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ORIGINAL PAPER

The dynamic response to trade policy: evidence from the US 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, uncertainly anticipated increase in foreign competition through the removal of import quotas. I find a large secular decline in capital investment in the industries that are likely to have been the most vulnerable to such competition. The decline is significant beginning immediately after announcement of the policy–nine years before the scheduled liberalization date. The investment decline is interrupted by a large, short-lived increase when the policy uncertainty is resolved. I show that each of these features of the data is predicted by a model of optimal industry investment in the presence of capital adjustment costs, under an anticipated but uncertain demand shock that mimics this liberalization. Using industry-level panel data, I examine other developments in the output and capital markets for these industries, and I find that they too are consistent with the model's predictions. Calibration to fit the observed investment path yields parameter values that are close to directly estimated values. These findings demonstrate that considering capital adjustment costs and policy uncertainty can be critical in understanding industry behavior, even over a relatively long time horizon.

Keywords International trade · Trade policy · Capital dynamics · Adjustment costs · Policy uncertainty

1 Introduction

Economists theorize that policy anticipation and uncertainty in general, and with respect to trade policy in particular, can have real and important effects on economic behavior, quite aside from the economic effect of the policy itself. Understanding the potential size of such effects, and the extent to which anticipation and uncertainty about the more distant future can affect current behavior, is ever more important as

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the policy environments in the U.S. and abroad become seemingly less predictable. In this paper, I study the fate of a US industry and find strong evidence that anticipated changes in policy had important effects a decade or more before implementation, even under uncertainty regarding the timing of the change, and that changes in agents' beliefs about policy (such as resolution of policy uncertainty) can have immediate and very large effects, even at the industry level.

The episode I study here comprises the US liberalization of international trade in textiles and clothing (T&C), and the contemporaneous accession of China to the WTO. Figure 1 shows a time series of average real investment, relative to previous investment trends, by groups of these industries across a period that includes announcement and implementation of import liberalization. Details of the groups and policy are provided later in the paper (including an explanation of the absence of "phase 1" industries), but the figure makes immediately clear that these industries experienced very large investment declines during this period, and that a good deal of this decline occurred after announcement of the liberalization policy, but before its implementation. Figure 2 highlights an important potential cause of these investment declines, in the form of a very large change in competition from Chinese imports coinciding with the date(s) of quota liberalization.

This paper provides a collage of evidence that together suggests that the fate of the most-affected T&C industries over this period was dominated by the announcement of, uncertainty about, and eventual implementation of trade liberalization. I will show below that such behavior is well-explained by a model of investment with internal capital adjustment costs when an industry is faced with an uncertain trade liberalization episode such as this one. I will then calibrate the model to show that the resulting simulated path for investment closely matches the observed investment path. Further, I will evaluate developments in the output and capital markets for these industries, which I find to be consistent with the model, and inconsistent with alternative explanations.

This paper informs ongoing efforts to model dynamic responses to trade policy changes, with a focus on the anticipatory changes in investment and output that arise from capital adjustment costs. The literature inspired by Melitz (2003) has developed

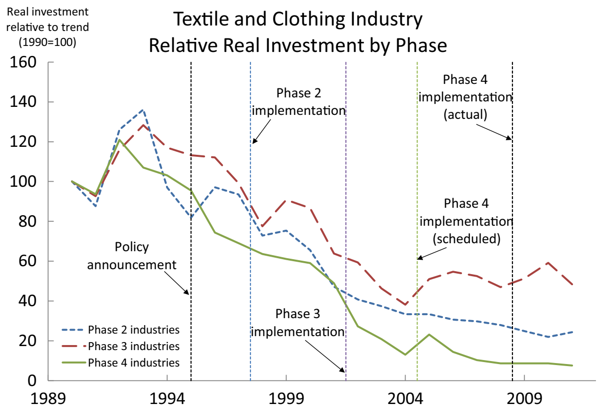

Fig. 1 Textile and clothing industry relative real investment by phase

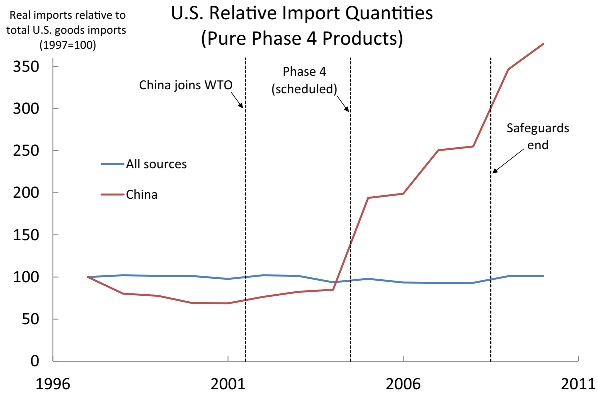

Fig. 2 US relative import quantities (pure phase 4 products)

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. An early example is Ghironi and Melitz (2005), which added dynamics driven by a stream of stochastic aggregate productivity shocks. Alessandria and Choi (2014) consider productivity shocks and capital accumulation together to construct a dynamic model to match certain features of the US 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 important. However, models of this type typically abstract from the presence of capital altogether.[1] If capital adjustment costs per se are important, their inclusion in future efforts may appreciably increase researchers' ability to reproduce observed behavior, to accurately predict responses to a trade policy changes, including anticipatory responses, and to properly estimate welfare implications.[2] For example, Metiu (2021) finds that there are measurable contractions in investment and output among exporters to the U.S. due to announcement, but prior to implementation, of US protectionist policies such as anti-dumping and countervailing duty policies.

