Measuring Productivity Change and its Components for Fisheries: The Case of the Alaskan Pollock Fishery, 1994-2003

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Introduction

A primary focus in the fisheries literature and of national and international fisheries policy is sustaining and enhancing fisheries' economic and biological performance. Traditionally, biological stock issues and a desire to achieve sustainable harvests have motivated fishery economics and policy implementation. However, because maximum sustainable yield and economic yield rarely coincide, fishery managers often must aim for one goal at the expense of the other.

Although these problems are often attributed at least partly to the common pool nature of most fisheries, they are also associated with technological changes that have increased the catching power of vessels, and environmental changes that have affected fish stocks. The (economic) productivity of fisheries thus involves a complex combination of technological, regulatory, environmental, stock, and utilization effects. The goal of productivity measurement for fisheries is to untangle or decompose these effects on growth or declines in output (catch) over time.

Recognizing such effects facilitates analyzing the productive impacts of and interactions among technological and other factors. However, this has not been accomplished in the existing literature on fisheries' economic performance, which has primarily focused on technical efficiency or capacity utilization.[1] The limited literature on fisheries' productivity[2] has been based on growth accounting methods that do not facilitate taking such a comprehensive view of productivity determinants, although a few studies do move in this direction (Squires, 1992, 1994, Jin al., 2002, Kirkley et al., 2004).

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[1] See, for example, Dupont et al. (2002), Felthoven and Paul (2004a), Kirkley Paul and Squires (2002), Kirkley et al. (2001).

[2] This literature includes Bell and Kinoshita (1973), Kirkley (1984), Davis, Gallman and Hutchins (1987), and Kirkley et al. (2004).

Our goal in this work is thus to simultaneously account for the contributions of a broader range of productive factors to catch, including bycatch, environmental conditions, scale economies and production biases in fishery productivity measurement. We use a parametric primal production model, based on a second-order approximation of a transformation function, to econometrically estimate productivity patterns and their determinants for the Bering Sea and Aleutian Islands (BSAI) pollock fishery.

Methodological Framework

Technological production relationships may be theoretically represented by a production function of the general form as $Y=f(\mathbf{X},\mathbf{K},\mathbf{S},\mathbf{T})$, where Y is aggregate output, **X** is a vector of (variable) inputs, **K** is a vector of (fixed) capital inputs, **S** is a vector of discretionary variables (e.g., stocks and production strategies), and **T** is a vector of external shift variables. With multiple outputs the technology can similarly be represented by the transformation function $F(\mathbf{Y},\mathbf{X},\mathbf{K},\mathbf{S},\mathbf{T})=0$, where **Y** is a vector of outputs, indicating the most outputs producible from a given input base and existing conditions.

By the implicit function theorem, $F(\mathbf{Y},\mathbf{X},\mathbf{K},\mathbf{S},\mathbf{T})$ may be specified (in explicit form) with that argument as the dependent and the other arguments as independent variables. We will thus use the asymmetric transformation function $Y_1= G(\mathbf{Y}_{-1},\mathbf{X},\mathbf{K},\mathbf{S},\mathbf{T})$, where, Y_1 is a chosen numeraire (the target "good output" species), and $\mathbf{Y}_{-1}$ the vector of all outputs except Y_1, to represent the technological relationships in the BSAI fishery.

Formally, growth over time (t) in output (the numeraire output for the transformation function) is attributed to the production determinants included as arguments of the function through the total derivative:

$$1)\quad \frac{dY_1}{dt}=\sum_m \frac{\partial Y_1}{\partial Y_m}\frac{dY_m}{dt}+\sum_j \frac{\partial Y_1}{\partial X_j}\frac{dX_j}{dt}+\sum_k \frac{\partial Y_1}{\partial K_k}\frac{dK_k}{dt}+\sum_s \frac{\partial Y_1}{\partial S_s}\frac{dS_s}{dt}+\sum_{r(r\neq t)} \frac{\partial Y_1}{\partial T_r}\frac{dT_r}{dt}+\frac{\partial Y_1}{\partial t}$$

