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Research Article

RANDOM FIXED POINT THEOREM FOR MULTI VALUED PERATORS ON POLISH SPACE

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ABSTRACT
In this note a random fixed point theorem for Multivalued operators on polish space has been presented which extends the result of Badshah and Farkhunda (2002). Our result is also a random version of a result of Basu (1990) on a complete metric space.

Key Word: *Multivalued Operators, Polish Spaces*

INTRODUCTION
Probabilistic functional analysis has emerged as one of the important mathematical disciplines in view of its need in dealing with Probabilistic models in applied problems. The study of random operator forms a central topic in this discipline.
Systematic study of random equations employing the methods of functional analysis was first initiated by Prague school of Probabilistic led by spacek (1995) and Hans (1957 and1961) about twenty five year ago. This has now received considerable attention of various authors notably Itoh (1977); Mukharjee (1982) and Barucha Reid (1972).

PRELIMINARIES
Let (X, d) be a polish space that is a separable complete metric space and (Ω, q) be a measurable space. We denote $d(x, B) = \inf\{d(x,y): y\in B)$ for any $x\in X$ and $B\subset X$. Let 2^x be the family of all subsets of X, the CB(X) the family of all closed and bounded subsets of X and B the σ- algebra of Borel subsets of X, respectively. Let H be the Hausdroff metric ton CB(X) induced by d. A mapping $T: \Omega\rightarrow 2^x$ is called measurable if for any open subset B of X.$T^{-1}(B) = \{\omega\in \Omega: T(\omega) \cap B \neq\phi\}\in q$. A mapping$\xi:\Omega\rightarrow X$ is said to be measurable selector of a measurable mapping $T: \Omega\rightarrow 2^x$, if ξ is measurable and for any $\omega\in\Omega$, $\xi(\omega) \in T(\omega)$. A mapping $f: \Omega\times X \rightarrow X$ is called random operator, if for every $x\in X$, f(.,x) is a measurable. A mapping $T: \Omega\times X \rightarrow CB(X)$ is a random multivalued operator, if for every $x\in X$, T(., x) is measurable. A measurable mapping $\xi : \Omega\rightarrow X$ is called random fixed point of a random multivalued operator $T :\Omega\times X \rightarrow CB(X)$ $(f:\Omega\times X \rightarrow X)$, if for every $\omega\in\Omega$, $\xi(\omega)\in T(\omega,\xi(\omega))$ $(f(\omega,\xi(\omega)) = \xi(\omega)$.Let $T :\Omega\times X \rightarrow CB(X)$ be a random operator and $\{\xi_n\}$ is a sequence of measurable mappings $\xi_n : \Omega\rightarrow X$. The sequence $\{\xi_n\}$is said to be asymptotically T-regular if $d(\xi_n(\omega), T(\omega,\xi_n(\omega)))\rightarrow 0$
In 2002 Badshah and Farkhunda (2002) proved the following
Theorem: Let X be a polish space and $T,S:\Omega \text{ x } X\rightarrow CB(X)$ be two continuous random multivalued operators, if there exists measurable mappings $a, b : \Omega\rightarrow(0,1)$ such that

$$H(S (\omega, x), T (\omega, y)) \leq \frac{a(\omega)d(x,(S(\omega,x))d(y,T(\omega,y))}{d(x,y)} + b(\omega)d(x,y)$$

for each $x,y \in X$, $\omega\in\Omega$ and $a, b \in R^+$ with $a(\omega) + b(\omega) < 1$, then there exists a common random fixed point of S and T (Here H represents the Hausdorff metric on CB (X) induced by the metric d).
In 1980 Jaggi and Dass generalized the fixed point theorem of Kannan showing that a self-mappingsatisfying a contractive type condition on a complete metric space have a common fixed point. Further Basu (1990) extended it to the case of a self- mapping satisfying the following more general contractive type condition.

$$d(Tx,Ty)) \le \frac{a_1 d(x,Tx)d(y,Ty)}{d(x,Ty)+d(y,Tx)+d(x,y)} + \frac{a_2 d(x,Tx)d(y,Ty)}{d(x,Tx)+d(y,Ty)} + \frac{a_4 d(y,Ty)d(y,Tx)}{d(y,Tx)+d(x,Tx)} + a_5(\omega)\, d(x,y)$$

Now we give a random version of the result of Basu (1990) which also generalizes the result of Badshah and Farkhunda (2002).

