** (.0069)
Three years	.018* (.0073)
Two years	.029** (.0076)
One year	.043** (.0080)
Year of liberalization	.056** (.0083)

* significant at the 5% level; ** significant at the 1% level N = 324; R^2 = .986

Notes: Values shown are average deviations by year, relative to CPI, from predicted shipment prices, with 1997 relative price = 1. Standard errors appear in parentheses.

Table 5: Deviation in Phase 4 Log(Investment Prices) by Proximity to Policy Change

Years before liberalization	Phase 4
Four years	-.020** (.0046)
Three years	-.030** (.0047)
Two years	-.031** (.0048)
One year	-.029** (.0048)
Year of liberalization	-.037** (.0049)

*significant at the 5% level; **significant at the 1% level N = 729; R^2 = .999

Notes: Values shown are average deviations by year, in log points, from predicted investment prices. Standard errors appear in parentheses.

Figure 1a

Textile and Clothing Industry

Relative Real Investment

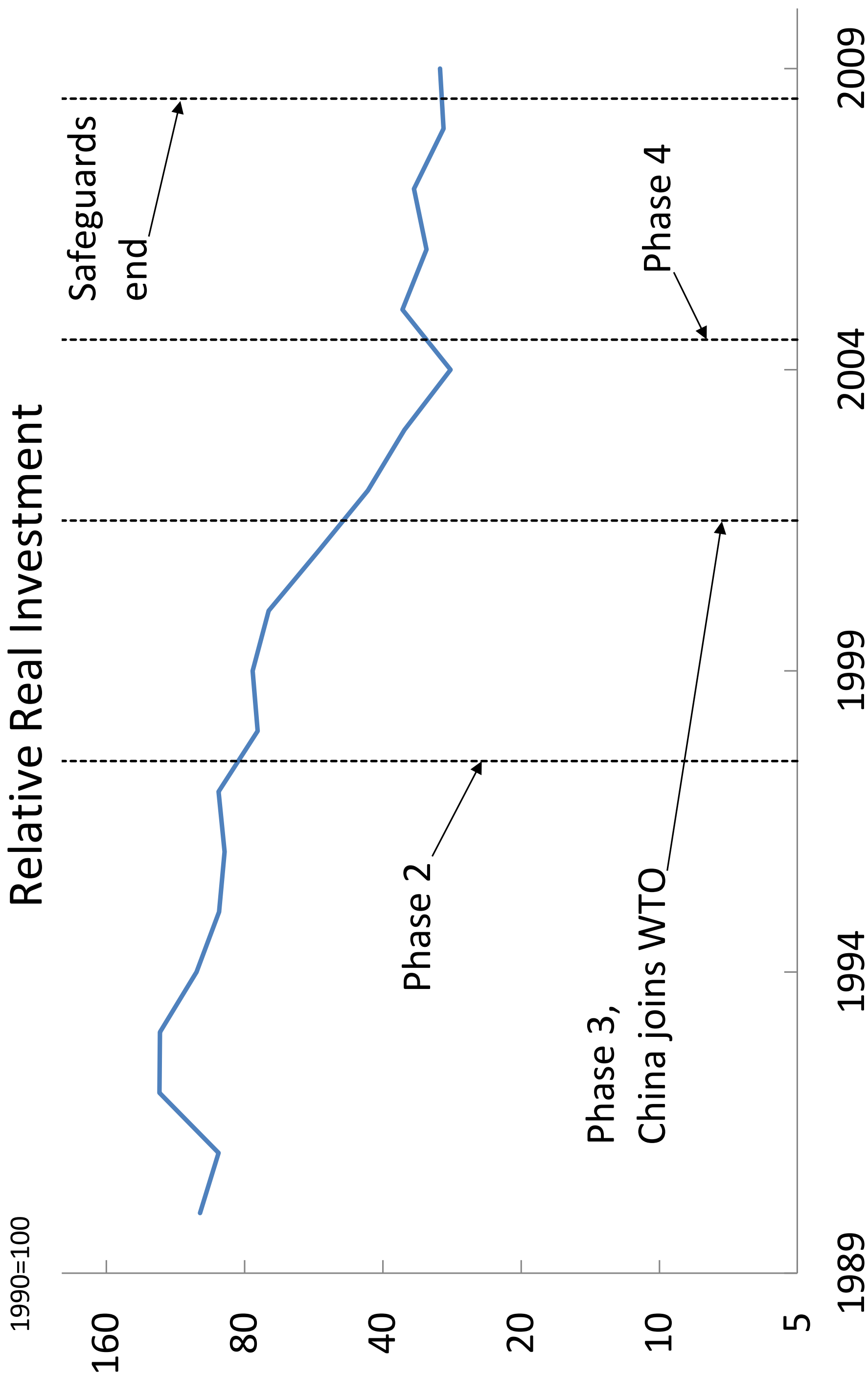


Figure 1b

Textile and Clothing Industry
Relative Real Investment by Phase

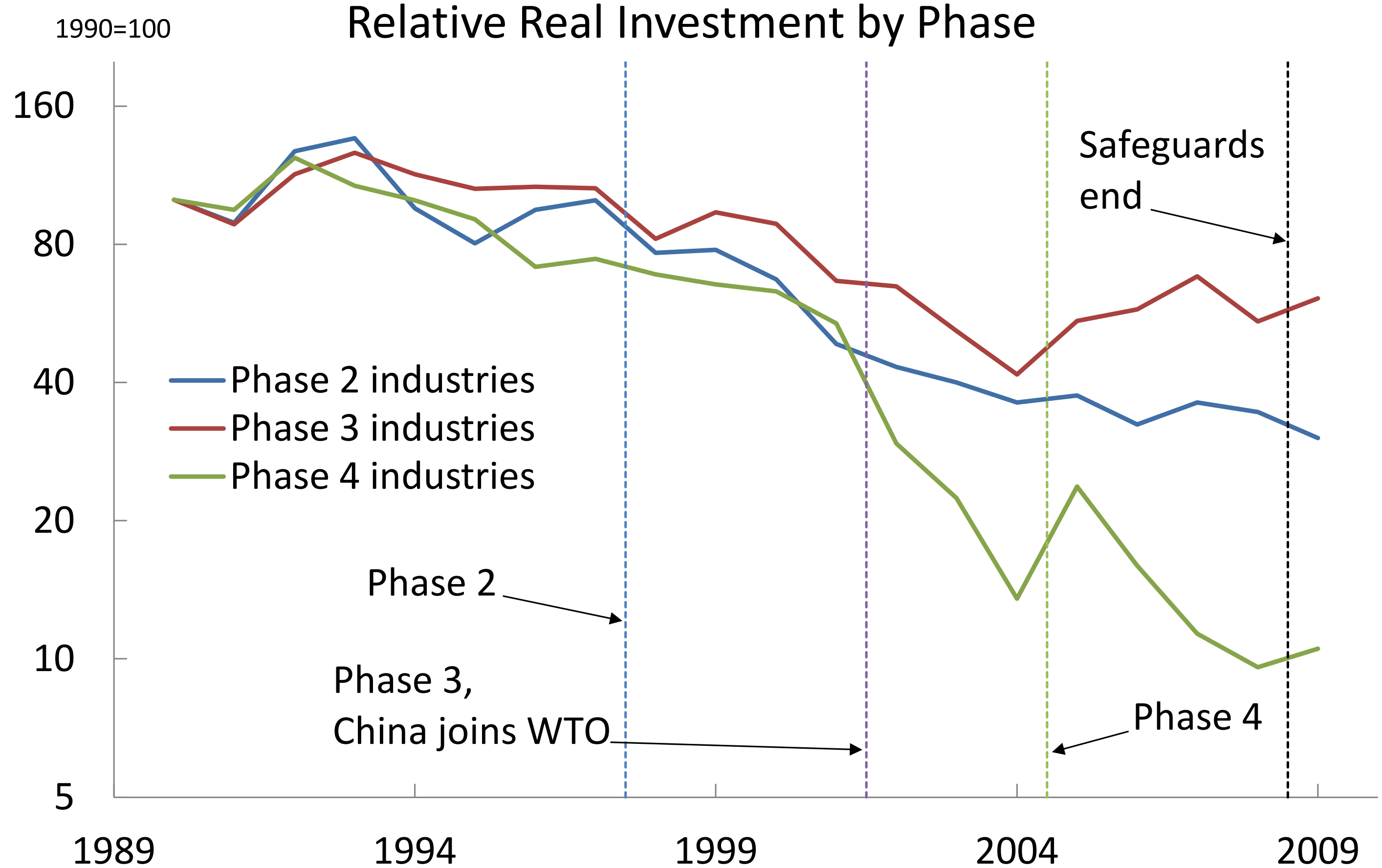


Figure 2
Capital Market Dynamics

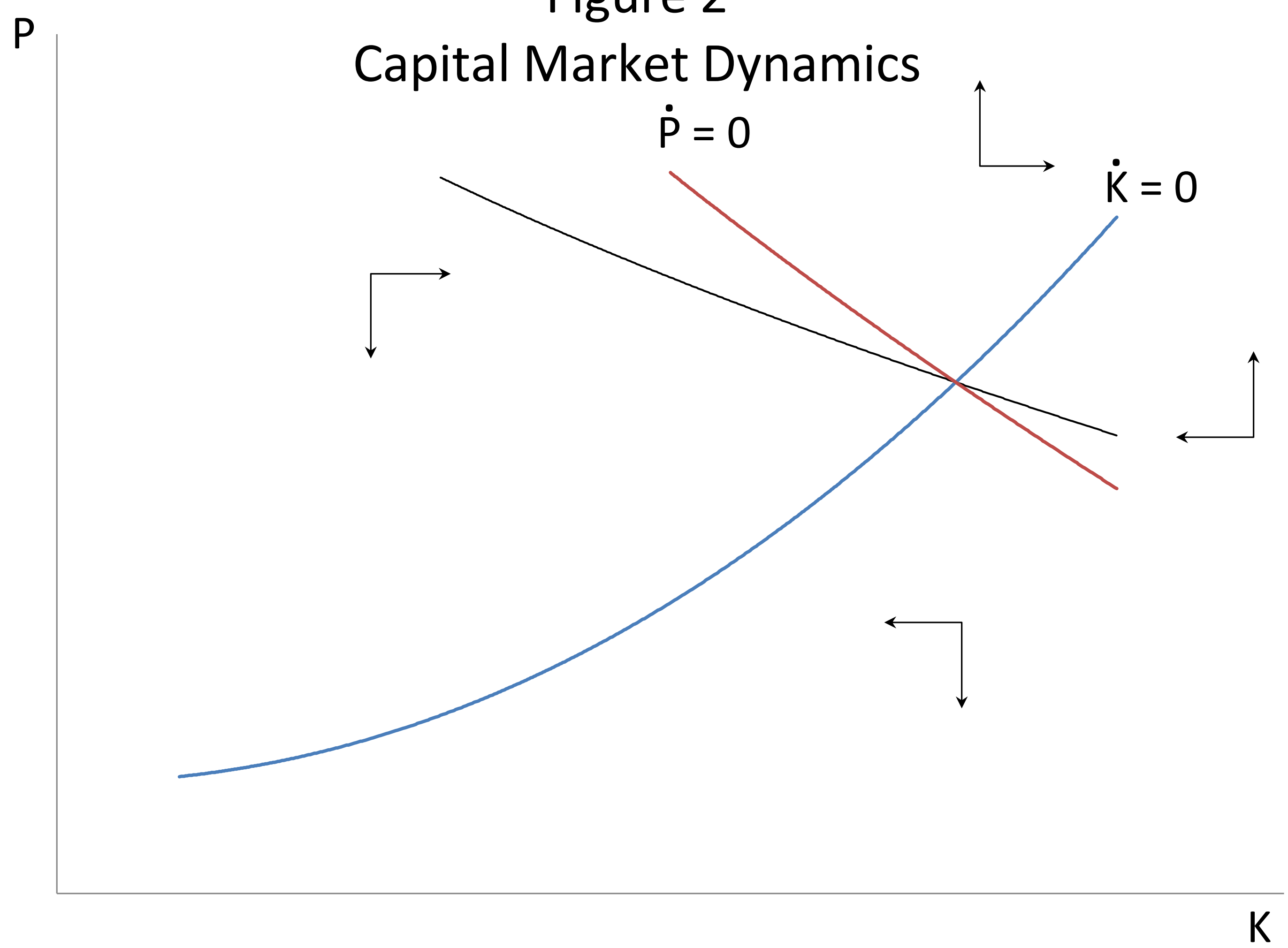


Figure 3

Dynamics with Foreseen Demand Shock

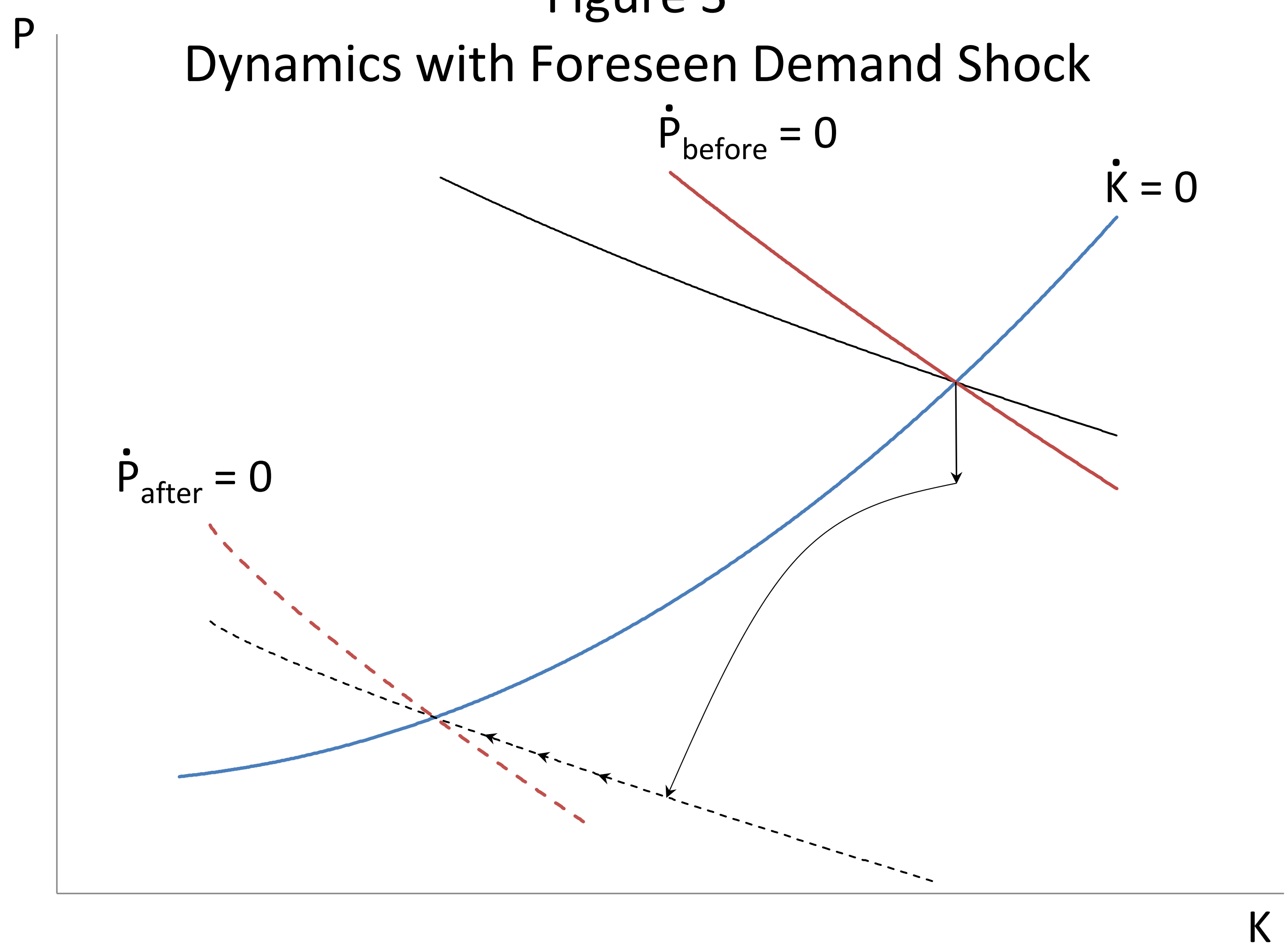


Figure 4a