or, in percentage or proportional terms (log-changes):

$$2)\quad \begin{aligned}\frac{d\ln Y_1}{dt} &= \sum_m \frac{\partial \ln Y_1}{\partial \ln Y_m}\frac{d\ln Y_m}{dt} \sum_j \frac{\partial \ln Y_1}{\partial \ln X_j}\frac{d\ln X_j}{dt} + \sum_k \frac{\partial \ln Y_1}{\partial \ln K_k}\frac{d\ln K_k}{dt} \\ &+ \sum_s \frac{\partial \ln Y_1}{\partial \ln S_s}\frac{d\ln S_s}{dt} + \sum_{r(r\neq t)} \frac{\partial \ln Y_1}{\partial \ln T_r}\frac{d\ln T_r}{dt} + \frac{\partial \ln Y_1}{\partial t}\end{aligned}$$

Output change over time not "explained" by the other arguments of the function is thus:

$$3)\quad \begin{aligned}\mathrm{e}_{Y_1,t} &= \frac{\partial \ln Y_1}{\partial t} = \frac{dY_1}{dt} - (\sum_m \mathrm{e}_{Y_1,Ym}\frac{d\ln Y_m}{dt} + \sum_j \mathrm{e}_{Y_1,Xj}\frac{d\ln X_j}{dt} \\ &+ \sum_k \mathrm{e}_{Y_1,K_k}\frac{d\ln K_k}{dt} + \sum_s \mathrm{e}_{Y_1,S_s}\frac{d\ln S_s}{dt} + \sum_{r(r\neq t)} \mathrm{e}_{Y_1,T_r}\frac{d\ln T_r}{dt})\end{aligned}$$

where $\mathrm{e}_{Y1,t}$ represents the elasticity of Y_1 production with respect to a change in t, the productivity residual, holding all other arguments of the function constant. The weights on input changes representing their contributions to output growth, $\mathrm{e}_{Y1,Xj}$ = ¶$ln Y_1$/¶$ln X_j$ and $\mathrm{e}_{Y1,Kk}$=¶$ln Y_1$/¶$ln K_k$, are output elasticities with respect to (variable) input j and (fixed) input k, respectively. The $\mathrm{e}_{Y1,Ym}$ capture the contributions of Y_m changes. $\mathrm{e}_{Y1,Ss}$ and $\mathrm{e}_{Y1,Tr}$ similarly represent the contributions of changes in the **S** and **T** factors.

Measures for Empirical Analysis

To evaluate productivity relationships one must compute and interpret the components of (1)-(3). $dln Y_m/dt$, $dln X_i/dt$, and $dln K_k/dt$ are simply measured as observed percentage increases in outputs and inputs between time periods (usually years). Given appropriate measures of the **S** and **T** vector components, $dln S_s/dt$, and dT_r/dt can also be directly computed. However, the output elasticities (proportional marginal products) $\mathrm{e}_{Y1,Xj}$, $\mathrm{e}_{Y1,Kk}$, and the conceptually analogous weights on Y_m, S_s and T_r growth, $\mathrm{e}_{Y1,Ym}$ $\mathrm{e}_{Y1,Ss}$, and $\mathrm{e}_{Y1,Tr}$, are not directly observable and so must be empirically estimated.

The contributions of the variable inputs, the most familiar of these relationships, can be written as $\varepsilon_{Y1,Xj} = \partial lnY_1/\partial lnX_j = \partial Y_1/\partial X_j \cdot (X_j/Y_1) = MP_j \cdot X_j/Y_1$, where MP_j is the marginal product of X_j in terms of the target species. In growth accounting studies this elasticity is commonly approximated by a cost or revenue share, based on the assumptions of profit maximization, perfectly competitive input and output markets, and no adjustment constraints. This reasoning provides the rationale for approximating output elasticities by cost shares in Squires (1992, 1994) and Jin et al. (2002). Such methods implicitly assume hicks neutrality and/or homotheticity. The parametric estimation of the transformation function, approximated by a flexible functional form, like we do in this study, relaxes these assumptions (Felthoven and Paul, 2004b).

