Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.4, No.22, 2014
www.iiste.org

Fixed Point Theorem Result in Vector Metric Spaces.

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Abstract

In this paper we give prove some fixed point theorems for contractive conditions in vector metric space, our results are generalized form of some well known results. Our results are motivated by Ishak Altun and Cuneyt Cevik [10]

Keywords: - fixed point, vector metric space.

Theorem 1.1 Let X be an vector metric space with E is Archimedes, suppose the mappings $F, G: X \to X$ satisfies the following conditions

for all $x, y \in X$ $(G_x\ G_y)$

$$\le K_1 u(x,y) + K_2 d(F_x, F_y) + K_3[d(F_x, G_x) + d(F_y, G_y)] + K_4[d(F_x, G_y) + d(F_y, G_x)] + K_5\ Min\ \{d(F_x, G_y), d(F_y, G_x)\}$$

Where $K \in [0,1]$ is a constant and

$$u(x,y) \in \{d(F_x, F_y), d(F_x, G_x), d(F_y, G_y), \frac{1}{2}[d(F_x, G_y) + d(F_y, G_x)\}$$

$G(X) \subseteq F(x)$

$F(X)\ or G(X)$is complete subspace of X , $K_1 + K_2 + 2K_3 + 2K_4 < 1.$

Then G and F have a unique point of coincidence in X, moreover of F and G are weakly compatible, then they have a unique common fixed point in X.

Proof:-Let $x_0, x_1 \in X$ define the sequence $\{x_n\}$ by $Fx_{n+1} = Gx_n = y_n\ for\ n \in N$

$$d(y_n, y_{n+1}) \le K d(y_{n-1}, y_n)$$

We have that $d(y_n, y_{n+1}) = d(Gx_n, Gx_{n+1})$

$$\le K_1, u(x_n, x_{n+1}) + K_2 d(Fx_n, Fx_{n+1}) + K_3[d(Fx_n, Gx_n) + d(Fx_{n+1}, Gx_{n+1})] + K_4[d(Fx_n, Gx_{n+1}) + d(Fx_{n+1}, Gx_n)]$$

$$+ K_5 Min\ \{d(Fx_n, Gx_{n+1}) d(Fx_{n+1}, Gx_n)\}$$

$$d(y_n, y_{n+1}) \le d(Gx_n, Gx_{n+1})$$

$$\le K_1 u(x_n, x_{n+1}) + K_2[d(y_{n-1}, y_n)] + K_3[d(y_{n-1}, y_n) + d(y_n, y_{n+1})] + K_4[d(y_{n-1}, y_{n+1}) + d(y_n, y_n)] + K_5\ Min\ \{d(y_{n-1}, y_{n+1}). d(y_n, y_n)\}$$

$$\le K_1 u(x_n, x_{n+1}) + K_2(y_{n-1}, y_n) + K_3[d(y_{n-1}, y_n) + d(y_n, y_{n+1}) + K_4[d(y_{n-1}, y_n) + d(y_n, y_{n+1})]$$

$$\le \frac{K_1}{2} d(y_{n-1}, y_{n+1}) + K_2 d(y_{n-1}, y_n) + K_3[d(y_{n-1}, y_n) + d(y_n, y_{n+1})] + K_4[d(y_{n-1}, y_n) + d(y_n, y_{n+1})]$$

$$\le \frac{K_1}{2}[d(y_{n-1}, y_n) + d(y_n, y_{n+1})] + K_2 d(y_{n-1}, y_n) + K_3[d(y_{n-1}, y_n) + d(y_n, y_{n+1})]$$

$$+ K_4[d(y_{n-1}, y_n) + d(y_n, y_{n+1})]$$

$$\le \left(\frac{K_1}{2} + K_2 + K_3 + K_4\right) d(y_{n-1}, y_n) + \left(\frac{K_1}{2} + K_3 + K_4\right) d(y_n, y_{n+1})$$

$$d(y_n, y_{n+1})(1 - \frac{K_1}{2} - K_3 - K_4) \le d(y_{n-1}, y_n)(\frac{K_1}{2} + K_2 + K_3 + K_4)$$

$$d(y_n, y_{n-1}) \le \frac{\left(\frac{K_1}{2} + K_2 + K_3 + K_4\right)}{\left(1 - \frac{K_1}{2} - K_3 - K_4\right)} d(y_{n-1}, y_n)$$

$$d(y_n, y_{n-1}) \le R.d(y_{n-1}, y_n)$$

Where $\frac{\left(\frac{K_1}{2} + K_2 + K_3 + K_4\right)}{\left(1 - \frac{K_1}{2} - K_3 - K_4\right)} = R.\ K_1 + K_2 + 2K_3 + 2K_4 < 1.$

Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.4, No.22, 2014

$d(y_n, y_{n-1} \leq R^n d(y_0, y_1)$
$d(y_n, y_{n+p}) \leq d(y_n, y_{n+1}) + d(y_{n+1}, y_{n+2}) + \cdots + d(y_{n+p-1}, y_{n+p})$
$\leq [R^n + R^{n+1} + R^{n+2} \ldots + \cdots + R^{n+p-1}](y_0, y_1)$
$d(y_n, y_{n+p}) \leq \frac{R^n}{(1-R)} d(y_0, y_1)$

Now since E is Archimedean then $\{y_n\}$ is an E-cauchy sequence since the range of F contains the range of T and the range of at least one is E-complete. There exists $\alpha\ z \in F(X)$ such that $Fx_n \to Z$ Hence there exists a sequence $\{\alpha_n\}$ in E such that an and $d(Fx_n, Z) \leq \alpha_n$, on the other hand, we can find $w \in x$, such that $F_w = z$

Let us show that $G_w = z$ we have $d(G_w, z) \leq d(G_w, Gx_n) + d(Gx_n, z)$
$\leq k_1 u(x_n, w) + K_2 d(Fx_n, F_w) + K_3[d(Fx_n, Gx_n) + d(F_w, G_w)]$
$+K_4[d(Fx_n, G_w) + d(F_w, Gx_n)] + K_5 Min\{d(Fx_n, G_w) d(F_w, Fx_n)\} + \alpha_{n+1}$
$d(G_w, z) \leq K_1 u(x_n, w) + K_2 d(Fx_n, z) + K_3[d(Fx_n, Gx_n) + d(G_w, z)] + K_4[d(Fx_n, z) + d(Gx_n, z)]$
$+K_5\ Min\{d(Fx_n, z) d(Gx_n, z)\} + \alpha_{n+1}$
$\leq K_1 u(x_n, w) + K_2 d(Fx_n, z) + K_3[d(Fx_n, z) + d(z, Gx_n) + d(G_w, z)]$
$+ K_4[d(Fx_n, z) + d(Gx_n, z)] + K_5 Min\{d(Fx_n, z). d(Gx_n, z)] + \alpha_{n+1}$

Case-I when $Min\{d(Fx_n, z). d(Gx_n, z)\} = d(Fx_n, z)$
$\leq K_1 u(x_n, w) + (K_2 + K_3 + K_4 + K_5) d(Fx_n, z) + K_3 d(G_w, z) + (k_3 + K_4) d(Gx_n, z). + \alpha_{n+1}$
$(1 - K_3) d(G_w, z) \leq K_1 u(x_n, w) + (K_1 + K_3 + K_4 + K_5)\alpha_n. + (K_3 + K_4 + 1)\alpha_{n+1}$
$d(G_w, z) \leq \left(\frac{K_1}{1-K_3}\right) u(x_n, w) + \frac{K_1 + K_3 + K_4 + K_5)}{(1-K_3)} \alpha n + \frac{(K_3 + K_4 + 1)}{(1-K_3)} \alpha_{n+1}$
$d(G_w, z) \leq R_1 u(x_n, w) + R_2 \alpha_n + R_3 \alpha_{n+1}$

For all n, since.

$u(x_n, w) \in \{d(Fx_n, F_w) d(Fx_n, Gx_n). d(F_w, G_w) \frac{1}{2}[d(Fx_n, G_w) + d(F_w, Gx_n)]$

At least one of the following four cases hold for all n,

Case-II $d(G_w, z) \leq d(Fx_n, F_w) + R_2 \alpha_n + R_3 \alpha_{n+1}$
$\leq d(Fx_n, z) + R_2 \alpha_n + R_3 \alpha_{n+1}$
$\leq \alpha_n + R_1 \alpha_n + R_3 \alpha_{n+1}$
$d(G_w, z) \leq (1 + R_1)\alpha_n + R_3 \alpha_{n+1} \leq 2\alpha_n$

Case-III $d(G_w, z) \leq d(Fx_n, Gx_n) + R_2 \alpha_n + R_3 \alpha_{n+1}$
$d(G_w, z) \leq d(Fx_n, z) + d(Gx_n, z) + R_2 \alpha_n. + R_3 \alpha_{n+1}$
$\leq d(Fx_n, z) + \alpha_{n+1} + R_2 \alpha_n + R_3 \alpha_{n+1}$
$\leq d?(Fx_n, z) + (1 + R_3)\alpha_{n+1} + R_2 \alpha_n$
$\leq (1 + R_2)\alpha_n + (1 + R_3)\alpha_{n+1} \leq 3\alpha_n.$