In addition, this paper adds to the growing literature that studies the effects of (especially policy) uncertainty on welfare and producer decisions (see Baker et al. (2016) for an overview). A branch of this literature studies the effects of uncertainty on trade. For example, Reyes-Heroles (2016) shows that uncertainty regarding future trade costs can affect current interest rates, while Steinberg (2019) estimates the macroeconomic impact of uncertainty over Brexit on the economy of the UK. Caldara et al. (2020) develop measures of trade policy uncertainty and find that increases in the level of

[1] Alessandria and Choi (2014) 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.

[2] A related literature has recently focused on the implications for trade of adjustment costs in the labor market. See McLaren (2017) for an overview.

uncertainty are associated with decreases in investment. In contrast to these papers, which tend to examine the effects of changes in the level of uncertainty, the present paper studies investment behavior under fixed uncertainty with respect to policy, illuminating a clear example of how firms take such uncertainty into account, and how they respond to its resolution.

This paper also touches on the extensive literature on optimal industry investment behavior in the face of capital adjustment costs. I consider internal adjustment costs: costs that a firm faces, in addition to the purchase price of its capital, when it changes the size of its capital stock.[3] Doms and Dunne (1998) give an early overview of evidence regarding firm-level adjustment costs. Cooper and Haltiwanger (2006) test empirically for evidence of a variety of such costs, again at the firm level. One of the main results 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. Further, if it is known when and how market conditions will change ex ante, it is typically optimal to begin adjusting the capital stock before the change occurs. Other research has documented such an anticipatory response to future shocks in a wide variety of settings. Becker et al. (1994) find evidence of changes in consumer behavior prior to a policy change in the presence of what might be called "addiction capital"; Goolsbee and Syverson (2008) find evidence of changes in pricing behavior in anticipation of a shock when "loyalty capital" is important. The present study 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. For example, the price effects in Goolsbee (1998) last perhaps two to three years after the policy change, and are not perceptible 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 was fully implemented. And while the magnitude of the effects picked up by, for example, Goolsbee (1998) is 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 spike in which real investment nearly doubled.

2 Industry and policy details

The policy changes that I study here are as follows: (1) the unwinding of the Multifibre Arrangement (MFA) in the U.S. that was negotiated as part of the creation of the

[3] I document evidence of internal adjustment costs, as opposed to external adjustment costs: costs that arise outside of any single firm that affect the purchase price of its capital whenever there is a change in the size of the aggregate investment. Previous studies document evidence for such costs in some cases. 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. I do not find evidence of such costs in my setting.

WTO in 1995 and implemented piecemeal through 2008 and (2) the accession of China to the WTO in December, 2001. Liberalization by the U.S. of trade in textiles and clothing (T&C) is an attractive setting to study for several reasons. First, T&C liberalization was unusual in that trade in a given product was essentially liberalized fully on a single day, rather than gradually over time as is typically done in such agreements, making the shock easy to identify and to credibly model. Second, the trade restrictions that were liberalized were economically important,[4] which enables me to easily spot reactions to the policy change amid noise in the data. Third, although trade was liberalized all-at-once for any given product, not all product trade was liberalized on the same date. This not only gives ready sets of comparable industries that are not being contemporaneously liberalized for comparison; it also (I will argue) concentrates those industries that are likely to have been most vulnerable to import competition in the same phase of liberalization, making it easier to detect the effects of the policy announcement and implementation in the data. Fourth, there was evident and important uncertainty regarding the policy change, the nature of which presents a set of testable implications (which, I will show, do match the data). Finally, the T&C trade liberalization did not coincide with other large trade policy changes, which allows me to abstract from general equilibrium effects that might otherwise be of greater concern.

This liberalization was the last in a long series of policies governing textile and clothing trade. Beginning in the 1950s, world trade in these products were anomalously held outside the GATT. Instead, T&C trade was managed by a web of bilateral agreements. The typical agreement imposed annual quotas separately on the quantities of imports of each of several textile and clothing products. The number and complexity of these agreements grew and, in 1974, they were collectively codified into the Multifibre Arrangement, which was conceived as an attempt to impose some multilateral discipline on trade in these products, 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.[5] Finally, as part of the Uruguay Round of negotiations, 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 quotas on textile and clothing trade, to be completed by January 1, 2005.

Despite the protection they received, US textile and clothing industries have 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 4.

[4] The affected industries had been protected by import quotas since at least the 1970s, with some protections dating back to the 1950s.

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

[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.

The ATC is an oddity because of the structure of its liberalization schedule. Countries with quota restrictions on imports were required to implement some measure of liberalization by January 1 in each of four years: 1995, 1998, 2002, and 2005[7] (which I refer to as 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.[8] However, it was essentially up to each importing country to decide in 1995 which products would be liberalized in which phase. For example, if a country had quotas on imports of “hats”, “shirts”, “pants”, and “shoes”, it could choose the order in which it would like to liberalize imports of those products. If it chose to liberalize them in the order listed, then it would then have removed all hat import quotas on January 1, 1995; all shirt import quotas on January 1, 1998; and so forth. As noted, this all-at-once approach differs markedly from the more common practice of gradual liberalization by product.[9]

The second important policy change that occurred during this period was China’s accession to the WTO, which effectively coincided with the implementation of phase 3 of ATC liberalization.[10] 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 weeks after the date of its accession. Because of the magnitude of China’s T&C exports to the U.S., I consider China’s accession as a T&C trade liberalization event per se. Importantly, 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. Indeed, trade associations representing the US textile and clothing industries lobbied to invoke this clause for trade in certain product lines.[11] As a result, safeguards were applied to several lines of T&C imports from China beginning in late 2005, and extending through 2008. At the outset, lobbying industries will not have been certain that they would succeed in getting this additional protection invoked. However, due to the particulars of the safeguard clause, they will have known that, if invoked, the safeguards were likely to last exactly three years (which is indeed what occurred).

[7] While there were other minor aspects to liberalization, such as an incremental easing over time of the import quantities allowed, they were dominated by the wholesale removal of the quotas.