RESULTS

Our theorem is as follows:

Theorem 2.1: Let X be a polish space. Let T, S: Ω x X$\rightarrow$ CB(X) be two continuous random multivalued operators. If there exist measurable mappings a_1, a_2, a_3, a_4, a_5: $\Omega \rightarrow (0, 1)$ such that

$$H(S(\omega,x),T(\omega,y)) \le \frac{a_1(\omega)d(x,S(\omega,x))d(y,T(\omega,y))}{d(x,y)} + \frac{a_2(\omega)d(x,S(\omega,x))d(x,T(\omega,y))}{d(x,S(\omega,x))+d(y,T(\omega,y))}$$
$$+ \frac{a_3(\omega)d(x,S(\omega,x))d(y,S(\omega,x))}{d(y,S(\omega,x))+d(x,T(\omega,y))} + \frac{a_4(\omega)d(y,T(\omega,y))d(y,S(\omega,x))}{d(y,T(\omega,y))+d(x,S(\omega,x))} + a_5(\omega)d(x,y)$$

For each $x, y \in X$, $\omega \in \Omega$ and $a_1, a_2, a_3, a_4, a_5 \in R^+$ with $2a_1(\omega)+ a_2(\omega)+ a_3(\omega)+a_4(\omega)+2a_5(\omega) < 2, a_i \ge 0$ holds , then there exists a common random fixed point S and T (Here H represents the Hausdroff metric on CB(X) induced by the metric d).

Proof: Let $\xi_0 : \Omega \rightarrow X$ be an arbitrary measurable mapping and choose a measurable mapping $\xi : \Omega \rightarrow X$ such that $\xi_1(\omega) \in S(\omega,\xi_0(\omega))$ for each $\omega \in \Omega$. Then for each $\omega \in \Omega$

$$H(S(\omega,\xi_0(\omega)),T(\omega,\xi_1(\omega))) \le \frac{a_1(\omega)d(\xi_0(\omega),S(\omega,\xi_0(\omega)))d(\xi_1(\omega),T(\omega,\xi_1(\omega)))}{d(\xi_0(\omega),\xi_1(\omega))}$$
$$+ \frac{a_2(\omega)d(\xi_0(\omega),S(\omega,\xi_0(\omega)))d(\xi_0(\omega),T(\omega,\xi_1(\omega)))}{d(\xi_0(\omega),S(\omega,\xi_0(\omega)))+d(\xi_1(\omega),T(\omega,\xi_1(\omega)))}$$
$$+ \frac{a_3(\omega)d(\xi_0(\omega),S(\omega,\xi_0(\omega)))d(\xi_1(\omega),S(\omega,\xi_0(\omega)))}{d(\xi_1(\omega),S(\omega,\xi_0(\omega)))+d(\xi_1(\omega),T(\omega,\xi_1(\omega)))} +$$
$$+ \frac{a_4(\omega)d(\xi_1(\omega),T(\omega,\xi_1(\omega)))d(\xi_1(\omega),S(\omega,\xi_0(\omega)))}{d(\xi_1(\omega),T(\omega,\xi_1(\omega)))+d(\xi_0(\omega),S(\omega,\xi_0(\omega)))} + a_5(\omega)d(\xi_0(\omega),\xi_1(\omega)).$$

It further implies [2, Lemma 2.3], than there exists a measurable mapping $\xi_2 : \Omega \rightarrow X$ such that for any $\omega \in \Omega$, $\xi_2(\omega) \in T(\omega,\xi_1(\omega))$ and

$d(\xi_1(\omega), \xi_2(\omega)) = H(S(\omega, \xi_0(\omega)), T(\omega,\xi_1(\omega)))$