Arguments of the Function

Our data are for catcher-processors operating with trawl gear in the fishery. The data include weekly observations from 1994-2003 for the 36 vessels in this fleet, from the federal observer program and weekly production reports required of the catcher-processors.[3] These vessels fish with similar gear and are comparably sized, although some are equipped with processing facilities to produce surimi (a fish paste used to make products such as imitation crabmeat) and others primarily produce fillets.

Various shift (**T**) factors in addition to a time counter (t), including the regulatory regime, likely affect catch in the fishery. The primary regulatory change for our data is the 1998 American Fisheries Act (AFA), which imposed a cooperative structure in the fishery. Within each cooperative, eligible vessels were assigned quota shares based on their historical catch, in an attempt to eliminate the race for fish. To reflect the resulting productivity effects we include in the **T** vector a dummy variable D_{AFA} for 1998 on.

Three weather indicators are also included as components of the **T** vector. T_{NPI} is a wind and storm indicator – the North Pacific Index measuring the anomalous atmospheric circulation of the North Pacific from Spring into Summer. T_{SW} and T_{SA} are temperature indicators – measures of surface air temperature for the winter (December-March) and annually (January-December), calculated as deviations from a 1950-2000 base.

We include the biomass (fish stock) as an **S** vector component (S_B) (because it is more discretionary than an external shift variable) measured as the metric tons of pollock (3+ years old) in the Eastern Bering Sea. In addition, we include in the **S** vector towing time spent each week (duration, S_{DUR}), and the number of hauls (S_H), both of which have been affected by regulatory changes. S_{DUR} distinguishes towing from steaming time, and thus more precisely identifies effort applied to obtain the observed catch than just a measure of days fished. S_H is a proxy for product quality changes in the BSAI fishery since the imposition of the AFA.[4]

The variable input **X** vector[5] includes days fished on a fishing trip (X_D), as well as a measure of crew size (X_C) (which varies from vessel to vessel and from season to season although it tends to be steady throughout a fishing season for a particular vessel). The (quasi-fixed) capital components in the **K** vector for fisheries involve the fishing vessel. We thus include measures of vessel size (length, K_L) and power (horsepower, K_{HP}), to specify the capital stock by its measurable characteristics.[6]

Finally, we turn to our output specification. The most commonly caught and targeted species for these vessels is pollock, but flatfish, crab, herring, halibut and salmon

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[3] See Felthoven and Paul (2004a) for further details.

[4] Vessels with more hauls likely to produce higher quality product due to the decreased bruising of fish from the smaller nets. Greater towing duration may also have quality implications if boats are doing more test tows to search for the best fish for their products.

[5] Such inputs are often assumed to have a fixed-proportions relationship with either a particular boat (crew size), or time spent fishing (fuel) (Squires and Kirkley, 1991). In addition, in most cases, the requisite data on use of specific inputs is not available.

are also caught during a season. Flatfish is a very small proportion of the catch (less than 1 percent) but is still considered a marketable catch, and thus a "good output." The other species are prohibited bycatch species that can be accidentally caught when fishing for pollock. This jointness implies that reducing bycatch requires reducing target catch, so pollock fishing generates "bad outputs," or externalities. Our "good" outputs are therefore pollock, Y_P and flatfish, Y_F. The bycatch species also included in the **Y** vector are herring and halibut, Y_H, salmon, Y_S, and crab, Y_C.[7]

Empirical Implementation

Using the target output, pollock, as the dependent variable ($Y_1=Y_P$), we can now express our transformation function as $Y_P=F(Y_F,Y_H,Y_S,Y_C,X_D,X_C,K_L,K_{HP},S_B,S_{DUR},S_H,D_{AFA},t, T_{NPI},T_{SW},T_{SA})$. We use a (flexible) quadratic functional form to approximate this function for empirical implementation. This allows us to accommodate zero or negative values, which arise for the environmental variables.