[8] The lines of goods liberalized in the first three phases had to represent at least 16%, 17%, and 18%, respectively, of the quantity of imports by that country, with the remainder (at most 49%) liberalized in the fourth phase.

[9] Phases could be 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 U.S. 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. Examples of phase 1 goods include the following: silk trunks and suitcases, fishing nets, cloth adhesive tape, lamp wicks, ice hockey gloves, garden umbrellas, watch bands, parachutes, and doll clothing.

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

[11] Three requests for protection appeared in the Federal Register during 2003; the next year, as phase 4 of liberalization loomed, twelve more notices appeared. When Chinese imports poured into the U.S. after liberalization 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.

3 Model of investment

In this section, I present a dynamic industry investment model with internal adjustment costs. I derive implications of a one-time trade policy change (a negative demand shock that is anticipated with uncertainty), which I compare with observed data in the following section.

In the model, perfectly competitive identical firms produce a textile or clothing product using capital.[12] 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 the supply of imports.[13] Imports are initially restricted in quantity by a quota, and when this quota is relaxed, the residual demand for output by the domestic industry decreases. Each firm purchases capital that is supplied perfectly elastically, but pays a penalty when it adjusts the size of its net capital stock. The magnitude of the adjustment cost is convex in the percent change in the net capital stock.[14] I refer to this cost as an "internal adjustment cost"—a firm 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. Once a firm pays the purchase price and adjustment cost for this capital, it may produce costlessly with it.

Meanwhile, US 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 demand shifter 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 capital with the constant-returns technology $F(k) = k$.[15] Each maximizes the present value of expected future profits by solving the problem

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

subject to the law of motion for capital by selecting time paths for i and k, where at time t: $P(t)$ is the instantaneous sale price of output, the time path of which will depend on the realization of future policy; P_k is the (constant) purchase price of capital; $i(t)$ is

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[12] Alternatively, the model can be interpreted to also include a variable input to production—call it "labor"—which is combined with capital using a Leontief production technology.

[13] In practice, 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.

[14] As mentioned earlier, Cooper and Haltiwanger (2006) find that, even in the presence of nonconvex adjustment costs at the firm level, industry-level investment behavior can be largely explained (about 85% of variation) by assuming only convex adjustment costs, at least when adjustments are moderate. In the next section, I will show that such a model matches industry investment behavior well even in this episode of much more extreme adjustment magnitudes.

[15] The model's predictions are qualitatively unchanged under the alternative assumption of decreasing returns to scale. The interpretation of the quantitative simulation would be affected in that, in addition to demand elasticity, the curvature of the production function would dictate the pace of the dynamics. In particular, an estimate of the demand elasticity that assumes CRS would tend to be biased downward (less elastic) if there are in fact DRS.

gross real investment; $k(t)$ is the firm's industry-specific capital stock (which is equal to its output); and r is the (constant) real interest rate. The function $c(\cdot)$ represents a cost that the firm bears for adjusting its net capital stock in addition to the purchase price it pays for capital—that is, an internal adjustment cost. I assume convex adjustment costs so that $c'' > 0$, with $c(\delta) = 0$[16] and $c(x) > 0$ for all $x \neq \delta$. Thus, the firm bears a cost equal to a share of its capital stock when it adjusts the size of its net capital stock, and that amount increases more-than-proportionately in the magnitude of the capital stock adjustment. This convexity makes it optimal for the firm to smooth its capital adjustment over time if it experiences or foresees a change in demand. The foreseen change need not be certain—indeed, it will be optimal for the firm to respond to some extent for any positive probability of a future demand shock. Expectations about future demand enter the firm's problem by way of the uncertain path of the price of output $P(t)$ which, along with P_k, the firm takes as given. The law of motion for its capital stock is

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

The variables i and k enter the firm's problem in such a way that a firm with twice as much capital as another firm will select an investment level that is twice as large as the smaller firm's. More generally, industry-level behavior 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 at each instant will be given by the market-clearing condition

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

where expected future demand and the path of the capital stock pin down the equilibrium expected time path.

I will use a standard functional form for $c(\cdot)$, namely $c(x) = \frac{b}{2}(x-\delta)^2$ with $b > 0$. The solution to this problem can be represented by a pair of differential equations in I and K, along with an initial condition for the capital stock, $K(0) = K_0$, and the transversality condition. Using the notation $\dot{X}(t) \equiv \frac{dX(t)}{dt}$, and suppressing the time variable, the solution is

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

$$\dot{K} = I - \delta K \tag{2}$$

where D^{-1} is defined implicitly by $D\left(D^{-1}(x, A), A\right) \equiv x$. The phase diagram associated with this system is shown in Fig. 3a. The upward-sloping solid line is the

[16] This condition implies that keeping capital properly maintained and in good repair—that is, choosing gross investment to just offset physical depreciation—incurs the minimum amount of costly disruption; and that allowing machines to operate in increasingly poor repair, or to be removed from the production line instead of being repaired, incurs costly improvisation and rearrangement in the production process. The alternative specification also used in the literature is $c(0) = 0$.