Case-IV $d(G_w, z) \leq k_1 d(F_w, G_w) + R_2 \alpha_n + R_3 \alpha_{n+1}$
$\leq k_1[d(F_w, z) + d(z, G_w) + R_2 \alpha_n + R_3 \alpha_n$
$d(G_w, z) \leq k_1 d(G_w, z) + (R_2 + R_3)\alpha_n$
$d(G_w, z) \leq \frac{1}{(1-K_1)}(R_2 + R_3)\alpha_n$

Case-V $d(G_w, z) \leq \frac{1}{2}[d(Fx_n, G_w) + d(F_w, Gx_n) + R_2 \alpha_n + R_3 \alpha_{n+1}$
$\leq \frac{1}{2}[d(Fx_n, G_w) + d(F_w, z) + d(z, Gx_n)] + R_2 \alpha_n + R_3 \alpha_{n+1}$
$\leq \frac{1}{2}[d(Fx_n, G_w)] + \frac{1}{2}\alpha_{n+1} + R_3 \alpha_{n+1} + R_2 \alpha_n$
$\leq \frac{1}{2}[d(Fx_n, G_w)] + \frac{1}{2}\alpha_{n+1} + R_3 \alpha_{n+1} + R_2 \alpha_n$
$\leq \frac{1}{2}[d(Fx_n, G_w)] + \left(\frac{1}{2} + R_3\right)\alpha_{n+1} + R_2 \alpha_n$
$\leq \frac{1}{2}[d(Fx_n, z) + d(z, G_w)] + \left(\frac{1}{2} + R_3\right)\alpha_{n+1} + R_2 \alpha_n$

$\leq \frac{1}{2}[d(G_w,z)] + \frac{1}{2}\alpha_n + R_2\alpha_n + \left(\frac{1}{2} + R_3\right)\alpha_{n+1}$
$\leq \frac{1}{2}d(G_w,z) + \left(\frac{1}{2} + R_2\right)\alpha_n + \left(\frac{1}{2} + R_3\right)\alpha_{n+1}$
$d(G_w,z) \leq (1+2R_2)\alpha_n + (1+2R_3)\alpha_{n+1}$

Since the infimum of sequence on the right side of last inequality are zero then
$d(G_w,z) = 0 \;\; i.e\; G_w = z$

Therefore z is a point of coincidence of F and G if Z_1 is another point of coincidence then there is $w_1 \in X \; with \; Z_1 = Gw_1 = Fw_1 \; now$

$d(z,z_1) = d(G_w, Gw_1)$
$\leq k_1 u(w,w_1) + K_2 d(F_w, Fw_1) + K_3[d(F_w,G_w) + d(Fw_1,Gw_1)] + K_4[d(F_w,G_{w1}) + d(Fw_1,Gw)]$
$+k_5\, Min\{d(F_w,G_w) + d(F_w,Gw_1)\}$
$\leq K_1 u(w,w_1) + K_2 d(z,z_1) + K_3[d(z,z) + d(z,z_1)] + K_4[d(z,z_1) + d(z_1,z)]$
$+ K_5\, Min\;\{d(z,z) + d(z_1,z)\}$
$\leq K_1 u(w,w_1) + K_2 d(z,z_1) + K_3 d(z,z_1) + 2k_4 d(z,z_1)$
$\leq k_1\, u(w,w_1) + (k_2 + K_3 + 2K_4)(z,z_1)$

Where
$u(w,w_1) \in \left\{d(F_w,Fw_1)d(F_w,G_w)d(Fw_1,Gw_1) + \frac{1}{2}[d(F_w,Gw_1) + d(F_w,G_w)]\right\}$
$= \;\; 0, d(z,z_1)$

Hence $d(z,z_1) = 0 \; that \;\; is \; z = z_1$

If F and G are weakly compatible then it is obvious, that Z is unique common fixed point of F and G.

Theorem 1.2 :- Let X be an vector metric space with E is Archimedean, suppose the mapping $F; G; X \to X$ satisfies the following conditions

$for \; all \; x,y, \in X \;\; (d(G_x,G_y)$
$\leq Ku(x,y) + K_2 d(F_x,F_y) + K_3[d(F_x\,,G_x) + d(F_y,G_y)] + K_4[d(F_x,G_y) + d(F_y,G_x)]$
$+K_5 \min\{d(F_x,G_y)d(F_y,G_x)\}$
$where \;\; k \in [0,1] \; is \; constant \; and$
$u(x,y) \in \{d(F_x,G_y), \frac{1}{2}[d(F_x,G_x) + d(F_y,G_y)], \frac{1}{2}[d(F_x,G_y) + d(F_y,G_x)]$

