A Model of Russia's "Virtual Economy"

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Abstract

The Russian Economy has evolved into a hybrid form, a partially monetized quasi-market system that has been called the *virtual economy*. In the virtual economy, barter and non-monetary transactions play a key role in transferring value from productive activities to the loss-making sectors of the economy. We show how this transfer takes place, and how it can be consistent with the incentives of economic agents. We analyze a simple partial-equilibrium model of the virtual economy, and show how it might prove an obstacle to industrial restructuring and hence marketizing transition.

1 Introduction.

The Russian transition from a "demonetized command economy" to a "monetized market economy" has taken an unexpected detour. The Russian economy appears to be evolving a new hybrid system, a partially monetized quasi-market economy.[1] This hybrid has been called the "virtual economy."[2] The

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[1] In his 1999 State of the Federation, Boris Yeltsin commented that, "We are stuck halfway between a planned, command economy and a normal, market one. And now we have an ugly model – a cross-breed of the two systems."

[2] See, for example, Gaddy and Ickes (1998b).

"virtual economy hypothesis" has been used to explain the lack of restructuring in Russian enterprises and the growth of barter and other non-monetary transactions. In particular, the virtual economy hypothesis implies that barter and non-monetary transactions play a key role in distributing value from productive sectors and activities to the loss-making sectors and enterprises in the economy. Without such transfers the virtual economy could not exist.

Here we begin an exploration of the heart of that redistribution of value through a simple model of the interaction between the principal actors in the 'virtual economy': the government, the primary value-adding sector, energy, and enterprises in the largely unrestructured, and hence low to negative value-added, industrial manufacturing sector. In this model we formalize the incentives of the key agents and the way those incentives support the 'virtual economy' as an equilibrium configuration of behaviors on the part of these economic actors. We also begin an exploration of some of the consequences of this economic system, in particular the additional barrier that it places before the restructuring and modernization of Russian industry.

1.1 Some Russian Transition Puzzles.

The "Virtual Economy" hypothesis provides a potential explanation for a number of anomalies and puzzles of the Russian transition, characteristics which set its experience apart from the transition experience of the emerging market economies of east central Europe. The most important puzzle, of course, is the failure of a large number of enterprises to restructure. In addition are a set of phenomena, elsewhere considered a "passing part" of early transition,[3] that have become *characteristic* — embedded in the structure of the economic system — in Russia. Among these are:

- Apparently permanent *arrears* of payments, wages, taxes;[4]

[3] See, for example, the discussion in Blanchard (1977).

[4] Industrial arrears measured as a share of industrial sales increased from over 40% in early 1998 to 60% in August. Since the sharp devaluation of the ruble they have gradually returned to about 40%. They are comprised primarily of two items: arrears to suppliers, and arrears to the budget and off-budget funds (*Russian Economic Trends*, June 1999: 3.). Total arrears as a percentage of annualized GDP have followed the same pattern (Ivanova and Wyplosz (1999: 24).

- Massive *Barter* among industrial enterprises, in elaborate chains, at 'idiosyncratic' (virtual) prices/rates of exchange;[5]

- Substantial use of *Quasi-moneys* [*Vekseli*, offsets (*zachëty*), and local or enterprise script], with idiosyncratic values, for closing transactions within 'barter chains', for taxes and for wages.

These distortions indicate a substantial *re-demonetization* of economic interaction and exchange in the core industrial sectors of the Russian economy, a resort to non-monetized intermediation reminiscent of the Soviet period. They have been accompanied by a continuing, indeed growing, inability to cover costs in manufacturing,[6] despite (explicitly & implicitly) subsidized prices for fundamental inputs, including energy, transportation, basic metals and industrial materials, and even — due to the ability to reduce wages through arrears, script and in-kind payments — labor. This has been accompanied by a continuing absence/decline in investment in the production sector,[7] limiting restructuring in core industry (despite massive debt accumulation, much from abroad), and by a surprising (given dramatic changes in economic and valuation environment) continuity/stability in business networks and relations. This state of transition has led to growing fiscal imbalances, at all levels, that culminated in the financial crisis of 1998.[8]

A large number of partially overlapping explanations are available for these phenomena. They include:

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[5]Barter increased from approximately 5% of sales in 1992 to over 45% of sales in 1997. See, for example, Hendley, et. al. (1998).

[6]For example, the share of industrial enterprises reporting net losses was 47.3 percent in October 1997 (that is, before the crisis of August 1998), up from less than 27 percent in 1995. Data are from Goskomstat as reported in Interfax Statistical Reports, nos. 14, 51/52: 1997, 4: 1998, and 5: 1998.

[7]Investment declined steadily throughout the period of transition, bringing the volume of capital investment for 1997 to less than 24% of its 1990 level [OECD (1997), 37]. See also *Interfax Statistical Report*, no. 4, 1998. In 1998 gross fixed investment declined 6.7%; during 1999 this finally showed an increase, 1% for the year. [*PlanEcon Report,* vol. XVI, 3, February 2000, 6]Although some decline in investment-GDP ratio was a necessary response to the excessive rates of the Soviet period, this seems to be an over-correction. This is evident in the aging of the capital stock. In 1980 the average age of plant and equipment was 9.5 years; in 1995 it was 14.1. This is all the more ominous given the fact that in the Soviet period replacement rate were very low, and capital was kept in place until physically obsolete.

[8]See, for example, Ericson (1998).

- insufficient liquidity due to misplaced 'monetarism' [Russian Academy (1997), Commander-Mumssen (1998), Woodruff (1999a)],
- irrationally high (controlled) monetary prices, especially for energy, inducing barter as a means to effect price cuts[Woodruff (1999a, 1999b)];
- tax evasion [Hendley *et al.* (1998), Yakovlev (1999)];
- inefficient monetary and credit systems [Poser (1998)];
- rent-seeking in monetized transactions by commercial and monetary intermediaries, raising transactions costs above those of barter and quasi-monies [Guriev-Pospelov (1998)];
- a lack of serious industrial restructuring, implying an inability to reproduce value with the inherited configuration of technologies, production facilities, social obligations, etc. [Commander-Mumssen (1998), Gaddy-Ickes (1998b), Ericson (1998)].

These explanations basically fall into two categories: (1) bad policy, and (2) bad structure. The "bad policy" arguments suggest that technical solutions could be devised that would eliminate barter.[9] In these explanations, barter is what needs to be explained. The "bad structure" explanations focus on more fundamental problems that plague the Russian transition. Barter is a side effect of agents' attempts to cope with the structural legacies of the previous system in the context of a quasi-market economy.

While both types of explanation are undoubtedly valid, the second seems to us more fundamental. Moreover, only the virtual economy hypothesis explains the lack of restructuring and the growth in barter as part of the same process. Specifically, it derives from the fact that much of inherited industry — the legacy of the Soviet Union — must avoid the monetized economy as it is not viable there. It can only survive in a "virtual economy."

1.2 The Virtual Economy Hypothesis.

Much of the economic activity and the stock of assets in Russia, as measured in monetary terms, is more apparent than real. It reflects an exaggerated valuation of both production and capital in the core manufacturing sectors of the

[9] These may be complex to implement, at least with respect to tax evasion, but in in principle they are feasible, technical solutions.

economy. These capacities reflect a structure of factor and input use inherited from the Soviet Union, despite sometimes substantial borrowing for investment in new equipment. They reflect a general lack of serious restructuring of facilities, processes and products, as well as little change in managerial practices.[10] Thus the core of industrial manufacturing contains many low (to negative) value-added enterprises at "market" [user/consumer value] prices. Particularly with import alternatives, much of manufacturing can't survive in an even partially competitive market. Yet the collapse/disappearance of this core is socially/politically unacceptable, even when it is economically rational (market-valued social surplus enhancing) to close and replace those enterprises. Indeed, in the extreme conditions of political, economic and institutional uncertainty that prevail in Russia, the replacement of closed enterprises would seem to be an extremely lengthy and uncertain process.[11] This helps explain why bankruptcy statutes have been effectively ignored.

It is not just governments that are reluctant to shut down loss-making enterprises. Enterprise directors have an incentive to keep them operating so that they can continue to appropriate cash flow on the basis of their control of enterprise assets.[12] The fact that the enterprise is not viable in the market economy means that some other way must be found to continue operation, allowing continued appropriation of cash flow. To make these enterprises *appear* viable (value-adding) they engage in specific strategies to keep output prices 'above market' and input costs held 'below market' through barter, arrears, or quasi-monetary instruments, generating "virtual prices."[13] Among such strategies are:

[10] This lack of restructuring, and the reasons behind it, are nicely summarized by a recent report of the McKinsey Global Institute (1999) to the Russian government on the situation in 10 critical sectors of the Russian economy in 1997-8.

[11] One important factor is the peculiar geographic location of enterprises in Russia. Enterprises were located under Soviet conditions without regard to transportation costs. If L/NVA enterprises were shut down it is not at all clear that new enterprises will form in the same location. For regional officials this is an important consideration operating against enforcing bankruptcy statutes. See Ickes, et. al. (1997).

[12] Even L/NVA enterprises have some cash flow, just not of a sufficient magnitude to cover costs. A director of such an enterprise can appropriate some of this cash flow if the operation can be maintained. This provides a good part of the explanation of the keen interest of directors in maintaining operation of loss-making enterprises. Notice the role of a regime where agents do not have to meet their fiduciary responsibilities to survive, e.g. a regime in which arrears to suppliers, government and workers is endemic.

[13] Note than none of these is possible in a legal environment in which property and contract rights are effectively enforced, providing recourse for creditors.

- trading industrial output at exaggerated value for energy, transportation, and basic material inputs (lowering their relative prices);
- forcing "natural" (in-kind) wages on, or ceasing to pay (i.e. imposing "arrears" on) workers, lowering the wage bill;
- bartering with, or using offsets/arrears on, governments at all levels to lower indirect/overhead costs and taxes.

Thus low/negative value added (L/NVA) enterprises can appear viable, able to cover costs, by pursuing these 'virtual' strategies. The only problem for them is how to get their hands on cash/money/credit [an apparent liquidity problem]; no one is willing to pay real money at these virtual prices. This provides a strong incentive for management, that would otherwise lose its (personally lucrative and politically powerful) position, to engage in this demonetized "virtual economy." In addition, the total lack of transparency in the resulting system of valuation covers the massive extraction of "rents" under the illusion of performance. Thus both the government and L/NVA enterprises have an interest in preserving the fiction, a mutual interest that is reflected in some (now generally indirect) government subsidization through tax offsets, tacit acceptance of arrears on taxes, wages, etc.