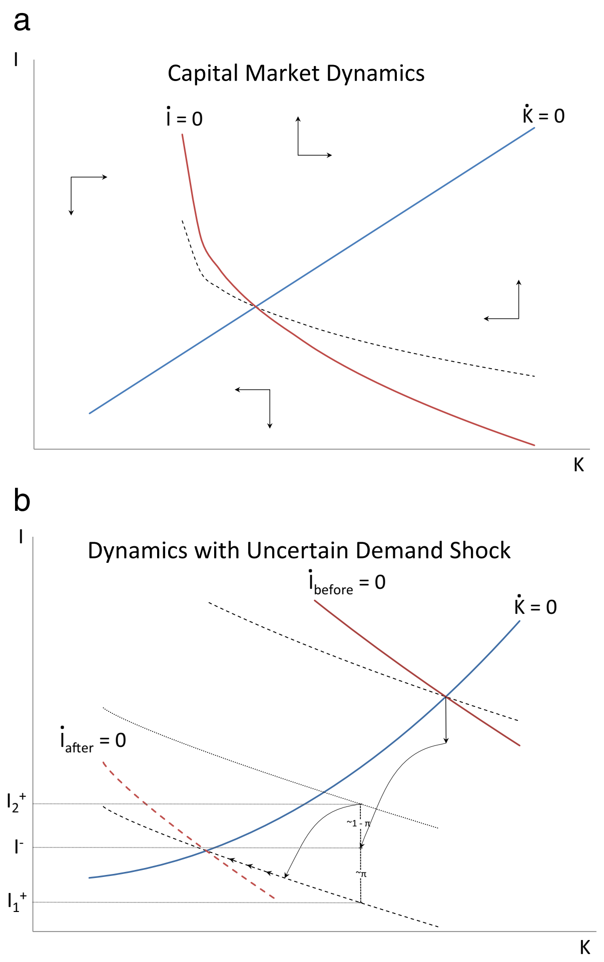

Fig. 3 **a** Capital market dynamics. **b** Dynamics with uncertain demand shock

$\dot{K}(t) = 0$ locus, and the other is the $\dot{I}(t) = 0$ locus.[17] The stable manifold (the dashed line) 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 for each value of A. The first condition of the pair comes from the law of motion for capital—in particular, the steady-state level of investment must simply make up for depreciation of the steady-state capital stock. The second condition represents market clearing, where demand for the product is equal to output of the product (which with this production function is equal to the size of the capital stock). The steady-state equilibrium price of the product gives zero instantaneous

[17] It can be shown that this locus is downward-sloping, as depicted, around and below the $\dot{K}(t) = 0$ locus, which is the region that concerns us here.

profits, so that the price of output must equal the cost of production (namely, rental and depreciation of one unit of capital).

If the representative firm in this model owns a capital stock other than the steady-state capital stock, it will not be optimal to adjust immediately to that level because of the convexity of the adjustment cost.[18] Furthermore, if the firm learns that a negative shock to demand for output will occur at a future date certain (i.e., the $\dot{I}(t) = 0$ locus will shift inward, but not until a future date), then there will be an immediate discrete effect upon learning of the future shock (which I will call "announcement"), with a smooth dynamic response until the arrival of the shock (which I will call "implementation") and afterward. In particular, the investment quantity will fall discretely upon announcement, then will continue to fall smoothly along with the capital stock until implementation, at which time the quantity of investment will begin to *rise*, although the capital stock will continue to fall.[19] Graphically, the capital stock and investment quantity will follow the dynamics of the pre-shock system until implementation, at which point the new dynamics will take effect.

In the output market, the quantity produced will track the capital stock—it will begin to fall at announcement. However, because this occurs before implementation, the output price in the meantime will *increase*. In economic terms, 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 implementation, 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 higher adjustment cost to shed capital. Upon implementation, 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.

[18] For example, if the firm's capital stock exceeds its steady-state value, then it is producing more output than it would in steady state, so the price for output is below its steady-state value. It will thus not be willing to pay the going price for capital, which exceeds its marginal revenue product. As the firm lowers its level of investment, the marginal adjustment cost rises. At some point, this adjustment cost will be high enough to induce the firm to make some positive investment despite the fact that its output price is low. (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.) However, this investment level will certainly be below its steady-state value, and because the capital stock is above its steady-state value, there will be net depreciation—that is, a shrinking capital stock. As the industry capital stock shrinks (and output along with it), the output price will begin to rise. Investment quantity will rise toward its steady-state value as the capital stock falls to its steady-state value. Graphically, for high levels of capital, I and K will follow the downward-sloping stable manifold toward the steady state, implying that I is low and increasing.

[19] Note that this dynamic investment behavior has implications for the demand observed by the producers of the capital, a point I will address in the next section.

In terms of the differential equations, suppose a forthcoming negative demand shock would cause the capital stock to begin shrinking immediately. This can only happen if the level of investment is less than depreciation of the capital stock, per Eq. (2). Whether the level of investment would be increasing or decreasing over time depends on Eq. (1)—in particular, on the sign of the bracketed terms. All else equal, a smaller capital stock requires less investment to maintain, which is captured by the second and third bracketed terms, both of which are negative if $I < \delta K$. The sign of the first term is positive if and only if $D^{-1}(K, A) < (r + \delta)P_k$—that is, if the output price $(D^{-1}(K, A))$ under current demand conditions is below the steady-state output price. However, as the capital stock begins to shrink, the current output price will be *above* this level, so that this term too will have a negative sign, and the level of investment will be falling.

The situation will reverse only when current demand conditions change—here, when the policy change occurs. As discussed earlier, the current output price will in fact be lower than the steady-state output price, but it will be rising. In terms of Eq. (2), we have $D^{-1}(K, 1) < (r + \delta)P_k$, so that the first bracketed term will be positive—sufficiently positive so that investment will then be increasing.

Finally, consider the case when there is uncertainty over the date of implementation. In particular, the firm faces two possible dates for implementation (T_1 and T_2), but will not learn the actual implementation date until T_1 (as was effectively the case for phase 4 industries in the U.S. under the ATC, where the safeguard clause could not be invoked until the surge in imports began to arrive, and the terms of which effectively set the duration of any safeguard protection to three years[20]). If firms believed that the policy change would occur at T_1, they would wind up their capital stocks more quickly than if they believed the change would occur at the later T_2. Because they were uncertain as to which of these dates would obtain, it was optimal for them to split the difference. Formally, at T_1, implementation will be delayed until T_2 with probability π; otherwise, implementation will occur immediately. Then the optimal path for investment up to time T_1 entails greater adjustment (more depressed investment) than would occur if the firm knew with certainty that implementation would occur at T_2 because the firm hedges against the possibility of implementation at T_1—and the lower is π, the greater the extent of this hedging. Another implication of this is that, if implementation were in fact delayed, investment would *increase* discretely (instantaneously) at T_1, only to resume its decline until implementation at T_2. I will show in the next section that this very particular investment pattern, illustrated qualitatively in Fig. 3b, is precisely what played out.