The general form of the quadratic function is:

$$4)\quad Y_p = a + 2\sum_j b_j Z_j + \sum_j \sum_k g_{jk} Z_j Z_k ,$$

where the a, b, d and g are parameters to be estimated, and Z_j, Z_k denote all arguments of $F(\bullet)$. This estimating equation allows for non-constant returns to scale as well as cross-effects among all outputs and inputs. The empirical results can thus determine which relationships are statistically significant.

"Sourcing" or explaining productivity patterns based on the estimated transformation function parameters requires computing and interpreting the components

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[6] Gross tonnage information is also available, but is generally considered an alternative measure of size, and length may be a better indicator of a vessel's processing capacity since it is a determinant of the number of processing machines that can be on the vessel.

[7] Herring and halibut are measured in metric tons and linearly aggregated; salmon andcrab are in numbers of animals.

of equations (1)-(3) – the elasticities representing the output growth attributable to the arguments of the function, $\varepsilon_{Y1,Ym}$, $\varepsilon_{Y1,Xj}$, $\varepsilon_{Y1,Ss}$, $\varepsilon_{Y1,Tr}$, $\varepsilon_{Y1,Kk}$, $\varepsilon_{Y1,t}$, and the associated changes over time in the variables, $d\ln Y_m/dt$, $d\ln X_j/dt$, $d\ln S_s/dt$, and dT_r/dt, where $Y_1=Y_P$, $Y_m=(Y_F,Y_C,Y_H,Y_S)$, $K_k=(K_L,K_{HP})$, $X_j=(X_D,X_C)$, $S_s=(S_B,S_{DUR},S_H)$, and $T_r=(D_{AFA},T_{NPI},T_{SW},T_{SA})$. Scale economies and biases are measured as combinations of, and second-order effects (cross-terms or parameters) embodied in, the output elasticities.

A final issue is the stochastic specification. We estimate our transformation function model based on three alternative stochastic assumptions. Our “base” model is estimated by standard Ordinary Least Squares (OLS), assuming a normally distributed error term can be appended to equation (4), with the standard errors transformed by robust-White procedures to accommodate possible heteroskedasticity. To take advantage of our panel data we also estimate “within” and “random effects” models.[8]

The Results

We initially estimated cross-terms for all arguments of the function (except for boat-invariant characteristics, which were not econometrically identified). We then constrained to zero cross-terms with t-statistics of less than 1, for which the null hypothesis that each parameter is zero could be rejected with about 70 percent confidence. An F-test of their joint significance also failed to reject the null hypothesis of zero values for these parameters.

The remaining estimated parameters have explanatory power for understanding productivity patterns as can be seen by the first and second order effects, β_j and the γ_{jk} parameter estimates in Table 1. The full range of productive contributions of the

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[8] A “between” model by contrast captures only the cross-sectional variation by averaging all the variables over time for each boat, but too few degrees of freedom were left to estimate our model by this method.

transformation function arguments is evident from the overall output elasticity for each factor. Note that the productive impacts of factors typically ignored in productivity estimation such as environmental conditions tend to be significant, so estimation ignoring such factors may be misleading. This implies that their impacts are non-neutral (implying economic biases, or non-radial expansions of input isoquants). Other factors like stock levels, however, have little apparent first *or* second-order impacts on catch; the output elasticity estimates indicate a negative, but not statistically significant, overall productive contribution. This is likely due to the increased TAC for this group of cooperative vessels after 1998, despite an annual average drop in the fish biomass estimates (except 2003).

Other productive factors not typically considered in fisheries studies like the bycatch species also prove to be important; Table 1 shows statistically significant first and second-order productive impacts for all of these variables. In terms of their overall impact on output, herring, halibut and crab all have significant elasticities; salmon, on the other hand, is insignificant due to counteracting cross effects.