The interests of the government and the L/NVA enterprises in maintaining the fiction that the core of the manufacturing sector is viable are clear. But these incentives are insufficient to maintain operation of these L/NVA enterprises; value must be transferred from the value-adding sectors of the economy to prop up loss-making enterprises. The primary source for the reallocation of value that preserves the virtual functioning of inefficient manufacturing is the same as it was in the Soviet Union — the energy and resource sectors.[14]

1.3 Is It Real?

As participation in the "virtual economy" involves a sacrifice of (potential) wealth, the question arises as to why value-adding producers in the energy and resource sectors would willingly participate in such a transfer of value to

[14]This continuity is nicely observed and discussed in Tompson (1998). These are not, however, the only sources of value. In addition, new private enterprise contributes in the form of higher effective tax rates and other costs associated with operating in the monetary economy. See Gaddy and Ickes (1999).

other enterprises. The basic answer seems to lie in separation of the incentives of those who control the resource and energy industries from the value created in their operation. As discussed in Gaddy and Ickes (1998a, 1999) the government is able to offer incentives for "cooperation," and threaten punishments if the 'value adders' do not continue to provide support for manufacturing, in terms of access (or its denial) to lucrative export markets, political power and influence, the toleration of rent-seeking ("leakages"), and the threat of loss of control by independently voting its shares or redoing tainted privatizations.

In addition it has been argued [Woodruff (1999a,b)] that these "natural monopolies" have an interest in using their market power to extract additional surplus through price discrimination.[15] This is reinforced if export (hard cash) markets are quantity and price constrained and the domestic cash prices are supported by a (high) regulated floor. Under such circumstances, energy producers will try to increase domestic sales,[16] and by employing barter they can segment the domestic "for cash" and "for barter" markets. Hence barter for overpriced manufactures can generate a desired "price cut" maximizing profits from the L/NVA sector. However, the question remains as to whether these incentives are sufficiently strong and consistent for the configuration of behaviors required by the virtual economy hypothesis to be self-reinforcing, i.e. to comprise an equilibrium.

There is also a question of the consequences of the existence of the "virtual economy" for the Russian transition. Should it be considered just a reflection of a passing stage in a long and difficult transition process, one generated largely by misguided policy choices and the optimal response of economic agents thereto? Or is it representative of a much deeper problem, as much a cause as a consequence of the extraordinary difficulties of the Russian transition? We believe that the latter is closer to the truth as the roots of the "virtual economy" lie in the inherited inefficiencies and deformities of the Soviet industrial and factor-use structures. The "virtual economy" has become a means of survival for wasteful economic activity, removing the incentives and pressures for the radical restructuring of production activity that is essential to success of the transition to a tolerably well-functioning market economy. It has erected a barrier to investment in restructuring,

[15] There are also incentives for price discrimination along "relational capital" lines within traditional inter-enterprise networks. See Gaddy and Ickes (1998a).

[16] Alternatively, they could simply store the gas and sell it in the future if the expected growth in price exceeds the market rate of interest.

further delaying the progress of transition.

Here we begin a formal analysis of this issue in a simple microeconomic model of the two key production sectors, energy (G) and manufacturing (M), their interaction through both monetized and barter/offset/*vekseli* markets, and the self-interested role of the government in supporting their interaction. In addition to providing a partial equilibrium model, we explore the conditions under which non-monetized interaction (aka "barter") supporting inefficient industrial enterprises is an optimal strategy for the energy sector, given government incentives, and then analyze conditions under which this optimal "barter" removes incentives for efficiency enhancing, surplus maximizing, and often Pareto improving restructuring of the manufacturing sector. Thus we take the first steps toward providing a general equilibrium model in which the "virtual economy" can be seen as a "bad" Nash equilibrium in comparison to a fully monetized and marketized equilibrium of a restructured economy.

2 The Model.

We model the "virtual economy" as consisting of two active (types of) agents: a monopolist energy sector (**G** — 'Gazprom') and a manufacturing sector, **M**, consisting of a continuum of producers with differing inherited efficiencies. The efficiency of manufacturing production is captured by an energy input coefficient, and the model is explicitly short run with fixed unit-input requirements up to an exogenously given capacity. We explicitly focus on the "energy" market where we model the determination of both monetized and 'barter' equilibrium prices and quantities; other market prices are taken as exogenously fixed. Enterprises in **M** are price-takers, while **G** is a monopolist who can discriminate between efficient and inefficient manufacturing enterprises.[17] The government participates in the equilibria of these markets through its (here fixed) choice of "incentive" parameters affecting the willingness of **G** to engage in 'barter' and hence the resulting transaction prices and quantities, the survival rate of manufacturing enterprises, and the revenues at the disposal of the state.

As a first approximation, we consider governmental behavior parameters, introduced in Section 2.2 below, to be fixed, and hence part of the environ-

[17] This ability comes from detailed knowledge of the rigid production networks and their planned energy requirements inherited from the Soviet Union.

ment faced by the active agents in the model. Although its support is critical to the existence and viability of the virtual economy, we take that support to be given in the parameters used here to influence the incentives of G. These parameters are assumed to result from the incentives of the government to support L/NVA manufacturers that were discussed in the Introduction. These include the (indirect) taxes that operating, even if unprofitable, firms still pay, and the avoidance of direct and indirect social and economic costs of shutdown and unemployment. These incentives are of course weakened when industry undertakes substantial restructuring, thereby increasing efficiency and taxable revenues but doing less for maintaining industrial operations and employment. Thus the support of barter and restructuring are to some extent substitutes in the preferences of the government. How they interact with the desire for tax revenue and the perceived need to maintain certain types of manufacturing capacity, regardless of efficiency, is the subject of further investigation and modeling that goes beyond the scope of this paper.

2.1 Manufacturing.

We model L/NVA firms in the manufacturing sector, **M**, as those wasteful in their use of energy. Let the **M** sector consist of a continuum of non-atomic plants/enterprises, indexed $f \in \left[0, \overline{f}\right]$, each with a linear homogeneous technology and energy input requirement a_f. Each has the capacity to use at most 1 unit of (energy) inputs from **G,** thereby producing a_f^{-1} units of output**.** Let p_m be the market price of manufacturing output,[18] and p be the price of energy inputs. Letting $\eta_f \equiv w\ell_f + \gamma_f$ be other unit production costs, where w is the wage rate, ℓ_f — unit labor requirements, and γ_f — capital, tax and other overhead unit costs, the full unit cost of output becomes: $pa_f + \eta_f$. Let plants be ordered by *decreasing* energy efficiency, i.e. by *increasing* input coefficient, a_f, where the energy input coefficient is parametrized as follows:

$$a_f = \varphi + \sqrt{f},\ f \in \left[0, \overline{f}\right].$$

Assume that $\eta_f = \eta$, $\forall f$, and that plants are uniformly distributed on $[0,\overline{f}]$.[19] Then to produce, the plant with input requirement a_f must be able

[18]This might be considered the price at which import substitutes become available.

[19]This is inessential, but makes the analysis much more transparent.

to cover unit costs:

$$p_m \geq pa_f + \eta. \tag{1}$$

This implies $p \leq (p_m - \eta)a_f^{-1}$ is necessary for the energy input to be purchased; for any p, only manufacturing enterprises with a_f sufficiently small will demand any energy input, as only they satisfy (1). As technology is linear, the plant f will use either 1 (i.e. up to capacity) or 0 units of energy; we will assume maximal output, i.e. $y_f = a_f^{-1}$ from 1 unit of energy input, whenever this condition is satisfied. This gives an inverse demand function for energy inputs of

$$P(f) = \frac{p_m - \eta}{\varphi + \sqrt{f}} \equiv D^{-1}(f) \tag{2}$$

where $D(p)$ denotes total demand at the price p, and f is the least efficient (marginal) enterprise demanding a unit of energy inputs. That is, $P(f)$ is the price at which each of the enterprises $\widetilde{f} \leq f$ would demand its capacity quantity of 1, while each enterprise with index greater than f would demand 0 energy inputs. Note that $\frac{p}{p_m}$ is the amount of manufactures that must be sold to pay for required energy inputs, while $\frac{\eta a_f^{-1}}{p_m}$ is the amount that must be sold to cover non-energy production costs. Thus a firm produces if and only if

$$\frac{p}{p_m} + \frac{\eta a_f^{-1}}{p_m} \leq a_f^{-1} \Leftrightarrow pa_f + \eta \leq p_m.$$

Enterprises with $p_m < pa_f + \eta$ are unable to pay for unit costs of production unless they can avoid paying some labor or capital costs, or can get a better price. This might be done by paying $q < p$ through bartering their output to $\mathbf{G}$ for $\theta p_m > p_m$, so that $q = \frac{p}{\theta}$. This barter can only reduce energy costs; other costs must still be covered by selling output $(a_f^{-1} - \frac{q}{p_m})$, beyond the amount $\frac{q}{p_m}$ required to purchase the unit of energy input, at the market price p_m.

Hence, enterprises f such that $P(f) < p$, or equivalently $D(p) > f$, produce insufficient value to cover their costs at prevailing market prices; their operation reduces the value produced in the economy if p is a competitive equilibrium market price. Such enterprises, unless they are subsidized, will have to cease production even if they cannot fully exit in the short run. It appears that Russian manufacturing is replete with such enterprises.[20] It is among such enterprises that the search for "barter" alternatives, that effectively raise the price of their output above p_m, is urgent.

2.1.1 Barter.[21]

We assume that **G**, from long prior experience, knows which enterprises/plants are sufficiently productive to be able to pay the market price, p, and which will cease operation if they can't get subsidized energy inputs. **G** will thus refuse to engage in subsidization through barter of those it knows able to pay. Thus a sufficiently efficient firm cannot engage in barter with the energy sector. Only those enterprises unable to afford the market price p can barter their product for a 'virtual' price θp_m, hence effectively paying only q per unit of energy input. This barter adds to the 'demand' for energy, expanding sales without cutting into effective monetized demand. The increment in energy 'demand', that is the quantity of 'energy' bartered for manufactures, then becomes:

$$D_b(q, p) = D(q) - D(p).$$

The reduction in its real energy costs from the ability to acquire inputs cheaply generates an increase in apparent ("virtual") value of a manufacturing enterprise's output. Let y_m be the share sold for the market (equilibrium) price of p_m, and y_b be the share bartered at an implicit price $\theta p_m > p_m$, with total output $y = y_m + y_b$. Since y_b is only used to acquire energy inputs, $\theta p_m y_b = p a_f y$ so $y_b = \frac{p}{\theta p_m} a_f y = \frac{q}{p_m} a_f y = \frac{q}{p_m}$ as $y = a_f^{-1}$, and $p_m y_m = p_m \left(1 - \frac{p}{\theta p_m} a_f\right) y \geq \eta y$ if barter makes the enterprise viable. This

[20] Many are kept alive by institutional imperfections such as the lack of effective bankruptcy. In 1997-8, 40-60% of Russian manufacturing operated at a loss. See *Russian Economic Trends*, 7, 4, 1998: 45. Notice that precisely because of the 'virtual strategies' employed by enterprises it is notoriously difficult to interpret enterprise financial statements.