4 Data and analysis

In this section, I first describe my data and sources. I then present my analysis, beginning by estimating the response of capital investment among phase 4 industries to

[20] 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.

the policy announcement, resolution of uncertainty, and implementation. I show that this response qualitatively matches the particulars of the model's predictions. I show that membership of an industry in phase 4 of liberalization can be predicted almost perfectly by the magnitude of the estimated decline in investment (another implication of the model); and that the intensity of investment response to safeguards at the industry level among phase 4 industries in 2005 and 2006 also match the model's predictions. Next, I simulate a path of real investment by phase 4 industries over the pre-implementation period, which I find closely matches the observed path for real investment. I then examine the output markets for those industries to see whether the predictions for those markets obtain. Finally, I consider contemporaneous developments in the domestic sector that produces much of the capital used by textile and clothing producers. Developments in these adjacent markets accord with my other findings in a way that is consistent with the model, but inconsistent with other explanations for the industry contraction.

4.1 Data

I take quantity and price series for investment, quantity series for real capital stock, and quantity and price series for shipments, by six-digit NAICS industry, from the NBER Manufacturing Productivity Database.[21] These data are based on the Census of Manufactures (CMF) and the Annual Survey of Manufactures (ASM) conducted by the U.S. Census Bureau, or estimated using other public data from these sources where needed; and from price series from the BEA and BLS.[22] The NBER Manufacturing Productivity Database contains 49 six-digit NAICS industries that make products affected by phases 2–4 of the quota liberalization.[23] I will ignore those industries that include some textile products, but that do not primarily make textiles or clothing.[24] In particular, I will only consider industries falling within NAICS categories 313–316,[25] for a total of 39 industries. For each of these, I have annual data for the years 1958–2011, giving me 54 annual observations (38 pre-announcement) for each six-digit industry, and 2106 observations in total. However, products were assigned among the liberalization phases at the HS product level, not at the NAICS industry level, and there is no one-to-one mapping between NAICS industries and HS product lines. To proceed, I assign each NAICS industry to a liberalization phase based on its 1990 product

21 I use the 1958–2011 version of the data, which amply covers the relevant time period while avoiding the complication of the inclusion of intangible investment that was made as part of the BEA's 2013 historical revision of the NIPA tables (see McCulla et al. (2013)).

22 See Bartelsman and Gray (1996).

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

24 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.

25 These respectively comprise "Textile Mills", "Textile Product Mills", "Apparel Manufacturing", and "Leather and Allied Product Manufacturing".

import intensity. Specifically, I disaggregate the total quantity of T&C imports[26] 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.

Economy-wide investment quantity and price data, which I use as controls in my main analysis and robustness checks, are from the U.S. National Income and Product Accounts from the BEA. 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). 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 website of the U.S. Department of Commerce Office of Textiles and Apparel (OTEXA) (http://otexa.trade.gov/) has time series for imports and production for each product, and provided historical information in personal correspondence. Information about the quota levels comes from Brambilla et al. (2010), from the OTEXA website, and from Peter Schott's website (https://sompks4.github.io/subXXSlahUndXXdata.html).

Industries' products were matched with phases of liberalization using a HTS-NAICS concordance. For the majority of product codes, Pierce and Schott (2012) contained the necessary concordance; the rest were gathered manually from the USITC website. The USITC website is also the source for most of the trade data used in the analysis.

4.2 Real investment

The adjustment cost model presented earlier predicts that producers should have low and falling capital investment between the policy's announcement and implementation. For phase 4 industries, it also predicts a one-time increase when uncertainty over the policy is resolved; and falling investment thereafter until implementation. In order to test for changes in real investment during this period, I use the 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, $GNRI$ is national real gross nonresidential fixed investment, and ∇_{pt} is a vector of year-phase indicator dummies, one for each post-announcement year.[27] This specification allows for

[26] 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.

[27] I also ran the specification including dummies for the two years immediately preceding announcement to explore whether investment had deviated from trend before the policy announcement. There was no evidence that it had.

industry fixed effects and industry-specific linear time trends in log investment, as well as industry-specific correlation between industry-level investment and national investment, during the period before announcement (1958–1995). I include the measure of national investment to control for factors that depress all investment, such as tight financial markets and recessions. In essence, the industry time trend and relationship between industry and national investment are estimated from correlations in the pre-announcement data, and the coefficients on the year dummies in the post-announcement period give estimates (in log points) of how far actual investment in those years deviates from the counterfactual—that is, from what would be expected given industry investment trends and the contemporaneous behavior of national investment.

The model predicts a particular pattern for the vector of dummy coefficients. Because investment is predicted to be low and falling between announcement and the realization of the policy uncertainty, the coefficients should be negative and decreasing during this period (1996–2004 for phase 4 industries); because three-year safeguards were in fact enacted for many industries, the coefficient on the year of safeguard implementation (2005 for phase 4 industries) should be higher than the previous year (but still negative); and because after that single-year increase investment is predicted to continue to fall, the coefficients on the remaining years before implementation should be negative and decreasing (2006–2008 for phase 4 industries).