The elasticity estimate for crab bycatch is, however, significantly negative. Technically, this negative estimate is driven by negative interactions with days, time, winter temperature and salmon bycatch. Anecdotally, however, data patterns reveal that after 1998, with the prohibition of bottom trawling, greater reliance on smaller hauls, and improved catch selectivity, crab bycatch was drastically reduced, while at the same time pollock catch rose, which is consistent with the negative estimated relationship.

The direct impact of regulatory change in the BSAI fishery represented by D_{AFA} is also important. Its estimates show a negative first-order productive effect from the imposition of the AFA in 1998, and a negative and significant overall output elasticity,

$e_{YP,AFA}$, consistent with the large reduction in total catch immediately after 1998 (in which a large portion of this fleet's catch was allocated to the inshore catcher boats).

Several of the parameters associated with the fishing intensity (S_{DUR} and S_H) are also statistically significant. Recognizing discretionary production processes (or fishing strategies) thus helps to explain productivity patterns. In terms of their overall output elasticity, only towing duration is significantly positive. The small and statistically insignificant impact of greater numbers of hauls could be due to convoluting quantity and quality effects; as noted above, since 1998 vessels have relied on a larger number of smaller hauls, resulting in higher fish quality but not necessarily measured quantity.[9]

As for the productive factors more typically included as inputs in standard fishery studies, like crew, days, HP and length, the results show that all exhibit significantly positive marginal output contributions, as would be expected. These inputs also all have non-positive own 2nd-order derivatives, which is consistent with diminishing returns.

Finally, the results also reveal that technical change has occurred in the fishery; catch has increased over time given effort levels and all other measured vessel and external characteristics. This is implied by the positive first-order effect $e_{YP,t} > 0$ (likely associated with the annual TAC increases), augmented by interactions with the AFA and salmon bycatch. Slight counteracting effects are evident from days at sea and crab bycatch; increased productivity over time appears to be restrained by increases in days fished (diminishing marginal productivity of effort over time, perhaps reflecting the slower pace of fishing mentioned above) and heightened limitations of crab bycatch.

Perhaps the most important point to note about nearly all these variables is that even when the overall output elasticities are not statistically significant, significant cross-effects reveal consequential interactions with other productive factors. In addition, the sum of the elasticities for the **X** and **K** variables imply significantly increasing returns.[10] The complex linkages among the arguments of the function also indicate that homothetic separability should not be assumed. Overall, the assumptions necessary to measure productivity by growth accounting methods are not supported for our data.

Further, evaluating the full contribution of each of the explanatory variables to pollock catch for our data requires combining the output elasticities presented in Table 1 with the actual changes in the productive factors. More specifically, Table 2 shows that all input variables have been increasing over time on average, although the year-to-year changes are often quite dramatic.[11]

Combining this information with the Table 1 elasticity estimates shows that the **X** and **K** inputs had the strongest catch impacts (particularly crew size and vessel length). In fact these input increases seem to more than offset the impacts of less favorable weather conditions on pollock catch, as the elasticities indicate that high values of T_{NPI} and low values of T_{Sw} enhance catch productivity, but Table 2 reveals that on average T_{NPI} decreased and T_{Sw} increased over this time period. The environmental impacts would thus imply diminished productivity if input changes had not counteracted that tendency.

Also, the strongly increasing average towing duration (S_{DUR}) evident from Table 2 combined with the positive contribution of S_{DUR} to pollock catch evident from Table 1 explains a significant proportion of pollock catch changes. However, other discretionary variables such as pollock stock, S_B, and hauls, S_H, had little apparent productivity impact;

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[9] In fact, 85% of the 19 vessels that have operated prior and after 1998 increased the hauls per amount of fish caught after 1998.

[10] The specification of inputs for fisheries, however, makes the definition and interpretation of returns to scale somewhat ambiguous.

[11] For the **K** variables the only changes arise when boats enter or leave the sample, because no individual boat size or horsepower changed during the sample period.

not only are their overall elasticities quite small and insignificant (Table 1), they have exhibited little variation over time (Table 2).