[21] We use the term "barter" to refer to any of the quasi- and non-monetary ways of implementing idiosyncratic prices that overvalue the product of L/NVA producers and undervalue that of the value-adding sectors. This includes the use of commodity or services backed script, *vekseli*, re-traded promissory notes and debt, and offsets, as well as the direct and indirect exchange of products at 'virtual' prices (rates of exchange). On the many forms used, see Aukutsionek (1998), Commander and Mummsen (1998), Poser (1998) and Yakovlev (1998), as well as any of the papers of Gaddy and Ickes.

generates, for $\theta > 1$, "virtual revenues" of

$$\begin{aligned} \theta p_m y_b + p_m y_m &= p_m\left[1+(p-q)a_f\right]y = \\ &= p_m y + \frac{p_m}{\theta}\left[\theta - 1\right] p a_f y > \\ &> (p a_f + \eta) y = p + \eta a_f^{-1}, \end{aligned} \tag{3}$$

which are necessary to appear viable.

For the rest of the paper we will normalize the (fixed by assumption) price of manufactures output to be 1. When $p_m = 1$, the manufacturing demand for energy input is

$$D(p) \equiv F(p) = \left(\frac{1-\eta-\varphi p}{p}\right)^2. \tag{4}$$

It is a decreasing, convex function of price with an elasticity, $\frac{-2(1-\eta)}{1-\eta-\varphi p}$, which is increasing in p (decreasing in f, i.e. in quantity sold) and greater (in absolute value) than $\frac{2\left(\varphi+\sqrt{f}\right)}{\sqrt{f}} > 2$ [for all $f \leq \overline{f}$, i.e. $p \geq \frac{1-\eta}{\sqrt{\overline{f}}+\varphi}$]. Thus there is a well defined optimum for the **G** monopolist selling to **M.** This demand function, and its associated marginal revenue curve, are illustrated in Figure 1 where $\eta = .3$ and $\varphi = .2$ are assumed.[22]

This demand curve reflects the willingness to pay for energy inputs of the manufacturing sector. It is the true "value of marginal product" of energy in manufacturing, derived from the market demand for manufacturing output. It is relevant for determining the quantity transacted at any real "price," whether monetary or bartered.

2.1.2 Restructuring.

An alternative to operating with current technology is to invest in restructuring. Restructuring by enterprises in **M** is assumed to involve raising investment funds through borrowing or surrender of equity, requiring opening the books of the enterprise, and establishing new economic relations, effectively breaking out of old relationships and barter networks. Restructuring investment has four primary consequences. For any enterprise f that restructures:

[22]Note marginal revenue (dotted line): $R(f) = p(f)\cdot f$ so $R'(f) = 1.75\frac{5.0\sqrt{f}+2.0}{\left(1.0+5.0\sqrt{f}\right)^2}$.

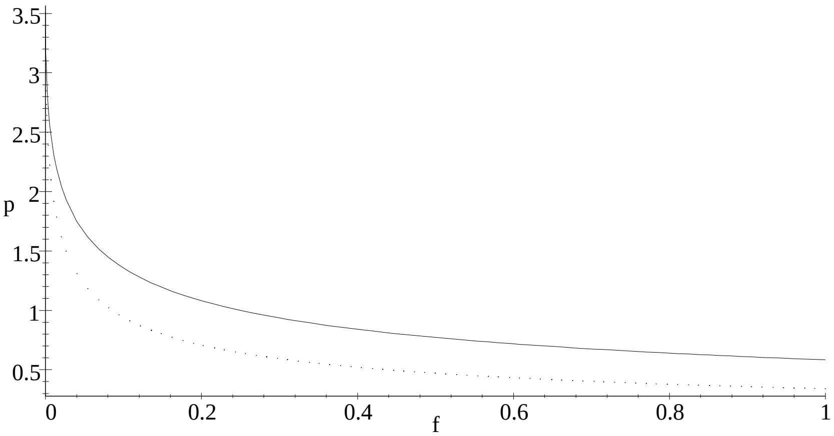

Figure 1: Manufacturing Demand for Energy

- energy efficiency rises: $\widehat{a}_f < a_f$;
- there is a rise in the other unit costs due to an increase in the "cost of capital" that exceeds any savings in unit costs from increasing factor/input productivity: $\widehat{\eta} > \eta$;
- the effective output (quality units) per unit bundle of inputs increases: $\varrho > 1$;
- the opportunity to barter output at more favorable than market rates is lost: network relations are broken and finances become transparent.[23]

These considerations are formalized as follows. Letting $\kappa > 0$ be the net increment of other unit costs per efficiency unit of output and $\varepsilon \in (0,1)$ parametrize the relative energy-efficiency gain, we have $\widehat{\eta} = \varrho^{-1}(\eta + \kappa)$ and $\widehat{a}_f = \varrho^{-1}\left(\varphi + \varepsilon\sqrt{f}\right)$. This gives an f that restructures a new cost covering condition

$$p_m \geq p\widehat{a}_f + \widehat{\eta}, \tag{5}$$

[23]Thus any restructured firm, regardless of its efficiency, is in the same position as a firm that **G** knows to be efficient: it must rely on arms-length market relations.

and a new 'willingness to pay' (demand price) of

$$\widehat{P}(f) = \frac{\varrho p_m - (\eta + \kappa)}{\varphi + \varepsilon\sqrt{f}} = \frac{\varrho - (\eta + \kappa)}{\varphi + \varepsilon\sqrt{f}}, \tag{6}$$

as $p_m = 1$. Thus the restructuring opportunity is characterized by three fixed parameters: $\{\varepsilon, \kappa, \varrho\}$. Only ε interacts with the prior efficiency of the enterprise; the others are given by the characteristics of the technology.

This formulation implies that restructuring has very little effect on initially energy-efficient ("world class") enterprises, and brings the greatest benefit to the least efficient enterprises. Another implication is that the restructuring of all enterprises will result in a more elastic sectoral demand for energy as $\varepsilon < 1$. Finally, note that, due to the fixed increase in other costs, the willingness (ability) of some enterprises, those with sufficiently low index f, to pay for energy *can fall* with restructuring.[24] This demand for energy from a restructured manufacturing industry can be seen in Figure 2, using the same parameters as in Figure 1, with $\varepsilon = .7$, $\kappa = .1$, and $\varrho = 1$. Notice that marginal revenue (circles) from sales to the restructured industry also rises (above dotted MR curve) for sales above some minimal $\widetilde{f}$, and hence the monetized market can expand dramatically.

A enterprise that restructures can no longer engage in barter as it has broken old connections, and undertaken strong commitments to outsiders. Enterprises thus rationally restructure only when the surplus they receive after restructuring, $\widehat{s}_f = 1 - \widehat{p}\widehat{a}_f - \widehat{\eta}$, where $\widehat{p}$ is the new market price for energy, is greater than that in its absence: $s_f = 1 - pa_f - \eta$ or (if it is initially bartering for its input) $s_f = 1 - qa_f - \eta$. Otherwise there is no restructuring chosen. Notice, however, that when restructuring is taking place in some manufacturing firms other firms may no longer face the original price p or q as the monopolist adjusts to some $\widetilde{p}$ in order to optimally exploit the restructuring market. Thus the relevant comparison, at least for firms in the monetized market, may be between $\widehat{s}_f$ and $\widetilde{s}_f = 1 - \widetilde{p}a_f - \eta$, where $\widetilde{p} > p$.

2.1.3 Economic Value in M.

To close this section we present the social surplus generated by the use of energy in the manufacturing sector. As the sector is competitive and technology linear homogeneous, each operating enterprise contributes $(p_m - c_f)\, a_f^{-1}$,

[24] Whether this occurs, and for which f, depends of course on the specific parameter values $\{\varepsilon, \kappa, \varrho\}$. This is discussed in Section 3 below.

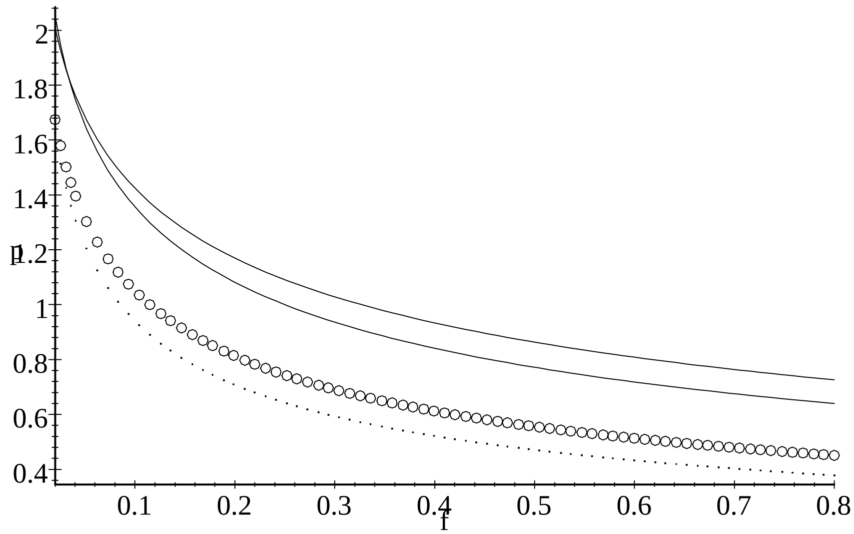

Figure 2: Impact of Restructuring on Energy Demand

where c_f is the unit cost of production in f that depends on the 'price' (p or q) paid for energy input. If a enterprise does not operate, then it imposes a fixed cost on society of $-\phi$.[25] Thus the surplus generated by the activity of the unrestructured industry with no barter and $p_m = 1$ is:

$$\int_0^{F(p)} (1 - ca_f - \eta)\, a_f^{-1} df - \phi \left[\overline{f} - F(p)\right],$$

where c is the social marginal cost of providing the energy input. If $p > c$, then part of this social surplus is taken as monopoly profit by the energy sector. When a portion of the industry, $F(q) - F(p)$, engages in barter, the surplus generated becomes:

$$\int_0^{F(q)} (1 - ca_f - \eta)\, a_f^{-1} df - \phi \left[\overline{f} - F(q)\right],$$

[25] It is the avoidance of these costs that, in part, provides the reason for the government setting incentives to encourage barter.

which is surely greater as long as $q \geq c$ so that no destruction of value takes place.[26] In any case, the portion of the surplus remaining with the industry, $\int_0^{F(p)} (1 - pa_f - \eta) a_f^{-1} df + \int_{F(p)}^{F(q)} (1 - qa_f - \eta) a_f^{-1} df - \phi \left[\overline{f} - F(q)\right]$, increases substantially.