Dummy coefficient estimates (including the two years immediately preceding announcement) from this regression for phase 4 are given in Table 1, and shown in Fig. 4 (along with bands of 95% significance). The deviation in investment is significantly negative beginning in 1996, the first full year after the liberalization schedule was announced,[28] but not before. Although many estimates are statistically indistinguishable from year to year, the point estimates decline in every year from 1996 to 2004, as predicted by the model. Such a series of consecutive yearly declines in the point estimates is itself unlikely if investment is not declining during that period. The estimate for the 2002 coefficient is statistically distinguishable from all previous coefficients. Further, investment fell significantly from 2003 to 2004 (to -193 log points, or just 15% of the counterfactual level), increased significantly in 2005, and then fell significantly in 2006. The point estimates beyond that, though not statistically distinguishable from one another in adjacent years, decline each year until 2009, which had the first year-on-year increase in estimated investment in the series (excluding the large single-year increase in 2005). All told, these qualitative year-to-year investment changes correspond exactly to the model's predictions in the years immediately around the policy announcement, scheduled liberalization, and actual liberalization. The qualitative trends in these coefficients are robust to using other controls for national economic conditions, including either current phase 2 or phase 3 investment.

The model has other testable implications. First, if costly adjustment of the physical capital stock was an important determinant in the process of assigning implementation

[28] The phase 2–4 liberalization schedule was announced near the end of April 1995.

Table 1 Deviation in phase 4 log(real investment) by proximity to policy change

Years before scheduled implementation	Deviation from trend	Years before scheduled implementation	Deviation from trend	Years before scheduled implementation	Deviation from trend
Eleven years	−0.07	Six years	−0.57**	One year	−1.93**
	(0.10)		(0.11)		(0.11)
Ten years (policy ann.)	−0.07	Five years	−0.64**	Resolution of uncertainty	−1.41**
	(0.10)		(0.11)		(0.11)
Nine years	−0.35**	Four years	−0.67**	First year of safeguards	−1.83**
	(0.10)		(0.11)		(0.11)
Eight years	−0.41**	Three years	−1.17**	Second year of safeguards	−2.10**
	(0.11)		(0.11)		(0.11)
Seven years	−0.52**	Two years	−1.44**	Last year of safeguards	−2.12**
	(0.11)		(0.11)		(0.11)

*significant at the 5% level; **significant at the 1% N = 864; R^2 =.937

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

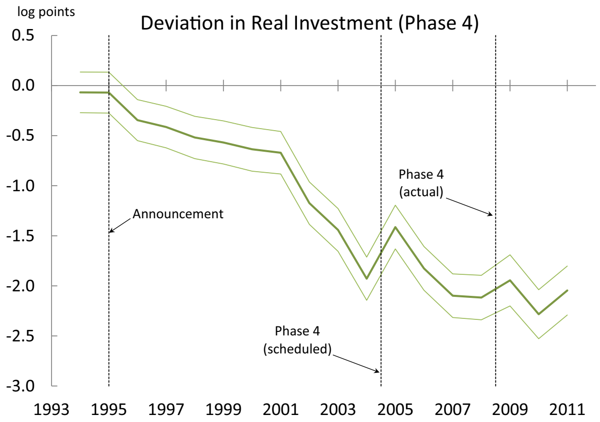

Fig. 4 Deviation in real investment (phase 4)

dates to products,[29] then those industries that foresaw large capital stock adjustments would be over-represented in the late stages of implementation.[30] To test this, I run a similar specification for all phase 2–4 industries, but allow the coefficients on the year dummies to vary by industry. I then order six-digit industries by the magnitude of deviation from trend in investment in the year immediately preceding the actual implementation date for that industry (the year during which capital investment is predicted by the model to bottom out).[31] Table 2 lists the 20 industries (out of 39) that showed the largest negative deviation in real investment from the counterfactual in the year before liberalization, along with the phase to which each industry was assigned. The list includes 15 out of 16 phase 4 industries, and only two of the top 16 industries belong instead to phases 2 or 3. In short, the logic of the model rationalizes the observed industry assignments extremely well.

Second, the model predicts that the industry-level investment response to the resolution of the safeguard uncertainty should depend on the extent of safeguards actually granted. In particular, industries that were granted safeguards for a large share of their products should have increased their investment more in 2005, all else equal, than industries that were granted safeguards on a small share; and furthermore, industries granted extensive safeguards in 2005 should have had the largest subsequent *decreases* in investment in the following year (2006), owing to the fact that their large 2005 increase has left them with a steeper fall to reach their steady-state capital stock. To test this, I compute the share of industry-competing imports that were granted safe-

29 Recall that under the ATC, each importing country was effectively free to choose which products would be represented in each phase of liberalization. Thus, the allocation of products across phases was effectively a political task, and US producers (rather than consumers) are likely to have exerted the bulk of the lobbying force.

30 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.

31 Because the investment behavior of phase 2 industries suggests that Chinese accession provided the main shock, I use 2002 as the implementation date for those industries.

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
315228	−2.52	4	315233	−1.81	4
315999	−2.46	4	313111	−1.77	4
315224	−2.45	4	313113	−1.74	4
315221	−2.44	4	315991	−1.69	4
315223	−2.37	4	315231	−1.68	4
315234	−2.03	4	313210	−1.56	4
315222	−2.02	4	313249	−1.55	3
316214	−1.86	2	316219	−1.23	2
315239	−1.82	4	316991	−1.18	3
315291	−1.82	2	315993	−1.11	4

Table 3 Correlation between safeguard protection and industry response

Correlation between	Pearson	Spearman rank-order
Pct. imports safeguarded and change in real inv. (2004 to 2005)	0.33	0.22
Pct. imports safeguarded and change in real inv. (2005 to 2006)	−0.60	−0.71
Change in real inv. (2004 to 2005) and change in real inv. (2005 to 2006)	−0.26	−0.38

guards in 2005 for each phase 4 industry. Using the industry-year dummies from the regression described in the preceding paragraph, I compute an estimate of the changes in investment from 2004–2005 and from 2005–2006 for each industry.[32] Results are shown in Table 3.