Market for Capital

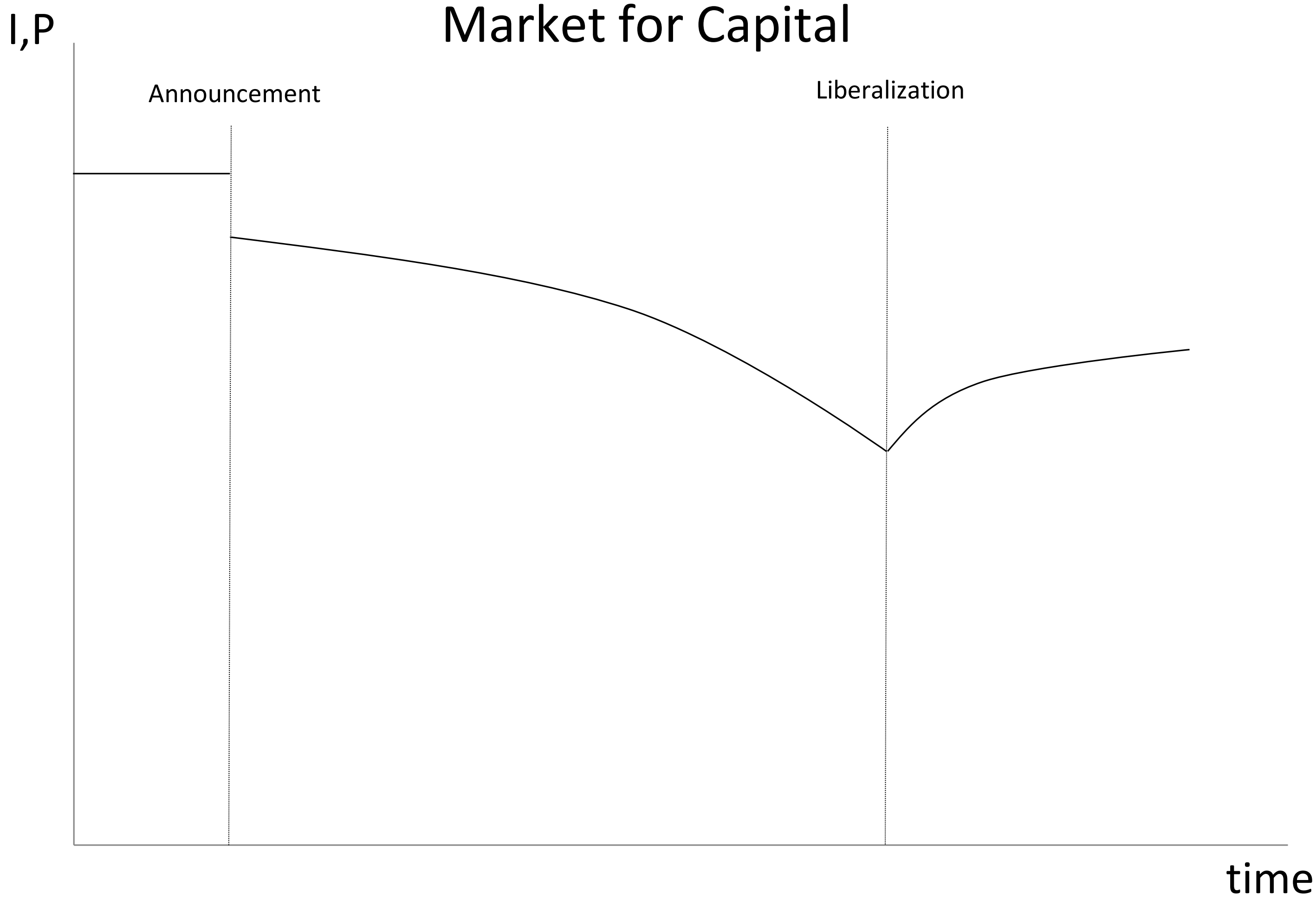


Figure 4b
Market for Output

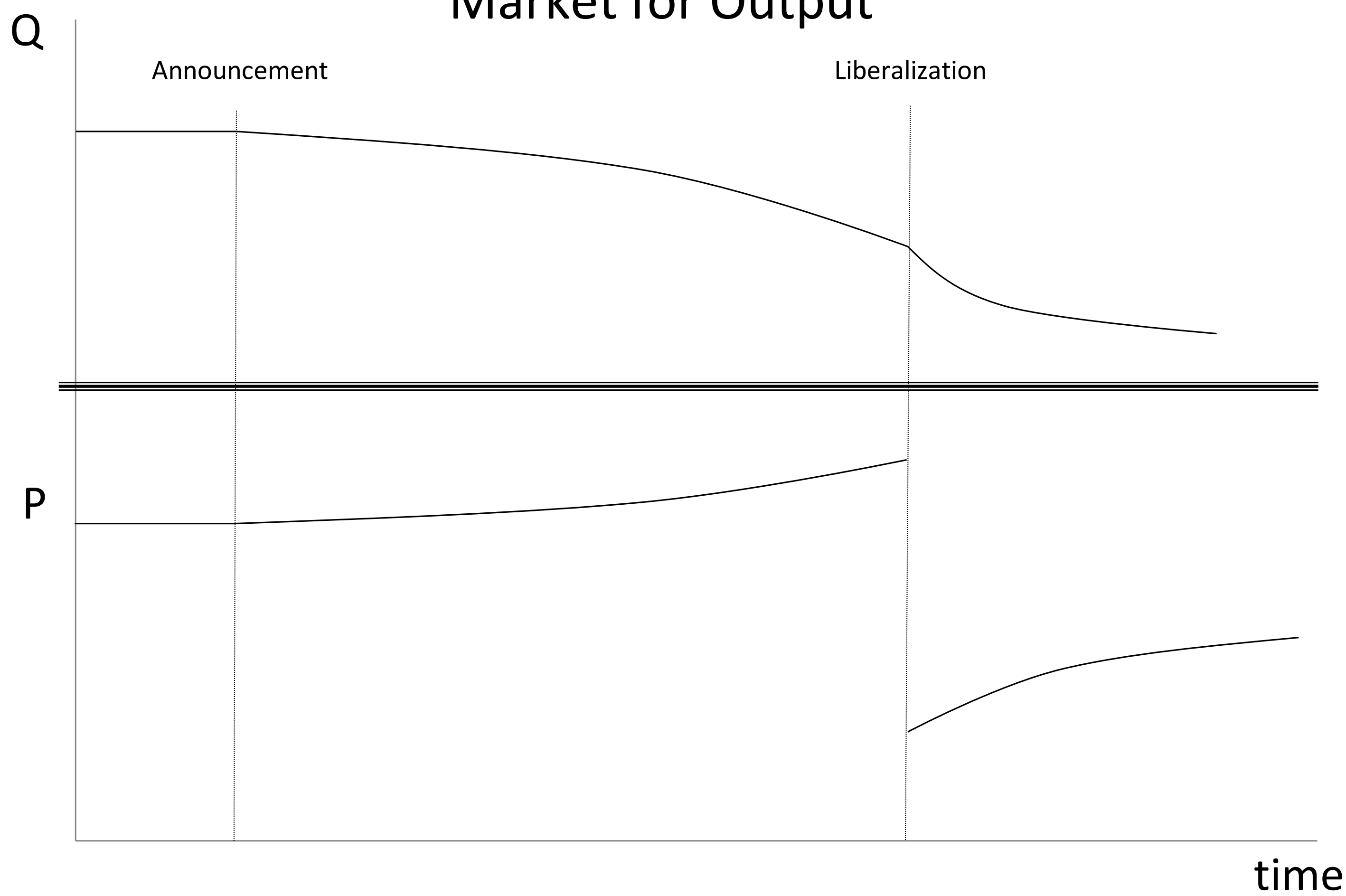


Figure 5
Dynamics with Uncertain Demand Shock

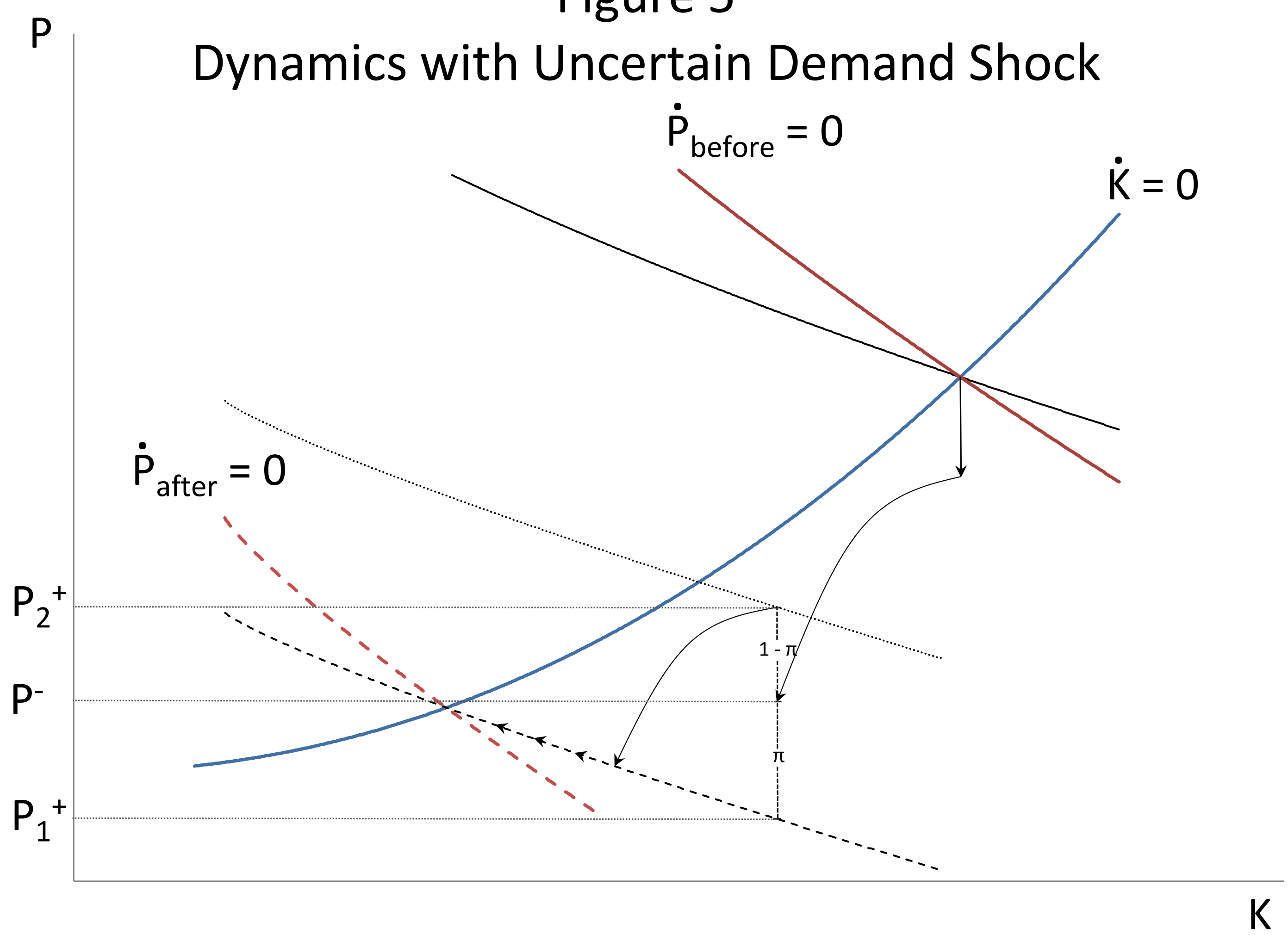


Figure 6
Capital Market with Uncertainty

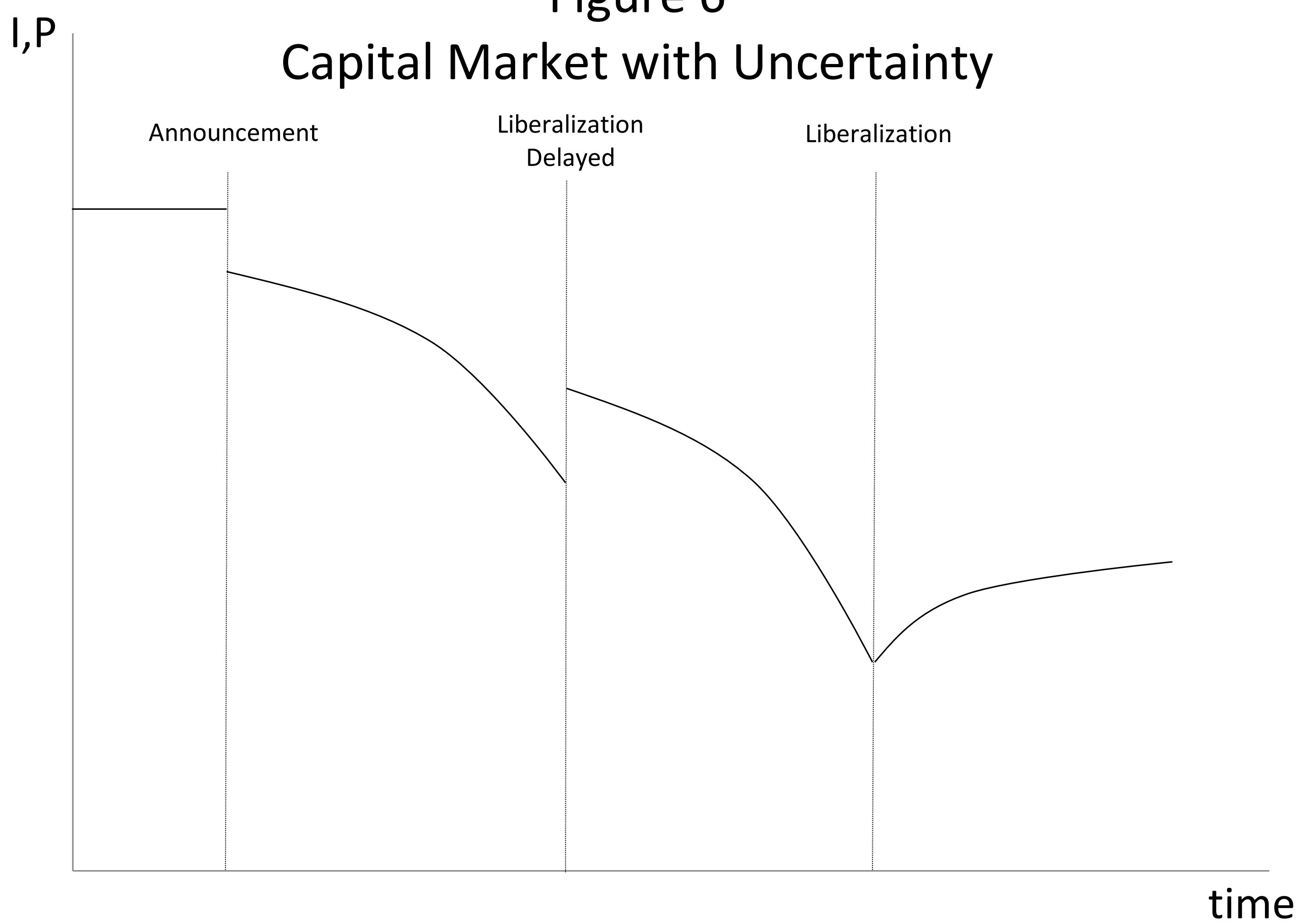


Figure 7
Capital Market Dynamics

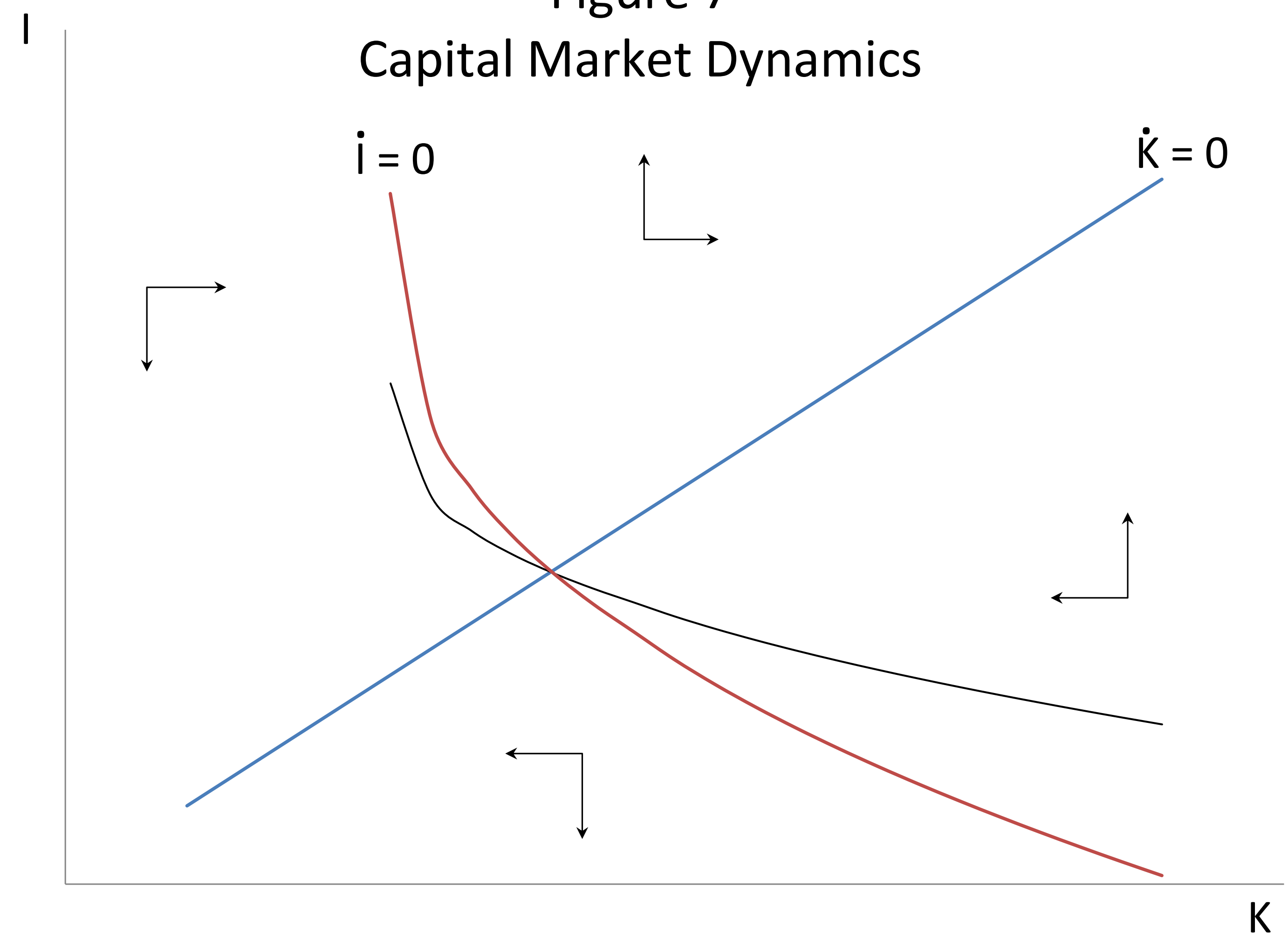


Figure 8a
Deviation in Real Investment (Phase 2)