Restructuring production in the industry further increases the value created in the industry, in particular by substantially reducing the number of operations that are not viable and hence impose a social cost ϕ. Thus restructuring is, in part, a substitute for barter in the eyes of the government. Letting $\widehat{F}(p)$ be the industry demand for energy after restructuring [the inverse of the willingness to pay function in (6)], we get

$$\int_0^{\widehat{F}(p)} (1 - c\widehat{a}_f - \widehat{\eta}) \widehat{a}_f^{-1} df - \phi \left[\overline{f} - \widehat{F}(p)\right],$$

where $\widehat{F}(p) > F(p)$ and can be greater even than $F(q)$, depending on precise parameter values. In this case it is the largest social value that might be created by the manufacturing sector. When $\widehat{F}(p) < F(q)$, there is a trade-off between increased value produced in each firm, and the cost savings from the increased number of firms surviving under barter. In either case, individual enterprises may be less well off, as the increase in demand from restructuring allows the monopoly provider of energy inputs to raise its price to $\widehat{p}$.

In all cases, the maximal social value that could be generated from energy use in manufacturing is

$$\int_0^{F(c)} (1 - ca_f - \eta) a_f^{-1} df - \phi \left[\overline{f} - F(c)\right]$$

without restructuring, and

$$\int_0^{\widehat{F}(c)} (1 - c\widehat{a}_f - \widehat{\eta}) \widehat{a}_f^{-1} df - \phi \left[\overline{f} - \widehat{F}(c)\right]$$

after restructuring. The latter is easily seen to be substantially greater than the former, as $(1 - c\widehat{a}_f - \widehat{\eta}) \widehat{a}_f^{-1} > (1 - ca_f - \eta) a_f^{-1}$ for all firms that restructure, and $\widehat{F}(c) \gg F(c)$.[27]

[26] Even when $c > q$, there is an increase in net social value as long as the loss in value added is less than the gain from avoiding shutdown of operations, $\phi [f(q) - f(c)]$.

[27] We provide illustrative numbers in the continuation of our numerical example below.

2.2 Energy: Gazprom, UES, etc.

The energy sector is modelled as a unitary actor.[28] It is taken to be a price-taker in international markets, its primary source of serious revenue, and a discriminating monopolist in domestic markets.[29] The world market (dollar) price of energy in rubles is $\overline{p}$, but **G** is export-constrained, by transport capacity and through licensing by the government, to a quantity $E(\cdot)$. The constraint can be altered by the government, and is assumed to depend on **G**'s support for industry **M**.[30] Let that support be measured by the volume of sales/barter, B, at below market (i.e. "barter") prices. Thus revenues from the hard currency export market are $\overline{p}E(B)$.

The domestic market is segmented into those who can pay cash and those who must barter, with the boundary determined by the price chosen by **G,** and the extent of the market determined by **G**'s choice of a barter 'price' q. Thus **G**'s total revenues are[31]

$$R(p,q) = \overline{p}E(B) + pD(p) + qD_b(q,p), \tag{7}$$

where the subscript b indicates the amount of energy bartered for manufactured goods. Those revenues are, however, subject to taxation leaving only some portion providing high-powered incentives to **G**. Assume that those incentives come from "leakages" from hard currency sales, $\alpha\overline{p}E(B)$, that are "overlooked" (i.e. implicitly allowed) by the government, and from (a share

[28] While clearly an exaggeration, this assumption captures the substantial market power exercised by the gas monopoly, *Gazprom*, the electric network, *UES*, the pipeline monopoly, *Rosneft*, and the major oil producers such as *Lukoil* and *Sidanko*.

[29] In 1997, for example, *Gazprom* exported 25% of its total production to Europe, receiving 100% cash in return, while 62% of total production was sold domestically with cash receipts constituting only 15% of the total. The remainder went to CIS countries which paid cash for 58% of deliveries. See Pinto *et al.,* (1999).

[30] This government policy can be derived as the optimal solution of government welfare in a more general model. That welfare will depend on tax revenues, the utility of maintaining a large manufacturing sector, the direct and social costs of entrerprise shutdown, etc.

[31] We assume that **G** only barters with manufacturers, while monetary sales are to the entire market including some manufacturers. This revenue function implicitly assumes that **G** sells all of the manufactured goods that it receives in barter, either to others or to itself, at the market price, p_m, thereby generating actual revenue per unit of bartered energy of $q = \frac{p}{\theta}$. If the price has to be discounted below p_m for resale or further barter, then **G**'s (marginal) revenues are below what is calculated below, reducing **G**'s incentive to barter with **M.**

of) after tax profits, given by[32]

$$\beta \left[\begin{array}{c} (1-\alpha)\overline{p}E(B) + pD(p) + qD_b(q,p) \\ -C(E(B)+D+B) \end{array} \right],$$

where $B = D_b(q,p)$ and $D = D(p)$. Finally, we might suppose that there are direct, non-pecuniary, incentives provided by the government to encourage support of manufacturing through lower input prices (barter); let this be given by $\delta u(B)$, and δ is a parameter allowing variation in the strength of this incentive.[33] The cost function is assumed to contain a large fixed cost, $\mathbf{F}$ (the model is short-run), and a low, constant marginal cost, c: $C(Q) = \mathbf{F} + cQ$.

2.2.1 The Monopoly Optimum.

Under these assumptions, **G**'s optimization problem is:

$$\max_{D,B} \left\{ \alpha\overline{p}E(B) + \delta u(B) + \beta \left[\begin{array}{c} (1-\alpha)\overline{p}E(B) + p(D)D + q(D+B)B \\ -c \cdot [E(B)+D+B] - \mathbf{F} \end{array} \right] \right\}, \tag{8}$$

Assume $E(B) = \overline{E} + \vartheta(B - \overline{B})$, and $\overline{p}\overline{E} > \mathbf{F}$ so that the unit cost of domestic sales is just c. Then optimization yields FOC's,

$$(\alpha + (1-\alpha)\beta)\overline{p}\vartheta + \delta u'(B) + \beta\left[q'(D+B)B + q(D+B) - c(1+\vartheta)\right] = 0 \tag{9}$$
$$\beta\left[p'(D)D + p(D) - c\right] = 0$$

The impact of these conditions, and how they exploit the segmentation of the market are easy to see in the analytic example introduced in the prior section. Letting $c = 0.7$,[34] we can explicitly solve for the monopoly optimum both with and without barter and with and without special government incentives. The basic monopoly optimum is $F(p) \approx .205$, with $p \approx 1.072$, as seen in Figure 3.

[32] This assumes that the government taxes actual revenues, and not the revenues that would have been received if the bartered output had actually been sold at price p.

[33] This might be justified in a more general model by threat/probability of expropriation and therefore losing the pecuniary incentives.

[34] And ignoring demand from other sectors, perhaps because their markets are further segmented and **G**'s marginal costs are constant.

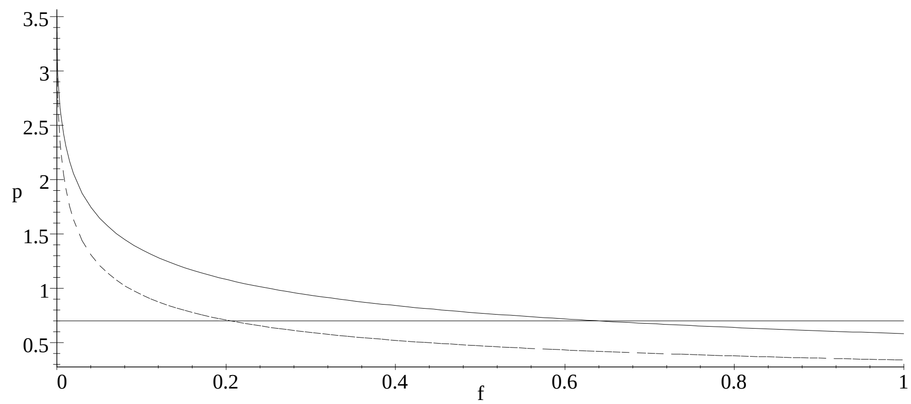

Figure 3: Monopoly Optimum without Barter

Introducing the option to segment the market and barter energy to manufacturers at a lower real price, allows **G** to expand sales and seize more of the surplus generated by the operation of manufacturers, even without added government incentives. In that case, the first order conditions are:

$$\begin{aligned} MR_D(D) &= c \\ MR_B(B,D) &= c \end{aligned}$$

as all of the terms involving the parameters $\alpha, \vartheta, \delta$ drop out of the first line of (9). In this case, the barter segment of the market is illustrated in Figure 4. Here barter reduces the inefficiency of monopoly, although it may drive $P(f)$ below ATC (full unit, including average fixed, cost) of energy production.