$$d(\xi_1(\omega),\xi_2(\omega)) \le \frac{a_1(\omega)d(\xi_0(\omega),\xi_1(\omega))d(\xi_1(\omega),\xi_2(\omega))}{d(\xi_0(\omega),\xi_1(\omega))} + \frac{a_2(\omega)d(\xi_0(\omega),\xi_1(\omega))d(\xi_0(\omega),\xi_2(\omega))}{d(\xi_0(\omega),\xi_1(\omega))+d(\xi_1(\omega),\xi_2(\omega))}$$
$$+ \frac{a_3(\omega)d(\xi_0(\omega)\xi_1(\omega))d(\xi_1(\omega),\xi_1(\omega))}{d(\xi_1(\omega),\xi_1(\omega))+d(\xi_0(\omega),\xi_2(\omega))} +$$
$$\frac{a_4(\omega)d(\xi_1(\omega),\xi_2(\omega))d(\xi_1(\omega),\xi_1(\omega))}{d(\xi_1(\omega),\xi_2(\omega))+d(\xi_0(\omega),\xi_1(\omega))} + a_5(\omega)d(\xi_0(\omega),\xi_1(\omega))$$
$$= a_1(\omega)d(\xi_1(\omega),\xi_2(\omega)) + \frac{a_2(\omega)d(\xi_0(\omega),\xi_1(\omega))d(\xi_0(\omega),\xi_2(\omega))}{d(\xi_0(\omega),\xi_1(\omega))+d(\xi_1(\omega),\xi_2(\omega))} + a_5(\omega)d(\xi_0(\omega),\xi_1(\omega))$$

$= (1-a_1(\omega))\, d(\xi_1(\omega),\xi_2(\omega)) \le [a_2(\omega) + a_5(\omega)]\, d(\xi_0(\omega),\xi_1(\omega))$ -------------(A)

Again, consider

$$H(T(\omega,\xi_1(\omega)),S(\omega,\xi_0(\omega)))\le \frac{a_1(\omega)d(\xi_1(\omega),T(\omega,\xi_1(\omega)))d(\xi_0(\omega),S(\omega,\xi_0(\omega)))}{d(\xi_1(\omega),\xi_0(\omega))}$$

$$+ \frac{a_2(\omega)d(\xi_1(\omega),T(\omega,\xi_1(\omega)))d(\xi_1(\omega),S(\omega,\xi_0(\omega)))}{d(\xi_1(\omega),T(\omega,\xi_1(\omega)))+d(\xi_0(\omega),S(\omega,\xi_0(\omega)))}$$

$$+ \frac{a_3(\omega)d(\xi_1(\omega),T(\omega,\xi_1(\omega)))d(\xi_0(\omega),T(\omega,\xi_1(\omega)))}{d(\xi_0(\omega),T(\omega,\xi_1(\omega)))+d(\xi_1(\omega),S(\omega,\xi_0(\omega)))}$$

$$+ \frac{a_4(\omega)d(\xi_0(\omega),S(\omega,\xi_0(\omega)))d(\xi_0(\omega),T(\omega,\xi_1(\omega)))}{d(\xi_0(\omega),S(\omega,\xi_0(\omega)))+d(\xi_1(\omega),T(\omega,\xi_1(\omega)))} + a_5(\omega)d(\xi_1(\omega),\xi_0(\omega))$$

Similarly as above there exists a measurable mapping $\xi_2 :\Omega\to X$ such that $\xi_2(\omega) \in T(\omega,\xi_1(\omega))$ and we have

$$d(\xi_2(\omega),\xi_1(\omega))\le \frac{a_1(\omega)d(\xi_1(\omega),\xi_2(\omega))d(\xi_0(\omega),\xi_1(\omega))}{d(\xi_1(\omega),\xi_0(\omega))}$$

$$+ \frac{a_3(\omega)d(\xi_1(\omega),\xi_2(\omega))d(\xi_0(\omega),\xi_2(\omega))}{d(\xi_0(\omega),\xi_2(\omega))} +$$

$$\frac{a_4(\omega)d(\xi_0(\omega),\xi_1(\omega))d(\xi_0(\omega),\xi_2(\omega))}{d(\xi_0(\omega),\xi_1(\omega))+d(\xi_1(\omega),\xi_2(\omega))} + a_5(\omega)d(\xi_1(\omega), \xi_0(\omega))$$

or $d(\xi_1(\omega), \xi_2(\omega)) \le a_1(\omega)d(\xi_1(\omega),\xi_2(\omega)) + a_3(\omega)d(\xi_1(\omega),\xi_2(\omega))$
$+ a_4(\omega)d(\xi_0(\omega),\xi_1(\omega)) + a_5(\omega)d(\xi_1(\omega),\xi_2(\omega))$