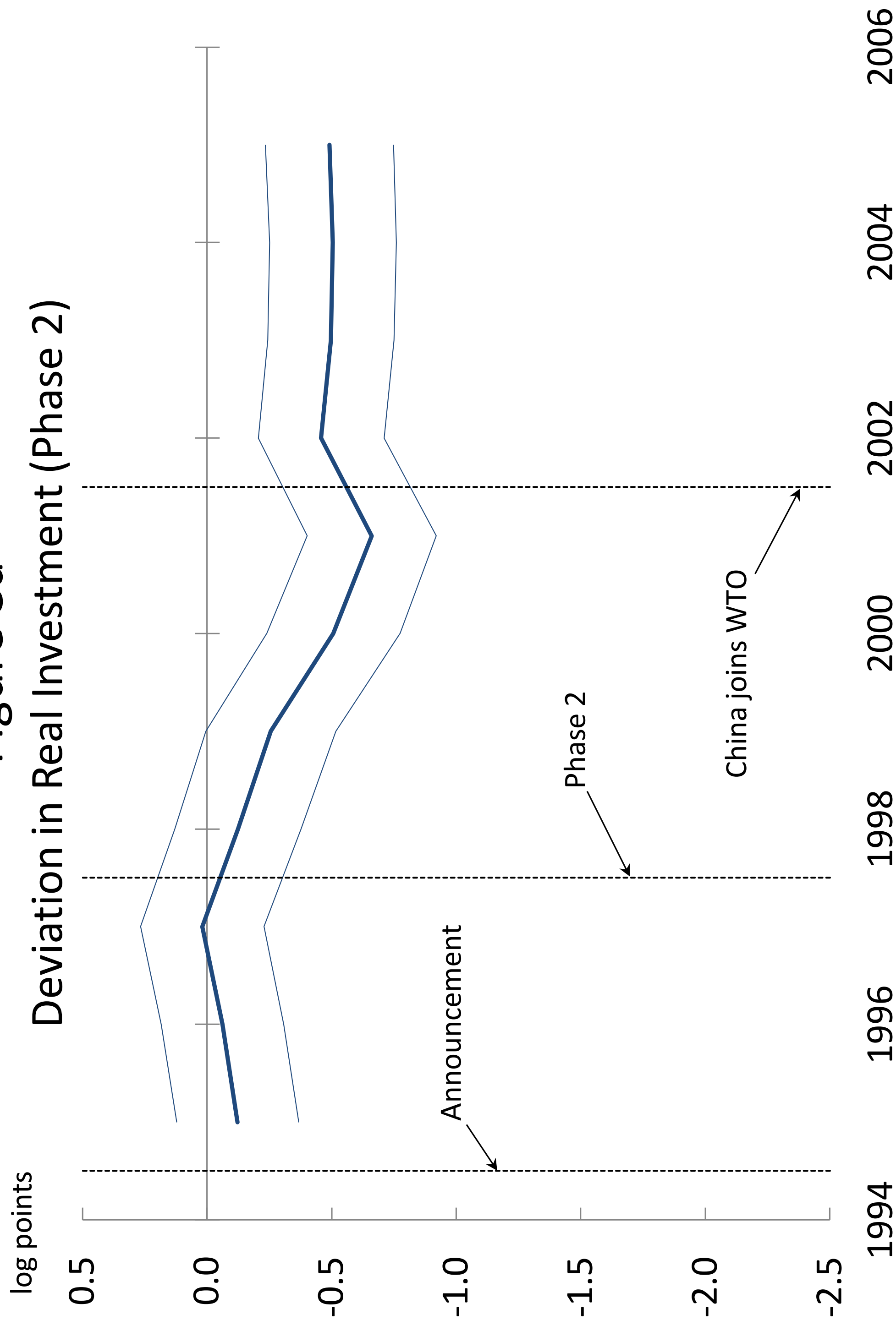


Figure 8b

Deviation in Real Investment (Phase 3)

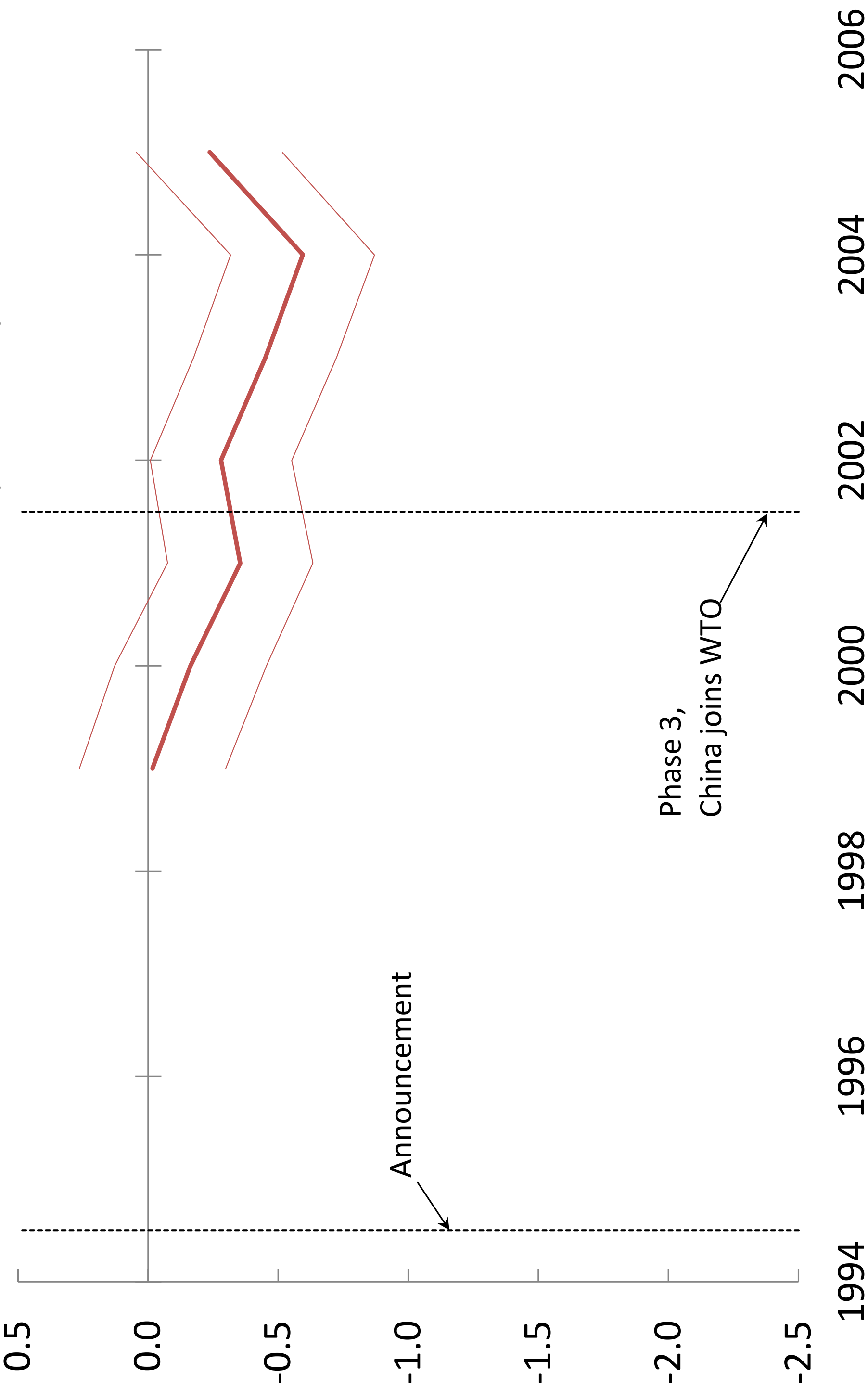


Figure 8c

Deviation in Real Investment (Phase 4)

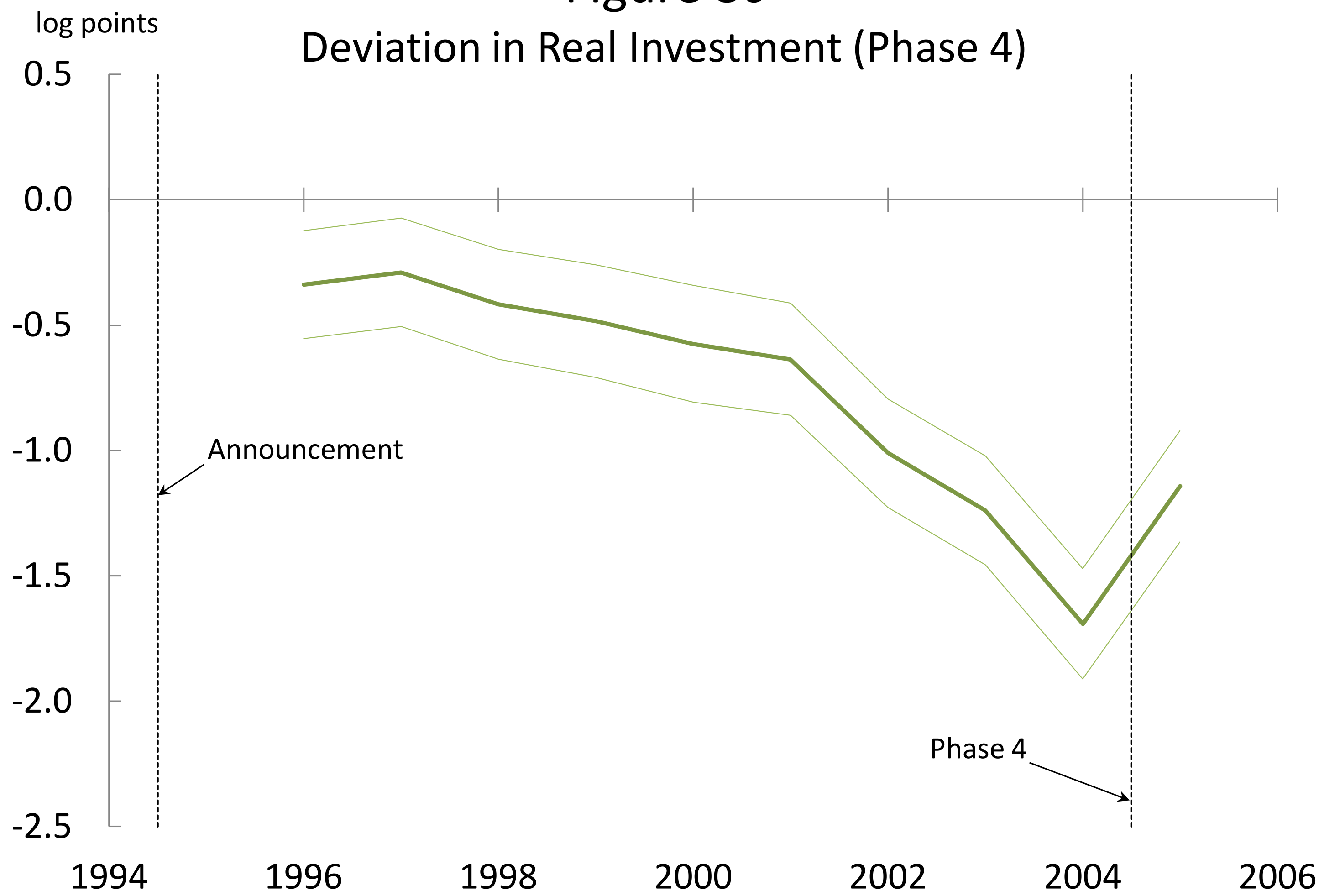


Figure 9

Phase 4 Shipments (Quantity)