The energy sector, **G,** however, faces strong incentives to further extend barter, due to government policy. The introduction of incentives for barter effectively lowers the marginal cost to **G** of providing energy to the barter segment of the market. Indeed, as its decision-relevant marginal cost, $c(1+\vartheta) - \beta^{-1}\left[(\alpha + (1-\alpha)\beta)\overline{p}\vartheta + \delta u'(B)\right]$, is below social marginal costs, c, **G** may find it optimal to supply manufacturing enterprises for whom $P(f) < c + \frac{\mathbf{F}}{Q}$, and hence to support true NVA producers. This can be easily seen in the FOC's for our example,

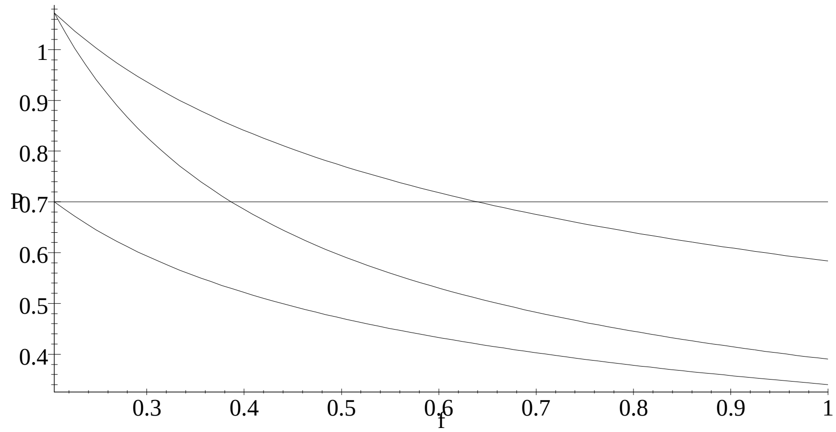

Figure 4: Barter Optimum without Government Incentives

$$
\begin{aligned}
MR_D(D) &= \frac{1-\eta}{2} \cdot \frac{2\varphi + \sqrt{D}}{\left(\varphi + \sqrt{D}\right)^2} = MC_D(D) = c \\
MR_B(B, D) &= MR_D(D+B) + \frac{(1-\eta)D}{2\sqrt{D+B}\left(\varphi + \sqrt{D+B}\right)^2} = \qquad (10) \\
MC_B(B, D) &= (1+\vartheta)c - \frac{1}{\beta}\left\{[\alpha + (1-\alpha)\beta]\,\overline{p}\vartheta + \delta u'(B)\right\},
\end{aligned}
$$

showing how political factors lower the real marginal cost of supplying to barter. The optimal solution in this case is illustrated in Figure 5, where the politically determined marginal costs in our example are given by

$$
\begin{aligned}
MC_B(B, .205) &= .38056 + .10B = \qquad (11) \\
&= c(1+\vartheta) - \frac{1}{\beta}\left\{(\alpha + (1-\alpha)\beta)\overline{p}\vartheta + \delta u'(B)\right\} < c = .7,
\end{aligned}
$$

while the relevant marginal benefit is $MR_B(B, D) > MR_D(D)$ [given by '+++' line above the '$\cdots$' line].

Here the monopolists optimal decisions are:

$$\{p = 1.072; F(p) \equiv D = .205; q = .6357; F(q) \equiv F(p) + B = .812\}.$$

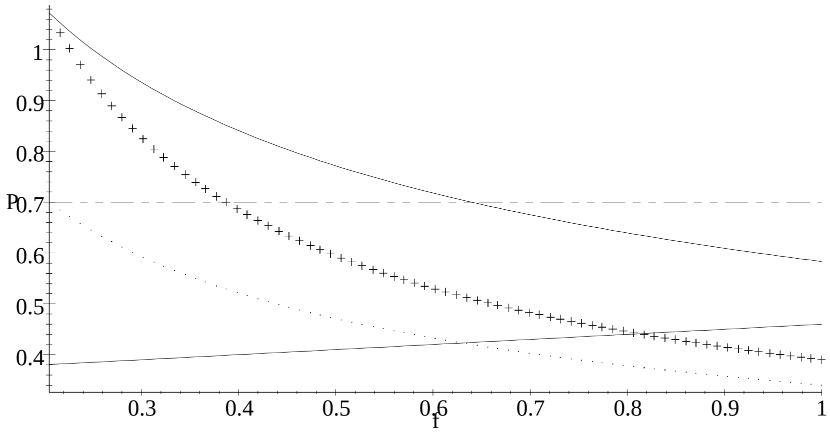

Figure 5: Barter Extension of Monopoly Optimum

Note that almost three quarters of the energy inputs acquired by manufacturers are acquired through barter.

When the manufacturing industry restructures, **G** loses its ability to distinguish the efficient from the inefficient among the "restructured" firms,[35] and hence the ability to segment the markets through barter. Thus it faces a single market with demand given by $\widehat{P}(f)$, and will choose an optimal $\{\widehat{p}, \widehat{D}\}$ such that $MR(\widehat{D}) = c$, where

$$MR(\widehat{D}) = \frac{\varrho - (\eta + \kappa)}{2} \cdot \frac{2\varphi + \varepsilon\sqrt{\widehat{D}}}{\left(\varphi + \varepsilon\sqrt{\widehat{D}}\right)^2}.$$

In the example with $c = .7$, $\epsilon = .7$, $\kappa = .1$, and $\varrho = 1$, optimal monopoly energy supply is $\widehat{D} = .2902 > D = .205$, and $\widehat{P}(\widehat{D}) = \frac{1-(\eta+\kappa)}{\varphi+\varepsilon\sqrt{.2902}} = 1.0397 < P(.205) = 1.072$. These results are illustrated in Figure 6. Thus, in this example, the monopolist allows some growth of the market, but nowhere near as much as with barter, even without extra government incentives, would allow.

[35] Firms, from the other perspective, lose the ability to credibly distinguish themselves as barter partners, due to their breaking out of the old networks during restructuring. Firms that do not restructure, however, maintain their old relationships, including that with **G.**

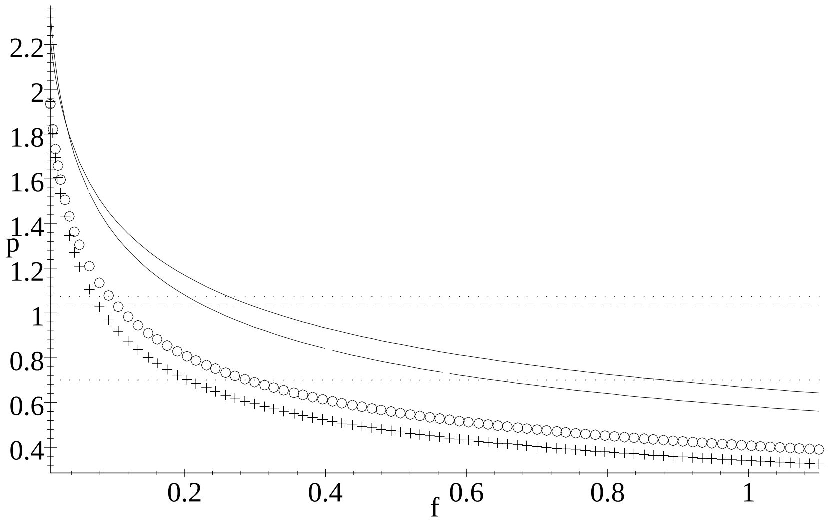

Figure 6: Monopoly Optimum in the Restructured Industry

2.2.2 Welfare Analysis.

The monopolization of the energy sector clearly leads to a loss of welfare in the economy, due to the value of energy (its demand price $F(p)$) being greater than the social cost of its provision ($\approx c$). This is reflected in a restriction in energy use in the monetized market, generating a deadweight loss of

$$\int_{F(p)}^{F(c)} (1 - ca_f - \eta)\, a_f^{-1} df,$$

and a monopoly rent of $(p - c)F(p)$. The introduction of barter, however, can reduce this distortion by profitably (for **G**) extending sales to a larger number of manufacturing enterprises. In the absence of special government incentives it surely increases welfare by cutting the deadweight loss to

$$\int_{F(q)}^{F(c)} (1 - ca_f - \eta)\, a_f^{-1} df,$$

while increasing profits by $(q-c)[F(q)-F(p)]$. Thus price discrimination cum barter can be an efficiency enhancing response to the monopoly distortion in the energy market in this model.

However, when the government lowers the incentive-effective marginal costs (11) of the energy monopolist, price discrimination through barter can drive energy use well beyond the point at which social marginal costs and benefits are equal, as is illustrated in Figure 5. There the social optimum occurs at $P(f) = .7$, that is when $f = .640$, while the discriminating monopoly optimum is $F(q) = .812$, so that the firms indexed in $(.64, .812]$ (over 21% of those operating) are truly negative value-added producers. Yet they appear to be viable, albeit cash constrained; a mirage of the virtual economy. This generates a deadweight loss of

$$\int_{F(c)}^{F(q)} (ca_f - (1-\eta))\, a_f^{-1} df,$$

while increasing the profits of the energy monopoly by $\int_{F(p)}^{F(q)} [q - MC_B(B, D)]\, df$ beyond the profits from monetized sales. This again illustrates the incentive that the monopolist has to transfer value to manufacturers, even when there is a net social loss; its private residual is thereby enhanced.

When manufacturing restructures, it suffers the full impact of the monopoly distortion. The deadweight loss imposed by monopoly restriction of output is

$$\int_{\widehat{F}(\widehat{p})}^{\widehat{F}(c)} (1 - c\widehat{a}_f - \widehat{\eta})\, \widehat{a}_f^{-1} df,$$

which is substantially greater than in the original unrestructured case. In our numerical example, $\widehat{F}(c) = .8813 > F(c) = .64$, $\widehat{F}(\widehat{p}) = .2902 > F(p) = .205$, and $(1 - c\widehat{a}_f - \widehat{\eta})\, \widehat{a}_f^{-1} > (1 - ca_f - \eta)\, a_f^{-1}$ as illustrated in Figure 2. In addition, monopoly rents increase to $(\widehat{p} - c)\, \widehat{F}(\widehat{p}) = .09858 > .205 \times .2476 = .050758$, the market monopoly rents from the unrestructured industry. These, however, are swamped by the rents earnable from barter, due to the special incentives that the government provides: $.050758 + \int_{.205}^{.812} (.6357 - .38 - .15f) df = .0508 + .1089 = .1597$. Thus again there is a substantial divergence between private and social incentives, one that can be expected to stand in the way of socially optimal restructuring.

3 Equilibrium and the "Virtual Economy" Trap.

Let us now explore in greater depth the equilibrium interaction between **G** and **M**, when enterprises in **M** have an option to invest in significant "restructuring." As argued in Section 2.1.2, restructuring by enterprises in **M** involves investment, requiring opening the books of the enterprise, which raises their energy efficiency and perhaps also labor efficiency and the quality/quantity of output. This gives an enterprise, f, that restructures a new cost covering condition

$$1 \geq p\widehat{a}_f + \widehat{\eta} \tag{12}$$

where $\widehat{a}_f = \varrho^{-1}\left(\varphi + \varepsilon\sqrt{f}\right)$, $\varepsilon \in (0,1)$, and $\widehat{\eta} = \varrho^{-1}(\eta + \kappa)$, $\kappa > 0$, generating the demand price for a restructured enterprise of $\widehat{P}(f)$ (6). As also argued there, an enterprise that restructures can no longer engage in barter since it has broken old connections, and undertaken strong commitments to outsiders.