Table 2 - Time Variation of Pollock Catch And the Explanatory Variables

	Pollock Catch	***Variable Inputs***		***Bycatch Variables***			***Discretionary Variables***		
Year	***Yp***	***Xd***	***Xc***	***Yh***	***Ys***	***Yc***	***Sb***	***Sdur***	***Sh***
1995	-0.02	-0.08	0.01	-0.46	-0.88	-0.97	0.21	-0.15	-0.13
1996	-0.01	0.10	0.09	0.48	1.45	-1.50	-0.14	0.26	0.08
1997	-0.01	-0.28	-0.18	-0.56	-0.38	1.37	-0.17	-0.37	-0.20
1998	0.04	0.24	0.14	-0.24	-0.64	-0.59	0.00	0.25	0.17
1999	0.16	0.18	0.25	0.27	-0.57	-2.16	0.11	0.01	0.16
2000	0.27	0.26	0.24	-0.43	0.24	-1.31	-0.10	0.34	0.26
2001	0.11	0.10	0.17	-0.41	1.49	0.40	-0.04	0.09	0.10
2002	0.01	-0.17	-0.15	-0.41	-0.68	-0.90	0.02	-0.16	-0.11
2003	0.11	0.11	0.16	1.23	0.96	-0.22	0.21	0.08	0.11
Average	**0.07**	**0.05**	**0.08**	**-0.06**	**0.11**	**-0.65**	**0.01**	**0.04**	**0.05**

	Flatfish	***Capital***		***Environmental Variables***		
Year	***Yf***	***KL***	***Khp***	***Tnpi***	***Tsw***	***Tsa***
1995	0.16	0.00	0.00	0.30	-0.89	0.08
1996	1.25	0.01	-0.02	-0.23	2.66	1.76
1997	-2.53	0.00	0.00	0.75	-1.51	-1.40
1998	1.78	0.00	0.01	-2.78	-0.67	-0.14
1999	0.69	0.08	0.12	1.00	0.47	-0.88
2000	0.31	0.00	0.02	0.33	-0.85	1.61
2001	0.09	0.00	-0.01	-0.23	2.57	-0.41
2002	0.22	0.00	-0.02	0.45	-2.50	0.37
2003	-0.40	0.01	0.05	-0.22	1.98	0.59
Average	**0.17**	**0.01**	**0.02**	**-0.07**	**0.14**	**0.18**

Finally, the results from our other stochastic specifications that further exploit the panel nature of our data support our reliance on OLS estimation methods. That is, parameter estimates for our within and random effects stochastic specifications corroborate the overall OLS implications of statistically significant first-order (β_j) and cross (γ_{jk}) terms. Although the associated output elasticity estimates were somewhat different in magnitude than the OLS estimates, they maintained the same sign and comparable t-statistics. However, tests of these models as alternatives to OLS show that the additional information they confer is not consequential.

Concluding Remarks

In this paper we specify and estimate a production/productivity model for the Bering Sea and Aleutian Islands (BSAI) fishery. The model recognizes a number of productive factors not taken into account in existing fisheries productivity studies, estimates their contributions parametrically rather than imposing theoretical assumptions such as marginal cost pricing, and relaxes other assumptions such as neutrality and homotheticity that have previously been maintained in the literature.

Overall, we find significant contributions and interactions not only for inputs often recognized in representations of fishery production, such as days fished, crew, and capital characteristics, but also for factors usually ignored in such models, including environmental factors, bycatch, and discretionary production strategies. Evaluating both the first-order productive impacts of such factors and their cross effects contributes to our understanding of fisheries productivity and shows that the usual assumptions underlying fisheries productivity models are not supported by our data.

On average most catch changes we observe are “explained” by input changes, but discretionary production factors such as towing duration have also had important effects. Further, the significant catch contributions of the individual production factors and interactions indicate that representing a full range of productive factors is important for understanding production relationships that are key to effective fishery management.