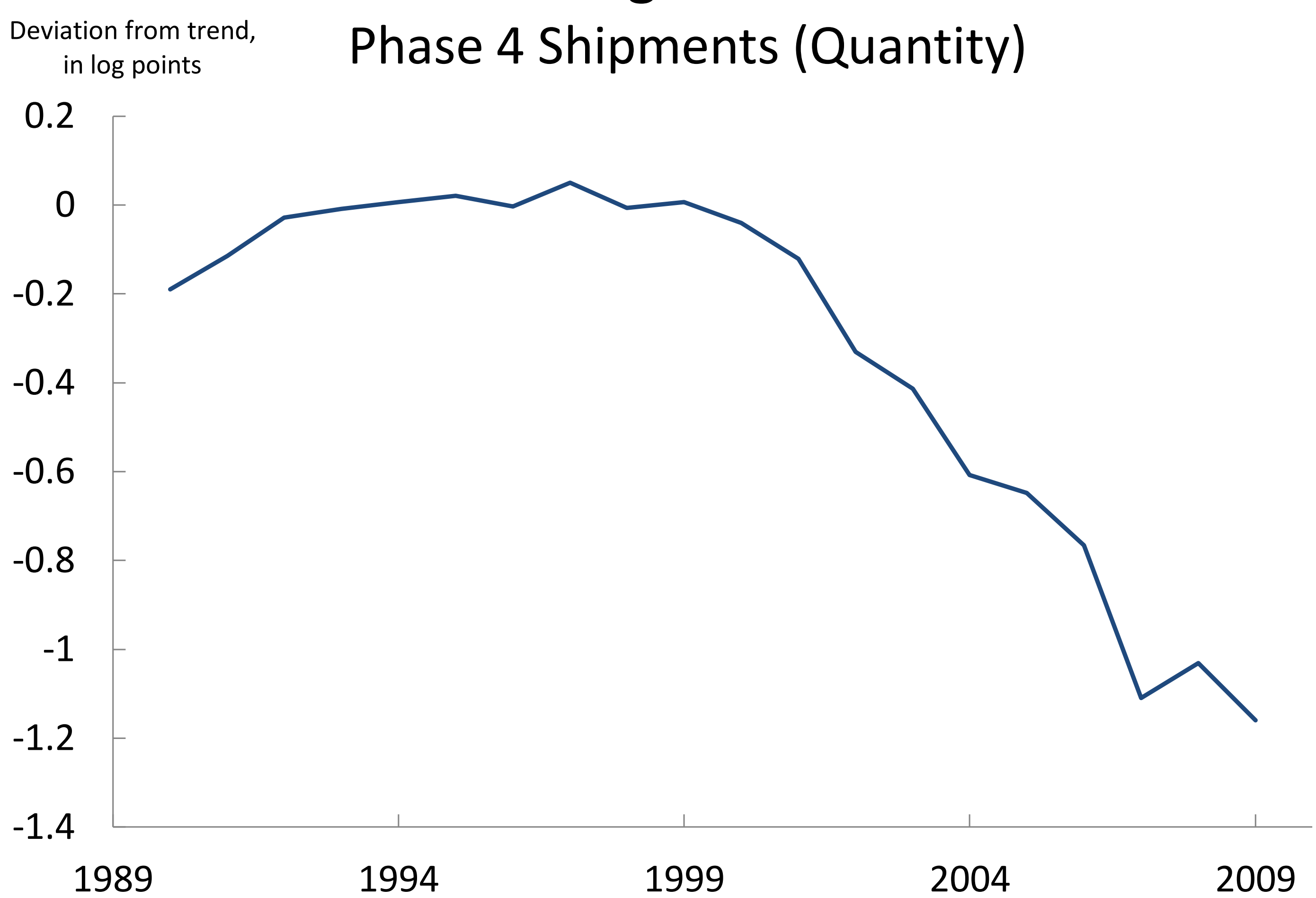


Figure 10
Phase 4 Shipment Prices

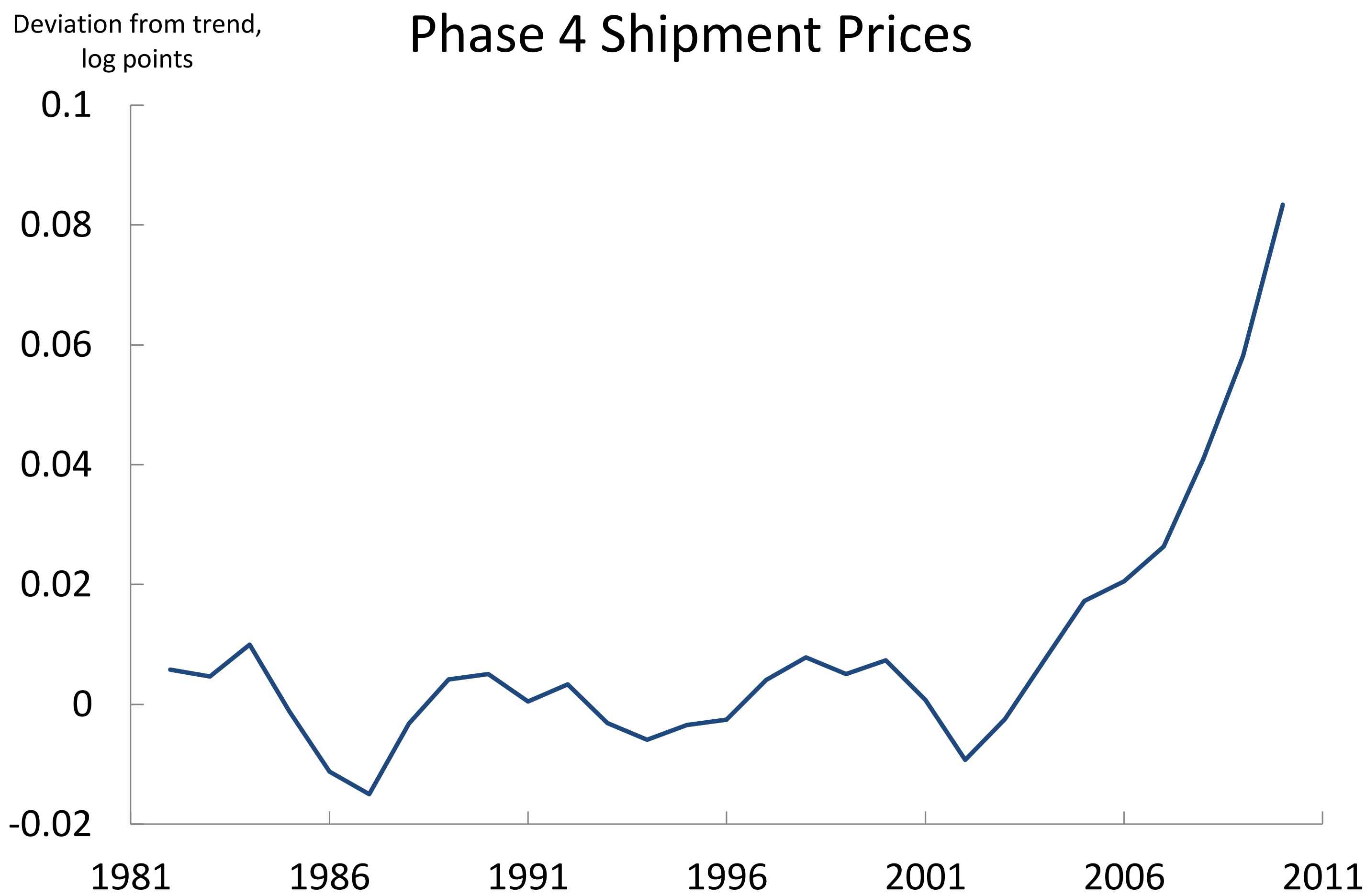