3.1 M's Response to the Restructuring Opportunity.

Whether an enterprise chooses to restructure depends on both how its "demand price," $\widehat{P}(f)$, changes and how the price it is paying will change. Because the improvement in energy productivity is assumed inversely proportional to initial efficiency, the demand price of the most efficient firm, $f = 0$, will rise only if $(\varrho - 1)p_m = \varrho - 1 > \kappa$, i.e. the increase in unit value of output exceeds the increase in unit capital costs, net of other factor input savings. Such a restructuring opportunity is essentially a 'free lunch' and will be assumed not to be available. This gives a simple characterization of the change in demand price:

Lemma 1 *Let $\kappa > \varrho - 1$. Then, if they restructure, the most efficient firms, $f \in [0, \widetilde{f})$, would experience a drop in the unit value of (their willingness to pay for) energy inputs, while the less efficient firms, $f \in (\widetilde{f}, \overline{f}]$, would be willing to pay more for energy inputs after restructuring. The demand price of firm $\widetilde{f} = \left\{\frac{[(\varrho-1)-\kappa]\varphi}{[\kappa+(1-\varepsilon)\eta-(\varrho-\varepsilon)]}\right\}^2$ remains unchanged with restructuring: $\widehat{P}(\widetilde{f}) = P(\widetilde{f})$.*

Proof. The formula for $\widetilde{f}$ is the solution to the equation $\widehat{P}(\widetilde{f}) = P(\widetilde{f})$, i.e.

$$\frac{\varrho - (\eta + \kappa)}{\varphi + \varepsilon\sqrt{f}} = \frac{1 - \eta}{\varphi + \sqrt{f}}.$$

When the numerator is nonnegative, the demand price for all firms must increase. ■

We will say that a firm, f, "has an incentive to restructure" if and only if restructuring increases the unit value of energy for it: $\widehat{P}(f) > P(f)$. Thus $\widetilde{f}$ and all $f < \widetilde{f}$ have no incentive to restructure, so only those firms $f > \widetilde{f}$ will consider restructuring. Each such enterprise rationally decides to restructure when the surplus it receives after restructuring is greater than that in its absence:

$$\widehat{s}_f > s_f, \tag{13}$$

where

$$\begin{aligned} \widehat{s}_f &= 1 - \widehat{p}\widehat{a}_f - \widehat{\eta}, \\ s_f &= \begin{cases} 1 - pa_f - \eta \\ 1 - qa_f - \eta \end{cases}, \end{aligned}$$

depending on whether the firm f had access to barter or not. Here $\widehat{p}$ is the new price set by **G**.[36] We assume that the restructuring decision is irrevocable, but taken in correct anticipation of **G**'s optimal pricing response to the changed demand that results.

The optimal restructuring decisions, i.e. the reaction functions, of manufacturing firms are straightforward to characterize:

Proposition 1 *Let $\widehat{p}$ be the anticipated price of **G** in response to restructuring by users, $p = P(f_m)$ — the market price to the unrestructured industry, and let $\overline{p} = \widehat{P}(f_m)$.*

1. *For all $\widehat{p}$, no firm $f \in [0, \widetilde{f}]$ will choose to restructure.*
2. *For all $\widehat{p}$, every firm $f \in \left(\widetilde{f}, f_m\right]$ will restructure if it must pay $\widehat{p}$ even if it doesn't restructure.*
3. *For $\widehat{p} \geq \overline{p}$, no firm $f \in [0, f_m]$ will choose to restructure if not doing so leaves the price at p.*
4. *For $\widehat{p} \leq p$, all firms $f \in \left(\widetilde{f}, f_m\right]$ will restructure: $\widehat{s}_f \geq s_f$ (13).*

[36] The price a manufacturer faces after restructuring, $\widehat{p}$, may or may not differ from p, depending on whether, and how, **G** responds to its restructuring.

5. *For each* $\widehat{p} \in (p, \overline{p})$, *there exists an* $\widehat{f_p}$ *such that* $\widehat{s}_{\widehat{f_p}} = s_{\widehat{f_p}}$; *i.e.* $f < \widehat{f_p} \Rightarrow \widehat{s}_f < s_f$ *and* $f > \widehat{f_p} \Rightarrow \widehat{s}_f > s_f$. *Hence the "no restructuring" set of efficient firms expands as* $\widehat{p}$ *increases, if not restructuring leaves the price at* p.

6. *Let* $\underline{p} = \widehat{P}(f_b)$. *Unless* $\widehat{p} < \underline{p}$, *no* $f \in [f_m, f_b]$ *will choose to restructure. If* $\widehat{p} < \underline{p}$ *then some firms* $f > f_b$ *will choose to renew operation by restructuring.*

Proof. Part 1 holds as there is, by Lemma 1, no incentive for these firms to restructure. Part 2 follows from (13) and the fact that $\widehat{P}(f) > P(f), \forall f \in \left(\widetilde{f}, f_m\right]$. Part 3 is a consequence of the fact that $\widehat{P}'(f) < P'(f)\ \forall f$. Hence the surplus of all but the least efficient firm, f_m, is less after restructuring and facing $\overline{p}$ than when facing p without restructuring. For prices above $\overline{p}$ all restructured firms generate a still smaller surplus, while those near f_m cannot survive. Part 4 is similarly clear, as $pa_f > \widehat{p}\widehat{a}_f + \kappa \Leftrightarrow \widehat{s}_f \geq s_f$. These can be easily seen from the relationship between $P(f)$ and $\widehat{P}(f)$ in Figures 2, 6 and 8.

To see Part 5, note that for $\widehat{p} = p$, there is no change in the surplus of $\widetilde{f}$ from restructuring, while all firms $f \in \left(\widetilde{f}, f_m\right]$ strictly gain. As $\widehat{p}$ increases above p, the surplus of all firms decreases, rendering that of $\widetilde{f}$, and all f such that $\widehat{P}(\widetilde{f}) - \widehat{P}(f) < \widehat{p} - p$, less than it would have been with no restructuring at p. Clearly $\widehat{f_p} = \widehat{P}^{-1}\left(\widehat{P}(\widetilde{f}) - \widehat{p} + p\right)$ and the set of efficient firms that chooses not to restructure expands to $\left[0, \widehat{f_p}\right]$. Part 6 follows from the observation that, at $\widehat{p} = \underline{p}$, we have the same situation with respect to bartering firms as we have in Part 2 with respect to $\overline{p}$ for firms buying on the monetized market; only the least efficient firm maintains its (zero) surplus, and all others get a smaller surplus than they would if they continue to barter without restructuring at the rate of exchange q. Thus no firm, with an option to continue bartering, would consider restructuring, implying a return to the monetized market, at any $\widehat{p} \geq \underline{p}$. As $\widehat{p}$ drops below $\underline{p}$, firms on both sides of f_b, in particular those $f > f_b$ which without restructuring could not operate, will begin to find restructuring a desirable option. ■

This proposition has as an immediate consequence: the opportunity to survive through "barter" creates a barrier to restructuring *if* **G** (e.g. for political reasons) fails to respond to restructuring by altering its terms of trade.

Corollary 1 *If $\widehat{p} = p$, then no bartering firm will choose to restructure, unless $\underline{p} > p$.*

Proof. Follows immediately from Part 5 of Proposition 1. ■
Under our assumption that $\kappa > \varrho - 1$, the condition $\underline{p} > p$ can only hold for ε close to 0: $\varepsilon < \frac{q(\varrho-\eta-\kappa)-\varphi qp}{p(\varrho-\eta-\varphi q)}$.[37]

3.2 G's Response to the Restructuring Possibility.

To characterize the equilibrium restructuring decision, we now need to analyze the optimal response of **G** to restructuring by its users. **G** reacts to the demand function generated by restructuring decisions of firms in **M** and chooses a ex-post monopoly price. That response depends naturally on the number and type of firms in **M** that choose to restructure. The basic cases are outlined in the following:

Proposition 2 *Letting $\widehat{P}(\cdot)$ be the restructured demand price function, and $\widehat{F}(\cdot)$ be its inverse (the restructured industry's demand for energy), the optimal decision of **G** depends on restructuring as follows:*

1. *If no firm in **M** restructures, the market and barter price-quantity decisions of **G** remain unchanged.*

2. *The restructuring of any set of **M**-firms of measure zero has no impact on the monopoly price or quantity.*

3. *If all firms with an incentive to restructure in **M** do so, then no "barter" occurs and sales are made to $\widehat{f} > f_m$ firms, where $\widehat{f}$ solves*

$$\frac{d}{df}\left(f \cdot \widehat{P}(f)\right) = c,$$

and $\widehat{p} = \widehat{P}(\widehat{f})$. Further, $\widehat{f} < f_b$ will hold for ε sufficiently large.[38]

[37] In our numerical example the right-hand side of this expression equals $0.399159 < \varepsilon = .7$.

[38] $\varepsilon > .41848$, in our numerical example.

4. *If some subset of positive measure, $\mathfrak{F}$, of **M**-firms restructures, then the optimal monopoly price is $\widetilde{p} \in [\widehat{p}, \overline{p}]$, and depends on the size and location, in initial efficiency terms, of the set of firms that restructure. The marginal restructured firm supplied is, $\widehat{F}(\widetilde{p}) \leq \widehat{f}$, and firms in $\mathfrak{F}$ with $\widehat{P}(f) \leq \widehat{p}$ are ignored by **G.** If $\widehat{F}(\widetilde{p})$ is less than f_b, then $f_b - \widehat{F}(\widetilde{p})$ firms continue to barter at $\widehat{q} < \widehat{p}$ where $\widehat{q} = B$ solving a condition similar to that in equation (10).*

5. *There exists a $f^v < f_m$ such that, if only firms up to some $f^* \in \left(f^v, \widehat{F}(\widehat{p})\right)$ restructure, then the optimal monopoly price is $p^* = \widehat{P}(f^*)$, the input price that eliminates the surplus of the marginal firm. If $f^* < f^v$ then it remains optimal to sell to f_m at the initial price p.*

Proof. The first assertion is obvious: raising the price reduces revenues by more than costs as manufacturers drop out of the market. The second follows from the observation that such restructuring has no noticeable impact on market demand. The third assertion is just the condition that the marginal revenue from the demand curve of the restructured industry equals the (constant) marginal cost of supplying that industry. $\widehat{f} > f_b$ can hold only when marginal revenue after restructuring at f_b exceeds the marginal cost, c, of supplying the market. Note that all barter incentives are lost in supplying these restructured firms. This condition will be true for all ε such that:

$$\frac{\varrho - \eta - \kappa}{2} \cdot \frac{2\varphi + \varepsilon\left(\frac{1-\eta-\varphi q}{q}\right)}{\left[\varphi + \varepsilon\left(\frac{1-\eta-\varphi q}{q}\right)\right]^2} > c, \tag{14}$$

as $f_b = \left(\frac{1-\eta-\varphi q}{q}\right)^2$. Direct calculation, using our parameter values, gives the lower bound of $\varepsilon \cong .41848$.