My first prediction is that the correlation between percent of imports covered by safeguards and change in investment from 2004–2005 will be positive. The computed Pearson correlation between these is 0.33, and the Spearman rank-order correlation is 0.22. My second prediction is that the correlation between safeguard coverage and change in investment from 2005–2006 will be negative. The computed Pearson correlation in this case is −0.60, and the Spearman rank-order correlation is −0.71. Finally, a related implication is that industries with larger 2004–2005 investment increases should have had larger 2005–2006 decreases: that is, that the correlation between 2004–2005 investment change and 2005–2006 investment change should be negative. The computed Pearson correlation for this test is −0.26, and the Spearman rank-order correlation is −0.38. All told, the observed industry-level investment behavior matches the model's predictions around the resolution of the policy uncertainty, and seems difficult to explain otherwise.

4.3 Simulation results

In this section, I use the model to simulate numerically the path of adjustment for phase 4 industries, using parameter values that make that path most closely match the observed path for investment. I then compare those parameter values to values derived directly from the data, which they match well.

The dynamics of the model are pinned down by values for b, r, and δ, elasticity of demand for output, and initial conditions on I[33] and K (that is, their values immediately after announcement). I constrain my search over these variables by adopting a value

32 Textile industries (NAICS 313) did not tend to show a spike in investment in 2005, perhaps because they more correctly anticipated the safeguard outcome than did apparel industries (NAICS 315). Because the implication in question applies only when industries are surprised by the safeguard outcome, I use only apparel industries for this test. (While the model also gives testable predictions when industries are negatively surprised by the degree of safeguard protection, I cannot credbily test those predictions with only three textile industries.)

33 I use the term "initial condition" loosely with respect to I, which is a choice variable. In fact, the value of I chosen immediately after announcement will depend on the parameter π (the probability of delay in implementation), which I cannot (and fortunately need not) independently estimate.

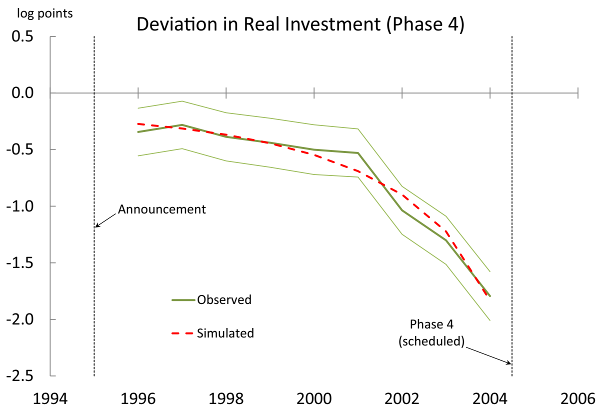

Fig. 5 Deviation in real investment (phase 4)

of $b = 0.195$ from Cooper and Haltiwanger (2006), using $r = \delta = 0.05$, and taking the initial value of K as its value prior to announcement of the policy (that is, its 1995 value). This leaves me with two unknown parameters: the elasticity of demand[34] and the initial value of I.

I conduct the search for the best-fit parameter values by numerically computing a real investment path for the nine years from 1996 (announcement) through 2004 (just before resolution of the policy uncertainty). I end my simulation here because I cannot estimate the value of π (the probability of delayed implementation) independently of the other parameters. I compare this investment path with empirical point estimates of real investment, and define as the "best fit" the parameter vector that gives the lowest sum of squared errors in this comparison.

Figure 5 plots both the best-fit simulated path for real investment and the estimated path (including bands of 95% uncertainty) for real investment by phase 4 industries. Each of the nine simulated values for annual investment falls within the bands of significance of the empirically estimated investment for the corresponding year.[35] An estimate of demand elasticity can be derived using output shipment and price data from 1996 to 2004, by taking the ratio of the observed log change in quantity (-1.025) to the observed log change in price (0.076), giving $\varepsilon_D = -13.5$. The best-fit elasticity of demand from the simulation of $\varepsilon_D = -16.6$ compares well with this value. Indeed, if I instead take the estimated demand elasticity and use it to simulate the path for investment, all but one of the simulated investment values still fall within the bands of significance of the empirical estimates.[36] In short, the simulation matches the observed data extremely well.

[34] As mentioned in Section 3, in the case of decreasing returns to scale, there would be a third parameter–curvature of the production function. I cannot credibly estimate this independently of the demand elasticity. If there are in fact decreasing returns to scale, then my estimate of demand elasticity will be too low (i.e., too inelastic).

[35] The same qualitative results obtain if I limit the analysis to only the apparel industries.

[36] This result holds whether I use the best-fit value for initial investment or the observed value.

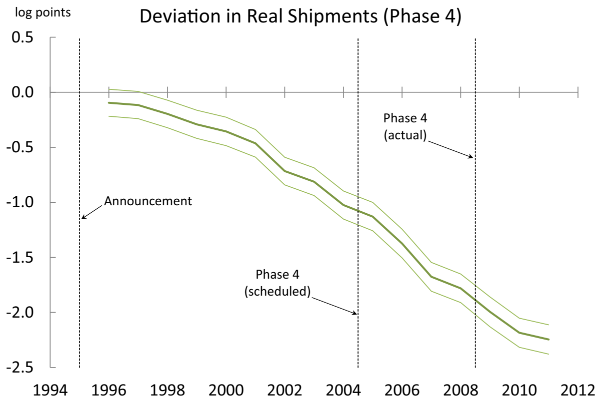

Fig. 6 Deviation in real shipments (phase 4)

4.4 The markets for output and capital

The model predicts that, between announcement and resolution of the policy uncertainty, the quantity of output should be decreasing. To test for this, I use a specifications similar to the one used for real investment. I estimate

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

where S_{it} is the real quantity of shipments by industry i in year t, $GDGP$ is real gross domestic product of goods, and ∇_t is again a vector of dummies for the years immediately preceding phase 4 liberalization. The results, illustrated in Fig. 6, show that each of the dummy coefficients after 1997 is negative and statistically significant, and each point estimate more negative than the last, as predicted.