$[1- a_1(\omega)-a_3(\omega)]d(\xi_1(\omega),\xi_2(\omega)) \le [a_4(\omega) + a_5(\omega)]\, d(\xi_0(\omega),\xi_1(\omega))$ -----------------------(B)

Adding (A) and (B) we get

$[2-2a_1(\omega)-a_3(\omega)]d(\xi_1(\omega),\xi_2(\omega))\le[a_2(\omega)+a_4(\omega)+2a_5(\omega)]d(\xi_0(\omega),\xi_1(\omega))$

$$d(\xi_1(\omega),\xi_2(\omega))\le \frac{a_2(\omega)+a_4(\omega)+2a_5(\omega))}{2-2a_1(\omega)-a_3(\omega))} d(\xi_0(\omega),\xi_1(\omega))$$

$d(\xi_1(\omega),\xi_2(\omega)) \le K\, d(\xi_0(\omega),\xi_1(\omega))$

Where $K= \dfrac{a_2(\omega)+a_4(\omega)+2a_5(\omega))}{2-2a_1(\omega)-a_3(\omega))} < 1$

By above lemma in the same manner, there exists a measurable mapping $\xi_3:\Omega\to X$ such that for any $\omega\in\Omega$, $\xi_3(\omega) \in S(\omega, \xi_2(\omega))$ and

$d(\xi_2(\omega),\xi_3(\omega)) =$

$$H(T(\omega,\xi_1(\omega)),S(\omega,\xi_2(\omega))) \le \frac{a_1(\omega)d(\xi_1(\omega),T(\omega,\xi_1(\omega)))d(\xi_2(\omega),S(\omega,\xi_2(\omega)))}{d(\xi_1(\omega),\xi_2(\omega))}$$

$$+ \frac{a_2(\omega)d(\xi_1(\omega),T(\omega,\xi_1(\omega)))d(\xi_1(\omega),S(\omega,\xi_2(\omega)))}{d(\xi_1(\omega),T(\omega,\xi_1(\omega)))+d(\xi_2(\omega),S(\omega,\xi_2(\omega)))}$$

$$+ \frac{a_3(\omega)d(\xi_1(\omega),T(\omega,\xi_1(\omega)))d(\xi_2(\omega),T(\omega,\xi_1(\omega)))}{d(\xi_2(\omega),T(\omega,\xi_1(\omega)))+d(\xi_2(\omega),S(\omega,\xi_2(\omega)))}$$

$+ \dfrac{a_4(\omega)d(\xi_2(\omega),S(\omega,\xi_2(\omega)))d(\xi_2(\omega),T(\omega,\xi_1(\omega)))}{d(\xi_2(\omega),S(\omega,\xi_2(\omega)))+d(\xi_1(\omega),T(\omega,\xi_1(\omega)))}$

$+ a_5(\omega)d(\xi_1(\omega),\xi_0(\omega))\ \ a_5(\omega)d(\xi_1(\omega),\xi_2(\omega))$

$$\leq \frac{a_1(\omega)d(\xi_1(\omega),\xi_2(\omega))d(\xi_0(\omega),\xi_3(\omega))}{d(\xi_1(\omega),\xi_2(\omega))} + \frac{a_2(\omega)d(\xi_1(\omega),\xi_2(\omega))d(\xi_1(\omega),\xi_3(\omega))}{d(\xi_1(\omega),\xi_2(\omega))+d(\xi_2(\omega),\xi_3(\omega))}$$

$$+ \frac{a_3(\omega)d(\xi_1(\omega),\xi_2(\omega))d(\xi_2(\omega),\xi_2(\omega))}{d(\xi_2(\omega),\xi_2(\omega))+d(\xi_1(\omega),\xi_3(\omega))} + \frac{a_4(\omega)d(\xi_2(\omega),\xi_3(\omega))d(\xi_2(\omega),\xi_2(\omega))}{d(\xi_2(\omega),\xi_3(\omega))+d(\xi_1(\omega),\xi_2(\omega))}$$

$+ a_5(\omega)d(\xi_1(\omega),\xi_0(\omega))\ + a_5(\omega)d(\xi_1(\omega),\xi_2(\omega))$

$[1- a_1(\omega)]d(\xi_2(\omega),\xi_3(\omega)) \leq [a_2(\omega)+a_5(\omega)]d(\xi_1(\omega),\xi_2(\omega))$ -------------------------(C)