The fourth assertion can be seen by noting that firms that restructure move up (to lower *input* coefficients), while those that were initially more efficient but don't restructure are displaced lower in the efficiency ordering. Let f^s be the most efficient firm in $\mathfrak{F}$ (assumed to be an interval; the generalization to a union of intervals is straightforward). It then displaces in the efficiency ordering to f_s such that $\widehat{P}(f^s) = P(f_s)$. The new demand curve has a discontinuous rise in marginal revenue at f_s due to the kink where the interval of length F from $\widehat{P}(\cdot)$ is pasted to $P(\cdot)$. There are two cases to consider: (a) if $|\mathfrak{F}|$ is smaller than $f^s - f_s$, then $\widetilde{p} = p$ with f_m firms supplied on the monetized market, or $\widetilde{p} = \widehat{P}(f^s + |\mathfrak{F}|)$ with only $f^s + |\mathfrak{F}|$ so supplied, depending on which generates greater profit. (b) If $|\mathfrak{F}|$ is greater than $f^s - f_s$ then $\widetilde{p} \in (p, \widehat{p})$ where the new higher marginal revenue equals c, or where the discontinuity (downward) crosses c at $f_s + |\mathfrak{F}|$.

To see assertion 5, note that there exists an f^v such that

$$\left[\widehat{P}(f^v) - c\right] f^v = \left[P(f_m) - c\right] f_m.$$

For $f^* > f^v$, the lhs of this expression grows ($\widehat{MR} > 0$), hence it pays to maintain the higher price even if selling to fewer than f_m. As marginal revenue exceeds marginal cost, f^* is supplied at the highest price maintaining that demand. For $f^* < f^v$, profits are greater from expanding the market to f_m. ■

Remark 1 *Although not necessary, it simplifies the argument to assume that government incentives (the parameters $\alpha, \delta, \vartheta$) are set such that $f_b > \widehat{f}$, i.e. the least efficient firm surviving on barter is less efficient than the marginal firm supplied on the market after its restructuring. Indeed, in our analytic example $f_b = .812$ is substantially greater than $\widehat{f} = .2902 > f_m = .205$.*

These results reinforce the corollary to Proposition 1. They show that the price of energy will never fall below $\underline{p}$ unless there are extraordinarily large efficiency gains to restructuring. Thus, $\widehat{p}$ remains near or above p, rendering restructuring undesirable for all firms engaged in, and subsidized through, "barter."

3.3 Equilibrium with Possible Restructuring.

We are now in a position to consider the equilibrium of the interaction between **G** and the continuum of nonatomic firms in **M.** We begin from an initial equilibrium, as characterized in Section 2 and illustrated in Figures 3 and 5, where no manufacturing firms have yet restructured, and ask which firms would choose to do so.

Formally, there are three stages to the interaction. First, **M**-firms simultaneously and independently choose to restructure or not. Restructuring is an irreversible decision, committing the firm to a new technology and to

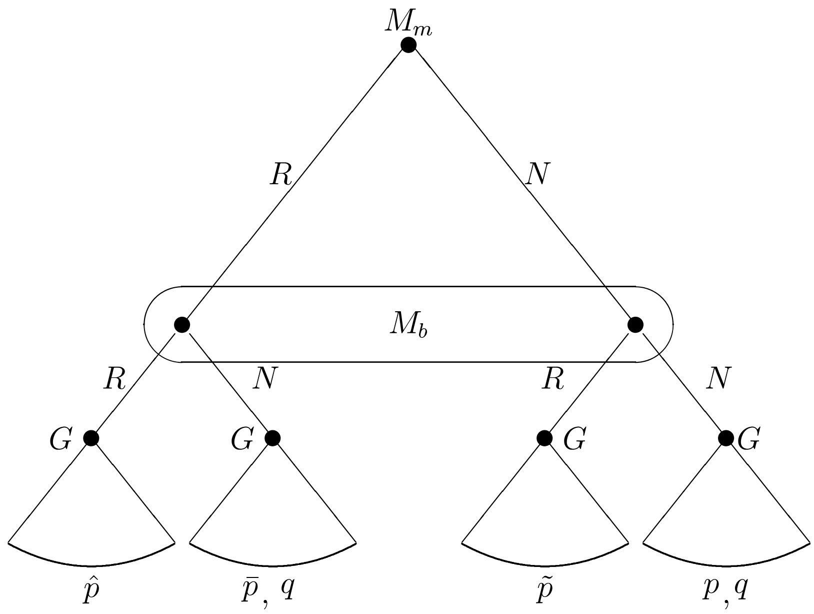

Figure 7: Simplified Restructuring Game Tree

abandoning all barter networks. In the second stage, after observing the restructuring decision of all manufacturers, **G** selects a monetized price charged to all firms on the open market, and an optimal barter price for those firms in the barter network that did not restructure. Finally, **M**-firms can either produce, acquiring inputs through purchase or barter (if they previously bartered and don't restructure), or cease production due to inability to cover costs. The choice to restructure is made knowing that **G** has a final move in which it will set a price optimally exploiting the restructuring decision. Thus firms in **M**, in choosing whether to restructure, will take into account the optimal pricing decision of **G**, which affects their viability in production. The general structure of the interaction in terms of firm 'types' is illustrated in the simplified game tree in Figure 7.

As Proposition 2 shows, if all manufacturers refuse to restructure, the optimal response of the monopolist is to maintain the discriminating prices (p, q). However, at those prices, every firm on the monetized market has an individual incentive to restructure, although in many cases those firms engaging in barter would give up too much by restructuring, and so avoid it. This observation gives a first simple equilibrium result:

Proposition 3 *Let the initial equilibrium in the manufacturing industry be*

$\{f_m, p\}$, *i.e. all active firms buy at the market price p and no firms are supported through "barter." Then all* ***M****-firms* $f \in \left(\widetilde{f}, \widehat{f}\right]$ *will restructure, giving equilibrium* $\left\{\widehat{f}, \widehat{p}\right\}$ *with* $\widehat{f} > f_m$ *and* $\widehat{p} < p$.

Proof. The result is obvious from Figures 6 and 8. Part 3 of Proposition 2 gives the new monopoly optimum for **G**. Part 4 of proposition 1 then shows that all initially active firms, $f \in \left(\widetilde{f}, f_m\right]$ will optimally choose to restructure, while some initially inactive firms, $f \in \left(f_m, \widehat{f}\right)$, can make a strict profit by restructuring and producing. The manufacturer $\widehat{f}$ just breaks even when producing with energy price $\widehat{p}$, and so also enters the market, while firms $f \in \left(\widehat{f}, \overline{f}\right]$ remain inactive. ■

If only those firms initially on the monetized energy market restructure, so that the monopoly price becomes $\overline{p}$, then every such firm loses some of the surplus that it originally had, and is worse off than if none had restructured. Hence, if manufacturing firms were able to explicitly cooperate, to coordinate their restructuring decisions, then all the firms in the monetized market would be better off by refusing (collectively) to restructure. But those who fail to restructure when others do so, unless they are safely in the "barter" network, suffer an even greater loss and run the risk of being forced to cease production, while any firm that restructures alone, when others fail to do so, reaps a windfall as productivity soars and the price of energy remains at p. Thus any firm on the monetized market has an individual incentive to restructure regardless of what the other manufacturing firms do. However, unless restructuring is phenomenally productive ($\widehat{p} < \underline{p} \Rightarrow \widehat{f} < f_b$ as in part 6 of Proposition 1), no firm in the "barter" network will have an incentive to restructure. This gives a "barter barrier" to restructuring as a subgame perfect Nash equilibrium.

Proposition 4 *Let* ε *be such that* $\widehat{f} < f_b$. *Then there exists a subgame perfect Nash equilibria of this Energy-Market Restructuring Game such that:*

1. *All firms* $f \in \left(\widetilde{f}, f_m\right)$ *choose to restructure, but no firms in* $[0, \widetilde{f}] \cup [f_m, \overline{f}]$ *choose to do so. The equilibrium is* $\{f_m, f_b; \overline{p}, q\}$, *where* $\overline{p} = \widehat{P}(f_m)$.

2. *There exists an open set of* $(\varepsilon, \kappa, \varrho)$ *such that no firm engaging in barter would choose to restructure at equilibrium:* $\widehat{s}_f \leq s_f$.

Proof. The first thing to notice is that no firm $f \in [0, \widetilde{f}]$ will choose to restructure, regardless of the price **G** charges, as for them restructuring lowers the *economic* efficiency of their use of energy [Proposition 1, part 1]. Further, Corollary 1 and Proposition 1, part 6 imply that no firm $f \in [f_m, \overline{f}]$ would ever choose to restructure as long as the condition on ε is met; for $f \in [f_m, f_b]$ too much is lost in giving up the subsidy, while for $f \geq f_b$ the condition on ε means restructuring fails to raise productivity sufficiently to cover the costs of production. Thus the only firms which might restructure in equilibrium are those $f \in \left(\widetilde{f}, f_m\right)$ who are active on the monetized energy market.