Figure 11
Phase 4 Import Prices

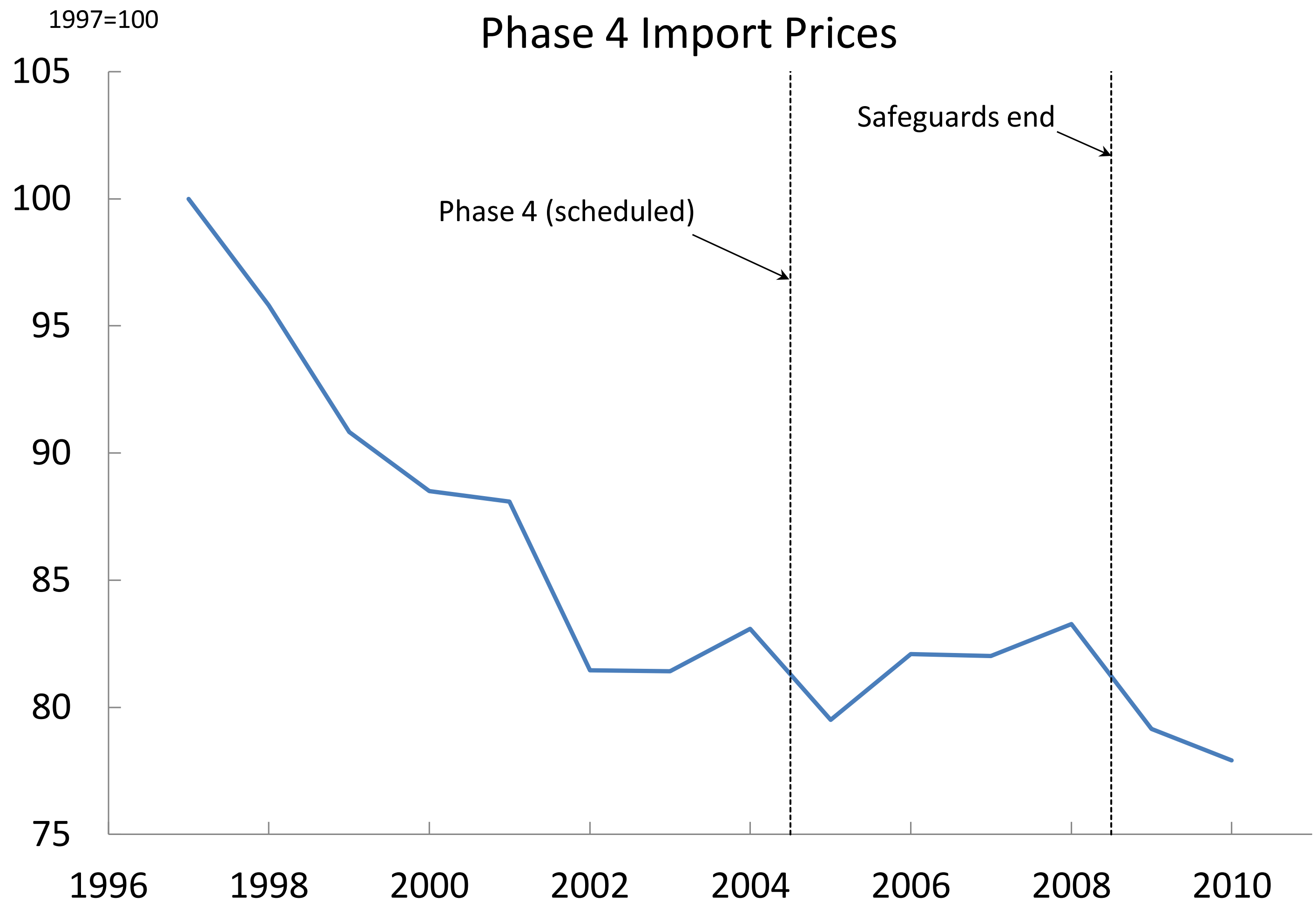
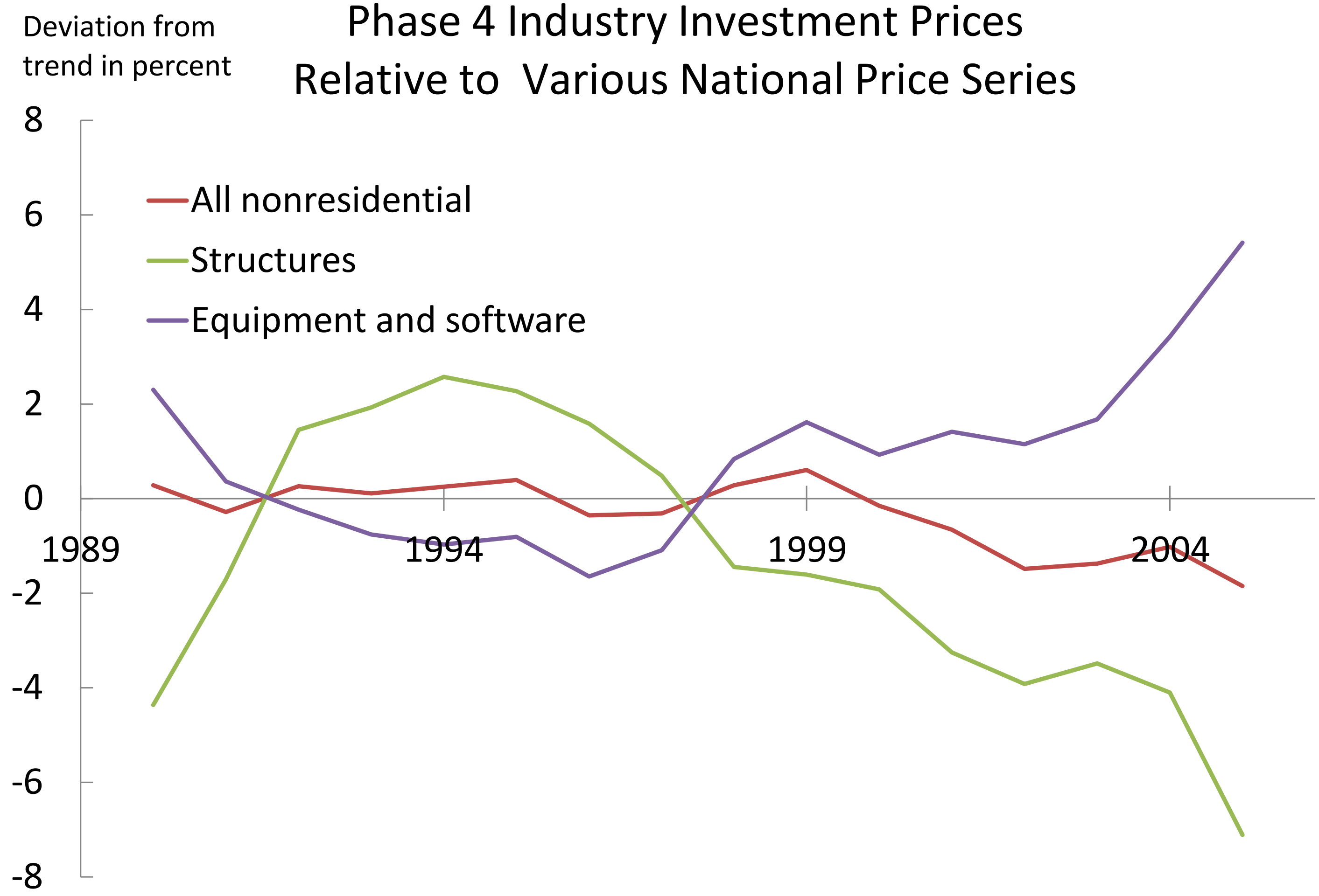