Again consider

$d(\xi_3(\omega),\xi_2(\omega))=H(S(\omega,\xi_2(\omega)),T(\omega,\xi_1(\omega))) \leq [a_1(\omega)+a_3(\omega)]d(\xi_3(\omega),\xi_2(\omega))+[a_3(\omega)+a_5(\omega)]d(\xi_2(\omega),\xi_1(\omega))$

$[1-a_1(\omega)-a_3(\omega)]d(\xi_2(\omega),\xi_3(\omega))\leq[a_3(\omega)+a_5(\omega)]d(\xi_2(\omega),\xi_1(\omega))$ ------------------- (D)

After adding (C) & (D) we get

$d(\xi_2(\omega),\xi_3(\omega)) \leq K\, d(\xi_1(\omega),\xi_2(\omega))$

or $d(\xi_2(\omega),\xi_3(\omega)) \leq K^2 d(\xi_0(\omega),\xi_1(\omega))$

Similarly, proceeding in the same way : by induction, we produce a sequence of measurable mapping $\xi_n :\Omega\rightarrow X$ such that $\gamma>0$ and $\omega\in\Omega$

$\xi_{2\gamma+1}(\omega) \in S(\omega,\xi_{2\gamma}(\omega)),\xi_{2\gamma+2}(\omega)) \in T(\omega,\xi_{2\gamma+1}(\omega))$

and $d(\xi_n(\omega),\xi_{n+1}(\omega))\leq Kd(\xi_{n-1}(\omega),\xi_n(\omega)) \leq$ ----- $K^n d(\xi_0(\omega),\xi_1(\omega))$

furtherfor m>n

$d[\xi_n(\omega),\xi_m(\omega))\leq d(\xi_n(\omega),\xi_{n+1}(\omega))+d(\xi_{n+1}(\omega),\xi_{n+2}(\omega))+ \ldots\ldots\ldots\ldots + d(\xi_{m-1}(\omega),\xi_n(\omega))$

$\leq [Kn+K^{n+1} + \text{--------}+K^{m-1]\,d}\,(\xi_0(\omega),\xi_1(\omega))$

$\leq d(\xi_0(\omega),\xi_1(\omega))K^n[\,1+K+K^2 + \text{--------}+K^{m-n-1}\,]$

$d(\xi_n(\omega),\xi_m(\omega))\leq \dfrac{K^n}{1-K} d(\xi_0(\omega),\xi_1(\omega)) \rightarrow 0$ as $n,m \rightarrow\infty$.

It follow that $\{\xi_n(\omega)\}$ is a Cauchy sequence and there exists a measurable mapping $\xi : \Omega\rightarrow X$ such that $\xi_n(\omega) \rightarrow\xi(\omega)$ for each $\omega\in\Omega$. It further implies that $\xi_{2\gamma+1}(\omega) \rightarrow\xi(\omega)$ and $\xi_{2\gamma+2}(\omega) \rightarrow\xi(\omega)$. Thus we have for any $\omega\in\Omega$.

$d(\xi(\omega),S(\omega, \xi(\omega)))\leq d(\xi(\omega),\xi_{2\gamma+2}(\omega))+d(\xi_{2\gamma+2}(\omega),S(\omega,\xi(\omega)))$

$\leq d(\xi(\omega),\xi_{2\gamma+2}(\omega))+ H(T(\omega, \xi_{2\gamma+1}(\omega)),S(\omega, \xi(\omega)))$

$\leq d(\xi(\omega),\xi_{2\gamma+2}(\omega))+ \dfrac{a_1(\omega)d(\xi_{2\gamma+1}(\omega),T(\omega,\xi_{2\gamma+1}(\omega)),d(\xi(\omega),S(\omega,\xi(\omega)))}{d(\xi_{2\gamma+1}(\omega),\xi(\omega))}$

$+ \dfrac{a_2(\omega)d(\xi_{2\gamma+1}(\omega),T(\omega,\xi_{2\gamma+1}(\omega)))d(\xi_{2\gamma+1}(\omega),S(\omega,\xi(\omega)))}{d(\xi_{2\gamma+1}(\omega),T(\omega,\xi_{2\gamma+1}(\omega))+d(\xi(\omega),S(\omega,\xi(\omega))}$