Regarding investment capital, the model assumes a fixed price for the capital good, ruling out the possibility that the investment decline was due to a contemporaneous contraction in the supply of capital. In order to check whether this assumption is plausible, I estimate the following specification for phase 4 industries:

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

where P_{it} is the price of investment for industry i in year t, and $PNFI$ is the price index for gross domestic nonresidential fixed investment.. The results, illustrated in Fig. 7, show a decline in investment prices over this period of about 1 percent per year. The decline is secular, and so it cannot explain the 2005 spike in investment. When compared to the magnitude of the change in investment quantity, the implied elasticity

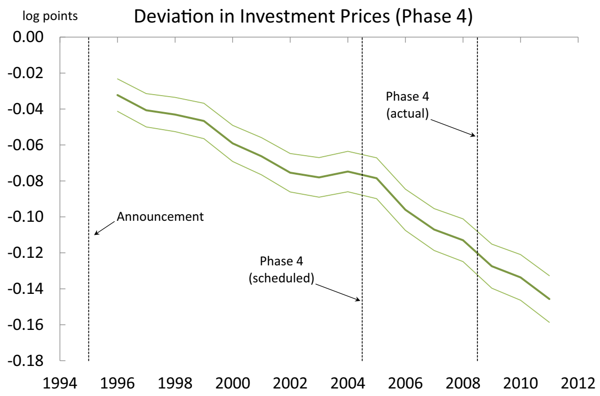

Fig. 7 Deviation in investment prices (phase 4)

of supply of capital to these industries is high.[37,38] Further evidence comes from data for NAICS industry 333292—producers of textile machinery. These results, illustrated in Fig. 8, tell the same story: the period saw a large decline in quantity accompanied by a relatively meager change in prices.[39] Together, these results are consistent with the model's assumptions and results regarding the supply of investment capital to these industries, but inconsistent with other explanations.

5 Conclusion

I have shown that investment patterns for affected US textile and clothing manufacturers around the time of this trade liberalization qualitatively match the predictions of the model of capital adjustment costs presented. The liberalization of textile and clothing imports scheduled for 2005 was preceded by an especially large episode of disinvestment by the directly competing US industries—so-called phase 4 industries. Investment by these industries was low and declining beginning immediately after the policy announcement and, after a one-year spike in 2005 during which investment by these industries nearly doubled, it continued to decline. Given the manner in which the uncertainty about the liberalization was resolved, this investment behavior too matches the predictions of the model.

Further, I showed that the observed pattern of industry assignments across phases is a very close match to what would be expected if those industries with the largest adjustments to make, and the largest costs to making them, lobbied intensely for such

[37] E.g., investment quantity in 2008 was 212 log points below trend, while investment price was 11 log points below trend.

[38] Theory also predicts that gradual capital adjustment can be driven by upward-sloping supply of the capital good at the industry level. To explore this, I performed an analysis similar to the one outlined in this paper, with capital adjustment driven by a declining price for capital. The observed price changes are insufficient to drive the observed investment quantity changes in such a model.

[39] The decline in shipments was not due to flagging international demand—imports and shipments both declined during this period, while exports were roughly flat.

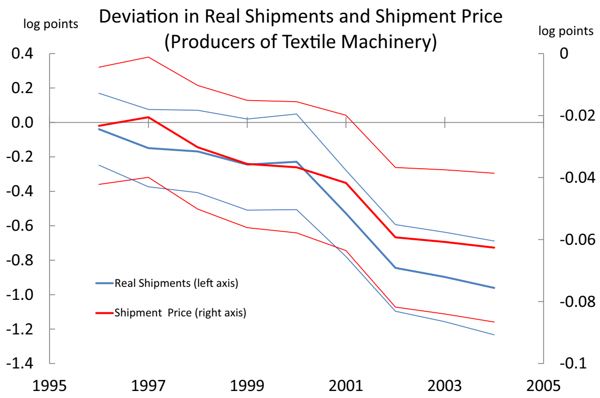

Fig. 8 Deviation in real shipments and shipment price (producers of textile machinery)

an outcome. I also showed that the magnitude of an industry's one-time investment increase upon imposition of safeguards in 2005 varied positively with the degree of coverage that the safeguard provided to that particular industry, and that the subsequent decline was larger for industries that exhibited larger increases in 2005. Both results are consistent with a response to the policy in the presence of meaningful adjustment costs, and are otherwise difficult to explain.

I then used the model to generate a numerical simulation of investment over the nine years between the policy announcement and scheduled implementation for phase 4 industries. The results of this exercise match the observed investment behavior both qualitatively and quantitatively, whether I take some parameter values from the literature and the observed path of investment as given, then use the model to generate a best-fit for the remaining parameters; or take parameter values directly from the empirical estimates and use the model to generate an investment path. I also found that developments in the adjacent output and capital markets tracked the predictions of the model.

Taken together, these findings are broadly consistent with the explanation that this episode of disinvestment by phase 4 industries, which began some thirteen years before actual policy implementation, was driven by an uncertainly anticipated decline in demand due to trade liberalization in the presence of capital adjustment costs. This result suggests that accounting for capital dynamics is an important element in modeling the response of markets to trade policy changes, and in estimating the welfare effects of those changes, even over time scales on the order of a decade. It also provides a useful example of the anticipatory investment behavior arising from adjustment costs under uncertainty 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 select a set of industries into phase 4 for which these costs are particularly important.

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

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