Next note that **G** solves an optimization problem at the final strategic stage of the game, i.e. in all proper subgames, insuring subgame perfection of any Nash equilibrium. By Proposition 2, part 2, **G** will never respond to a single firm's restructuring decision, but only to what a set of manufacturing firms of positive measure does. Proposition 2, part 5 then implies that the optimal price set by **G** is $p^* \geq \overline{p} = \widehat{P}(f_m)$ if any interval of the firms in $\left(\widetilde{f}, f_m\right)$ restructures. Thus any firm that restructures in that interval suffers a loss relative to the case where no manufacturing firm restructures: $\widehat{s}_f \leq s_f$, with equality holding only at the least efficient boundary of the interval, f^*. But every firm that fails to restructure when the monetized price rises to p^* suffers an even greater loss. Indeed, since no firm on the monetized market can individually affect the price it pays, Proposition 1, part 2 shows that it will always choose to restructure: if other manufacturers restructure, it must do so to maintain profitability $(p^*\widehat{a}_f + \widehat{\eta} < p^* a_f + \eta)$, while if others don't, it reaps a windfall $(p(a_f - \widehat{a}_f) + (\eta - \widehat{\eta}))$. Thus restructuring is a dominant strategy for manufacturing firms on the monetized market; the more efficient increase their surplus, while the less efficient in $\left(\widetilde{f}, f_m\right)$ avoid ceasing operation. As a consequence of all $f \in \left(\widetilde{f}, f_m\right)$ restructuring, **G** will set a monetized market price of $p^* = \overline{p}$ (Proposition 2, part 4) as illustrated in Figure 8. Firms in $\left(f_m, \overline{f}\right)$, including those operating on barter, will not restructure (Proposition 1, part 6), and will continue to face a "barter price," q, which remains optimal for **G** as the overall quantity of energy sold on the monetized market doesn't change (see Section 2.2.1, especially equation (10)).

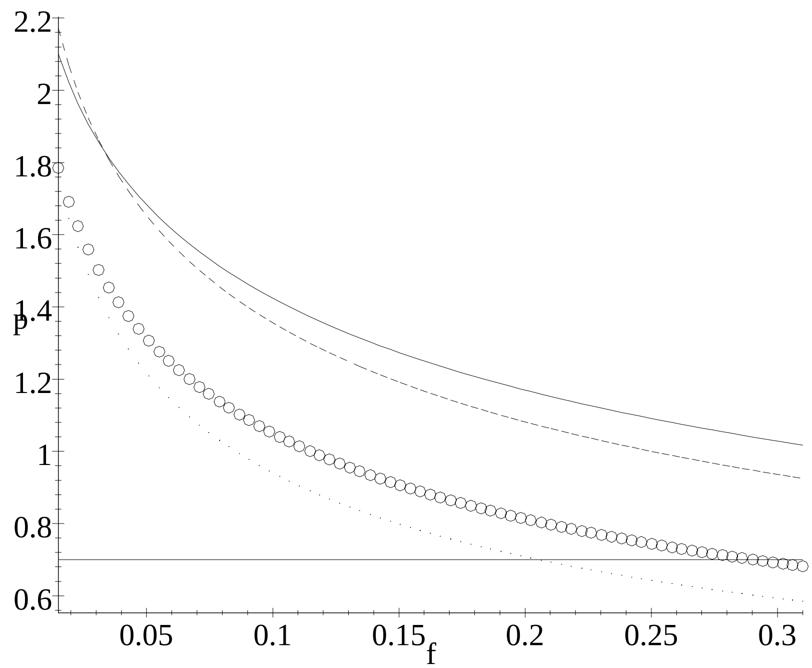

Figure 8: Restructuring Incentives on Market

Part 2 is obvious from our analytic forms. The constraints on $\varepsilon, \kappa, \varrho$ are clearly open and satisfied by intervals of values: $\varepsilon \in (\underline{\varepsilon}, 1)$, where $\underline{\varepsilon}$ satisfies (14); $\varrho - 1 < \kappa$. ■

Remark 2 *Clearly, given that no firm on barter will restructure, all manufacturers on the monetized market would be better off* not *restructuring:* $s_f > \widehat{s}_f, \forall f \in \left(\widetilde{f}, f_m\right)$. *But they must* all *(but for a set of measure zero) avoid restructuring in order for* $\boldsymbol{G}$ *to optimally maintain the lower price* $p < \overline{p}$. *Thus the first stage interaction among manufacturers on the monetized market has the nature of a Prisoners' Dilemma. That is not the case for firms in the barter network as their restructuring decision, by forcing exit from the network, directly affects the "price" they face, removing the collective action problem.*

Thus we see that there are equilibria in which no firm, already engaged in

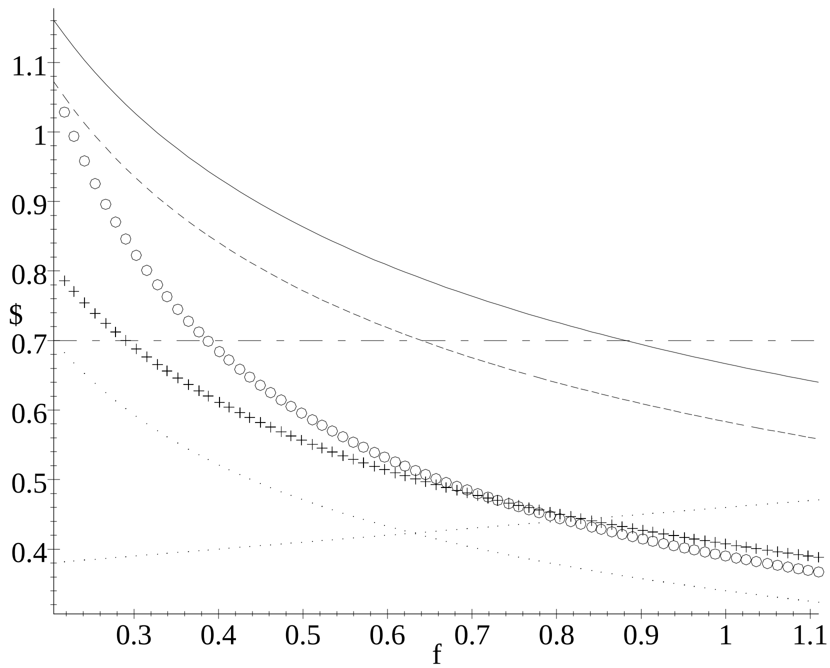

Figure 9: Barter and Restructuring

barter as a road to viability, would choose to abandon the barter network and restructure. A typical situation is depicted, using our example's parameter values, in Figure 9. For these firms, restructuring and buying energy at $\widehat{p}$ gives a far smaller surplus (shaded) than that (outlined) from sticking with the barter network.

As a result of government incentives, there is just too large a surplus generated by barter to be overcome by restructuring, within the bounds we have placed on the restructuring parameters. However, if the impact of restructuring is sufficiently strong, i.e. if ϱ is large enough or ε and/or κ small enough, then firms can be enticed from barter through restructuring. In addition, if the government removes the incentives to **G** to support barter [see Section 2.2.1], then the barter "price" of energy will be higher, and restructuring becomes a much more desirable option for inefficient manufacturing firms. That alone, however, is still insufficient to induce firms to leave barter networks unless restructuring is so effective that $\widehat{f} \gg f_b^0$ (i.e., the marginal firm operating on barter in the absence of government incentives). Notice also, that when bartering firms refuse to restructure, **G** can raise the price to those firms that do restructure to $\overline{p}$, reducing their incentive to do so ex-post. However, if any firm fails to restructure while others do so, leading to a price greater than p, it loses substantially more.

Under differing assumptions about manufacturers' expectations and ability to coordinate restructuring, and/or the ability of **G** to distinguish among manufacturers, there would seem to be many other equilibria also. But the result, that firms gaining from barter would refuse to restructure, seems robust.[39] Indeed, Proposition 3 shows that, without the option of virtual economy barter, all firms would choose socially efficient restructuring. When the virtual economy is available to inefficient firms, only substantial changes in government or **G**-sector policies can draw the firms out of barter networks. If the government removes its incentives for barter, and/or **G** loses the ability to discriminate among users, the incentives to restructure would become dominant for firms in barter networks. The "virtual economy" thus poses a substantial barrier to the successful transformation of the Russian economic system.

4 Conclusion

This paper begins an analytic exploration of the virtual economy hypothesis. It has provided a static partial-equilibrium model of a central component of that hypothesis — the transfer of value from a productive sector to loss-makers, giving them the appearance (a "virtual reality") of market viability. Thus it has begun the development of consistent micro-foundations supporting the behavior assumed in more macro-oriented analyses of the "virtual economy" such as Gaddy-Ickes (1998b, 1999).

The analysis provides a reason to suppose that the Russian virtual economy reflects a stable systemic configuration of economic behaviors, at least

[39] It is, for example, easy to show that, if **G** can observe and respond to an individual firm's isolated restructuring by raising the price of energy to that firm, then the unique perfect equilibrium involves all manufacturing firms refusal to restructure. This might reflect a situation in which **G** is under pressure by tax authorities to increase cash collections (as in 1997-8), and so jumps on any firm showing a discrete increase in profitability.

if agents horizons are sufficiently short.[40] It has also introduced a more formal welfare analysis of the benefits and costs of the functioning of the "virtual economy," focussing in particular on an indirect structural cost — the barrier it erects to the restructuring of L/NVA enterprises. It provides a robust example, and some more general conditions, such that involvement in a "barter" network counteracts any incentive to engage in productivity-enhancing restructuring of industrial processes. Hence "barter,"[41] which, as shown in our simple model, can be welfare enhancing given inherited structural distortions in the relevant (in the model — energy) market, can also provide a strong incentive to individual producers to avoid investment in productivity enhancing restructuring.

Thus the virtual economy poses an obstacle to the fundamental restructuring of industrial capacities that is essential for creating firms that are viable in a market economy. By substantially reducing incentives for investment in restructuring, the virtual economy provides a structural and institutional barrier to Russia's successful transition to a modern market economy. Therein lies a significant part of the explanation of the anomalies of the Russian transition discussed in the introduction.

Of course, we have only begun to scratch the surface of a very complex issue. There are other critical sectors to incorporate in a complete model of the phenomenon, including the budget sector and explicit derivation of government policy parameters as optimal decisions, a household sector active on both labor and consumers' goods markets, and the important interaction during transition with a "foreign" sector, the rest of the world. Incorporating such sectors would allow more adequately addressing the role of tax and wage arrears and offsets, other forms of involuntary credit provision, and the impact of import competition, export opportunities and exchange rate variation on the operation of the virtual economy and its interaction with industrial restructuring.

In addition, there are fascinating issues of the dynamic stability, development, and eventual decay of the virtual economy as a local equilibrium in the transition process. We expect the virtual economy to be, ultimately, a passing phenomenon, but one with a substantial half-life. It is an outgrowth of the still largely underappreciated distortions built into the social

[40] A dynamic version, explicitly considering the time preferences of agents is the subject of ongoing research.

[41] That is, the whole panoply of non-monetized practices and instruments of exchange allowing idiosyncratic pricing unrelated to economic costs or market demand.

and economic fabric of Russia by central planning and other institutions of the command economy. We believe that the virtual economy is a locally rational response to this legacy. We hope to have contributed in this paper to its analysis as such.

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