Although the direct impact of the American Fisheries Act (AFA) on catch in the BSAI fishery appears negative (possibly due to a reduction in their share of the pollock TAC), indirect effects are also implied by our estimates. In particular, the estimates support the notion that fish quality, and thus price and adaptability to different products, have been enhanced by decreasing the size of each haul and increasing the number of hauls. Bycatch reductions, implying fewer externalities from fishing operations, are an additional regulatory side effect. Environmental factors have also contributed significantly to catch, although the limiting effects of weather during the time period of our data appear to have been counteracted by changes in fishing conditions and practices.

That is, increased average crew size, given the larger vessels remaining in the fleet, appears to have been an important productive factor in this fishery during this time period. Increasing the number of fishing days has also augmented catch, although the marginal productivity of this effort has been affected by changing fishing strategies such as increased weekly towing duration (due to annual TAC increases) and other factors related to regulatory changes such as decreased bottom trawling (and thus crab bycatch). Finally, the remaining "unexplained" time trend of net output, traditionally interpreted as technical change or productivity growth, is significantly positive, indicating that catch is increasing over time given all input levels and other factors recognized in the model.

Table 1. First and Second-order Parameters and Elasticities Matrix

	D_{AFA}	X_C	K_L	K_{HP}	X_D	Y_F	S_B	t	S_{DUR}	T_{NPI}	T_{SW}	T_{SA}	Y_S	Y_C	Y_H	S_H
1st Order	-25507 *	-6.14 ***	221.38 *	3.66 **	655.68 *	100.1 *	1.22	2359.76 *	-4.37	-1464.4 *	9344 *	-6218 *	-18430 *	2224.28 **	-247	**58.26** **
D_{AFA}					120.47 *	12.13 ***		1824.9 *	-5.06 ***				-4497.5 *			
X_C		-0.01 *						0.82 *					-0.69 **	0.18 ***		**0.04** *
K_L				-0.01 *							-14.8 *		24.35 *		-0.78 *	**-0.21** *
K_{HP}		0.0007 *	-0.01 *			0.004 *		-0.21 *				0.39 *		-0.04 *	0.03 *	
X_D	120.47 *				-1.63 *	-0.16 *		-29.28 *					52.1 *	-10.71 *	-2.66 *	
Y_F	12.13 ***			0.004 *	-0.16 *	-0.10 *	-0.003	-1.57		4.24 ***	3.66 *			-0.75 **	-0.87 *	
S_B			0			-0.003			-0.001 **					-0.07 ***	0.02 *	
T	1824.89 *	0.82 *		-0.21 *	-29.28 *	-1.57							506.75 *	-80.02 *	14.5 *	
S_{DUR}	-5.06 ***						-0.001 **				-1.69 *	4.18 *		0.15 **	0.24 *	
T_{NPI}						4.24 ***							1358 *	35.46 **		
T_{SW}			-14.76 *			3.66 *			-1.69 *				812.6 *	-252.33 **	18.1 ***	
T_{SA}				0.39 *					4.19 *				-1170.1 *	375.03 **	-55.6 *	**-9.55** *
Y_S	-4497.5 *	-0.69 **	24.36 *		52.1 *			506.75 *		1358.04 *	813 *	-1170 *	-1198.5 *	-24.04	27.0 *	
Y_C		0.18 ***		-0.04 *	-10.72 *	-0.75 **	-0.07 ***	-80.03 *	0.15 ***	35.5 **	-252 **	375.0 **	-24.04		1.73 ***	**1.24** *
Y_H			-0.78 *	0.03 *	-2.66 *	-087 *	0.02 *	14.45 *	0.24 *		18.1 ***	-44.59 *	27.04 *	1.73 ***	-2.72 *	
S_H		0.04 *	-0.21 *									-9.55 *		1.24 *		**-0.12** *
ELASTICITY	-0.63 *	0.62 *	0.30 *	0.19 *	0.23 **	-0.001	-0.15	0.047 *	0.20 *	0.11 *	-0.08 ***	0.006	0.029	-0.12 *	0.04 *	0.05

Note: The symbols *, **, *** indicate respectively that the parameters and elasticities are statistically significant at 1, 5 and 10 percent.

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