$+ \dfrac{a_3(\omega)d(\xi_{2\gamma+1}(\omega),T(\omega,\xi_{2\gamma+1}(\omega)))d(\xi\ \ (\omega),S(\omega,\xi(\omega)))}{d(\xi\ \ (\omega),T(\omega,\xi_{2\gamma+1}(\omega))+d(\xi_{2\gamma+1}(\omega),S(\omega,\xi(\omega))} +$

$+ \dfrac{a_4(\omega)d(\xi\ \ (\omega),S(\omega,\xi(\omega)))d(\xi\ \ (\omega),T(\omega,\xi_{2\gamma+1}(\omega)))}{d(\xi\ \ (\omega),S(\omega,\xi(\omega))+d(\xi_{2\gamma+1}(\omega),T(\omega,\xi_{2\gamma+1}(\omega))} + a_5\, d(\xi_{2\gamma+1}(\omega),\xi(\omega))$

letting $\gamma\rightarrow\infty$, we have

$d(\xi(\omega),S(\omega,\xi(\omega)))\leq d(\xi(\omega),\xi(\omega))+ \dfrac{a_1(\omega)d(\xi(\omega),\xi(\omega)),d(\xi(\omega),S(\omega,\xi(\omega)))}{d(\xi(\omega),\xi(\omega))}$

$$+\frac{a_2(\omega)d(\xi(\omega),\xi(\omega)),d(\xi(\omega),S(\omega,\xi(\omega)))}{d(\xi(\omega),\xi(\omega))+d(\xi(\omega),S(\omega,\xi(\omega)))}+\frac{a_3(\omega)d(\xi(\omega),\xi(\omega)),d(\xi(\omega),\xi(\omega))}{d(\xi(\omega),\xi(\omega))+d(\xi(\omega),S(\omega,\xi(\omega)))}$$

$$+\frac{a_4(\omega)d(\xi(\omega),S(\omega,\xi(\omega)),d(\xi(\omega),\xi(\omega)))}{d(\xi(\omega),\xi(\omega))+d(\xi(\omega),S(\omega,\xi(\omega)))}+a_5 d(\xi(\omega),\xi(\omega))$$

$d(\xi(\omega),S(\omega, \xi(\omega)))\leq a_1(\omega)),d(\xi(\omega),S(\omega,\xi(\omega)))$

$[1-a_1(\omega)]d(\xi(\omega),S(\omega, \xi(\omega)))\leq 0$

$d(\xi(\omega),S(\omega, \xi(\omega)))\leq 0$

Hence $\xi(\omega) \in S(\omega, \xi(\omega))$ for $\omega\in\Omega$. Similarly, for any $\omega\in\Omega$

$d(\xi(\omega),T(\omega, \xi(\omega)))\leq d(\xi(\omega),\xi_{2\gamma+1}(\omega))+H(S(\omega,\xi_{2\gamma}(\omega)), T(\omega,\xi(\omega)))d(\xi(\omega),T(\omega, \xi(\omega)))\leq 0$

Therefore $\xi(\omega)\in T(\omega, \xi(\omega))$ for each $\omega\in\Omega$.

Corollary [2.1.1] : Let X be a Polish space and $T: \Omega\times X \to CB(X)$ be a continuous random multivalued operator. If there exists a measurable map $a_1, a_2, a_3, a_4, a_5 : \Omega\to (0,1)$ such that

$$H(T(\omega, x), T(\omega, y))\leq \frac{a_1(\omega)d(x,T(\omega,x))d(y,T(\omega,y))}{d(x,y)}+\frac{a_2(\omega)d(x,T(\omega,x))d(x,T(\omega,y))}{d(x,T(\omega,x))+d(y,T(\omega,y))}$$

$$+\frac{a_3(\omega)d(x,T(\omega,x))d(y,T(\omega,x))}{d(y,T(\omega,x))+d(x,T(\omega,y))}+\frac{a_4(\omega)d(y,T(\omega,y))d(y,T(\omega,x))}{d(y,T(\omega,y))+d(x,T(\omega,x))}+a_5(\omega)d(x,y)$$

Then there exists a sequence $\{\xi_n\}$ of measurable mappings $\xi_n : \Omega\to X$ which is asymptotically T- regular and converges to a random fixed point of T.

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