Figure 12

Phase 4 Industry Investment Prices Relative to Various National Price Series



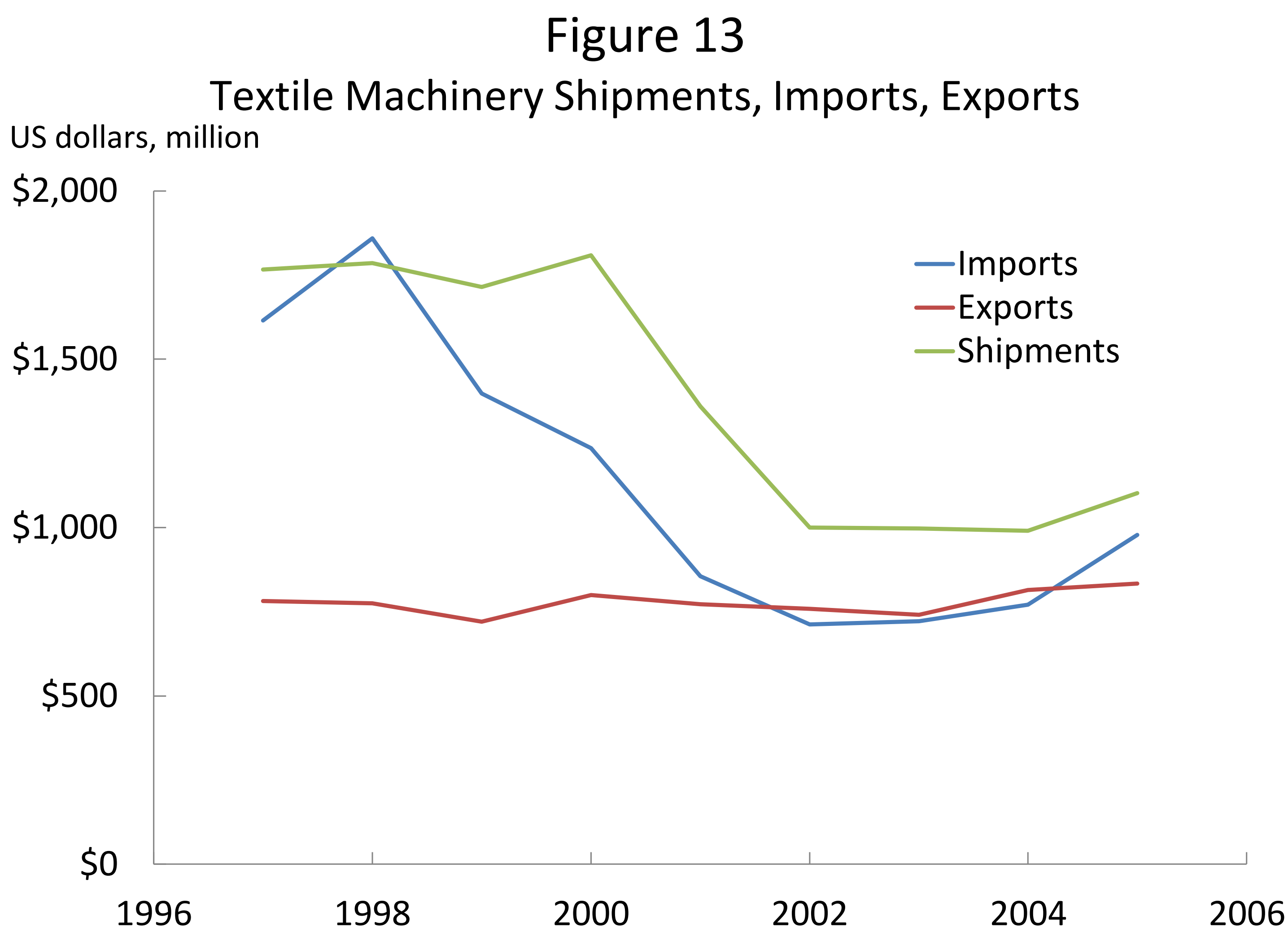


Figure 13
Textile Machinery Shipments, Imports, Exports
US dollars, million
$2,000
$1,500
$1,000
$500
$0
1996
1998
2000
2002
2004
2006
Imports
Exports
Shipments

Figure 14

Textile Machinery Manufacturers

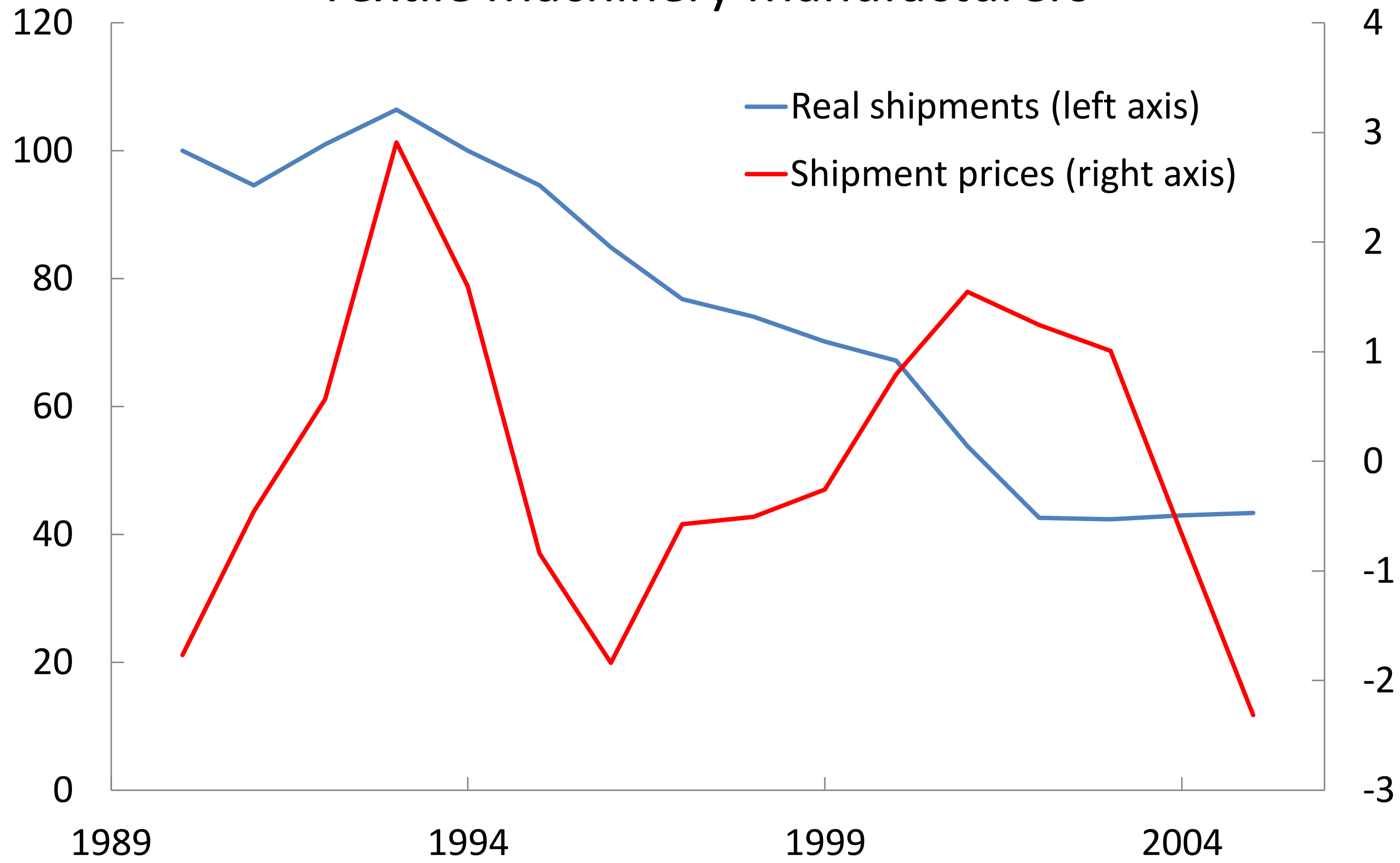


Figure 15

Textile Machinery Manufacturers

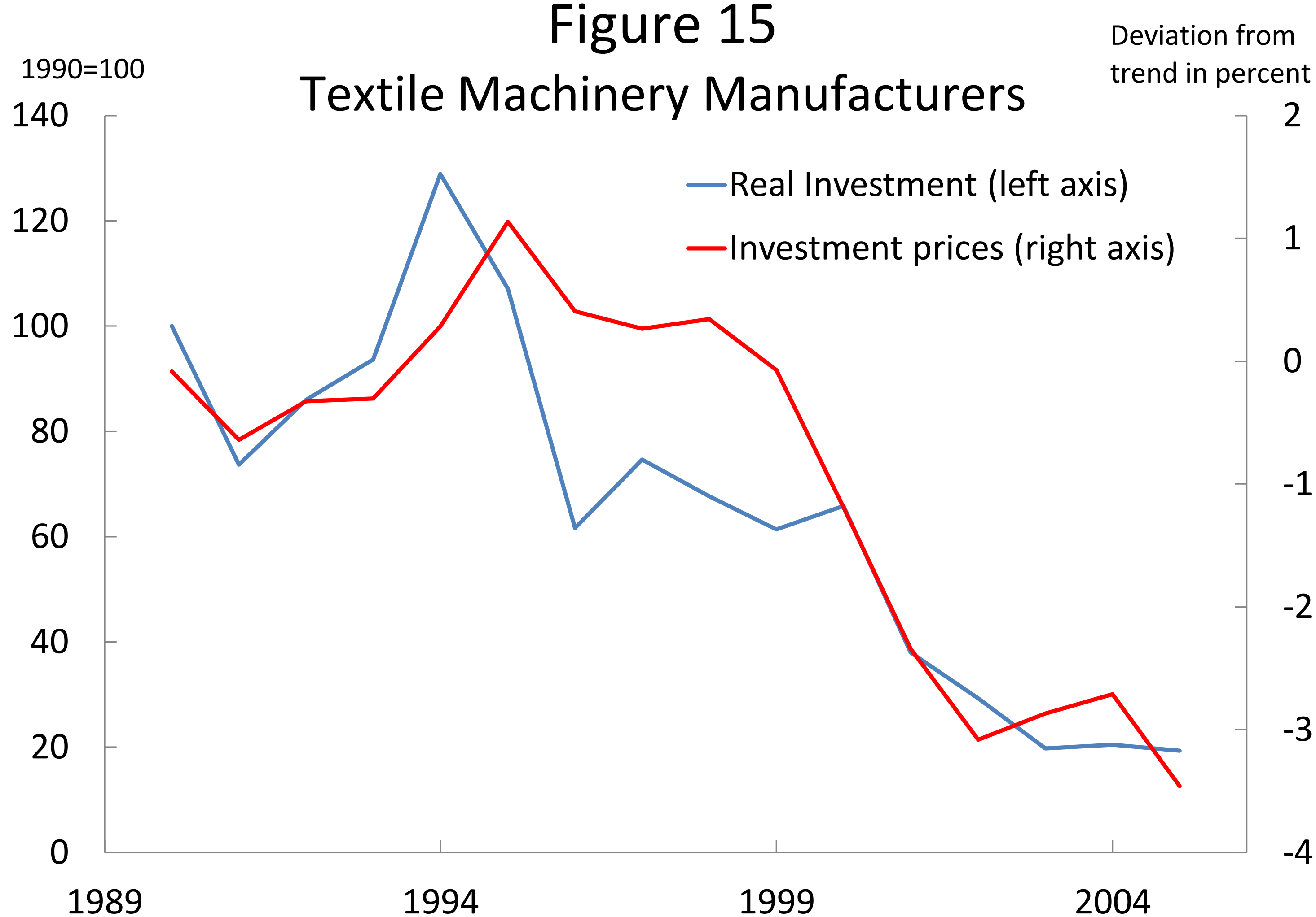


Figure 16
Real Investment (Phase 4)