1. $G(x) \subseteq F(x), k_1 + K_2 + 2K_3 + 2K_4 < 1.$
2. F(X) or G(X) is E-complete subspace of X then F and G have a unique point of coincidence in X moreover if F and G are weakly compatible then they have a unique common fixed point is X

Proof:- Let us define the sequence $\{x_n\}$ and $\{y_n\}$ as in the proof of theorem we show that
$d(y_n,y_{n+1}) \leq Kd(y_{n-1},y_n)$

$d(y_n,y_{n+1}) = d(Gx_n,Gx_{n+1})$
$\leq k_1 u(x_n,x_{n+1}) + K_2 d(Fx_n,Fx_{n+1}) + K_3[d(Fx_n,Gx_n) + d(Gx_{n+1},Gx_{n+1})]$
$+ K_4[d(Fx_n,Gx_{n+1}) + d(Fx_{n+1},Gx_n)] + K_5\; Min\;\{d(Fx_n,Gx_{n+1})d(Fx_{n+1},Gx_n)\}$

We have to consider three case$u(x_n,x_{n+1}) = d(y_{n-1},y_n)$
$u(x_n,x_{n+1}) = \frac{1}{2}[d(y_{n-1},y_n) + d\,(y_n,y_{n+1})] \;\; and \;\; u(x_n,x_{n+1}) = \frac{1}{2}[d(y_{n-1},y_{n+1})$

Only second case if $u(x_n,x_{n+1}) = \frac{1}{2}[d(y_{n-1},y_n) + d(y_n,y_{n+1})]$
$d(y_n,y_{n+1}) \leq d(Gx_n,Gx_{n+1}) \leq K_1 u(x_n,x_{n+1}) + K_2\, d(y_{n-1},y_n)$
$+K_3[d(y_{n-1},y_n) + d(y_n,y_{n+1})] + K_4[d(y_{n-1},y_{n+1}) + d(y_n,y_n) + K_5\; Min\;\{d(y_{n-1},y_{n+1}), d(y_n,y_n)\}$
$\leq K_1 u\,(x_n,x_{n+1}) + K_2 d(y_{n-1},y_n) + K_3[d(y_{n-1},y_n) + d(y_n,y_{n+1})] + K_4[d(y_{n+1},y_n) + d\,(y_n,y_{n+1})]$
$\leq \frac{K_1}{2}d(y_{n-1},y_n) + \frac{1}{2}d(y_n,y_{n+1}) + K_2 d(y_{n-1},y_n) + K_3[d(y_{n-1},y_n) + d(y_n,y_{n+1})]$

$+K_4[d(y_{n-1},y_n)+d(y_n,y_{n+1})]$

$d(y_n,y_{n+1}) \le \left(\frac{K_1}{2}+K_2+K_3+K_4\right)d(y_{n-1},y_n)+(\frac{1}{2}+K_3+K_4)d(y_n,y_{n+1})$

$(1-\frac{1}{2}-K_3-K_4)d(y_n,y_{n+1}) \le \left(\frac{K_1}{2}+K_2+K_3+K_4\right)d(y_{n-1},y_n)$

$$d(y_n,y_{n+1}) \le \frac{\left(\frac{K_1}{2}+K_2+K_3+K_4\right)}{\left(\frac{1}{2}-K_3-K_4\right)}\ d(y_{n-1},y_n)$$

Where

$$R=\frac{\left(\frac{K_1}{2}+K_2+K_3+K_4\right)}{\left(\frac{1}{2}-K_3-K_4\right)} \qquad since\ k_1+K_2+2K_3+2K_4<1.$$

$d(y_n,y_{n+1}) \le R\ d(y_{n-1},y_n)\ Hence$ (4)

In the proof of theorem, that $\{y_n\}$ is an E-cauchy sequence then there exist $z\in F(X),\ \ w\in X$ is (a_n)E such that $F_w=z,\ d(Fx_n,z)\le a_n$

Now we have to show that $G_w=z$ we have

$d(G_w,z)\le d(G_w,Gx_n)+d(Gx_n,z)\le u(x_n,w)+a_{n+1}$

$\le K_1u(x_n,w)+K_2d(Fx_n,F_w)+K_3[d(Fx_n,Gx_n)+d(F_w,G_w)]+K_4[d(Fx_n,G_w)+d(F_w,Gx_n)]$

$+K_5\ Min\ \{d(Fx_n,G_w)+d(F_w,Gx_n)+a_{n+1}$

$d(G_w,z)\le K_1u((x_n,w)+K_2d(Fx_n,z)+K_3[d(Fx_n,z)+d(z,Gx_n)+d(G_w,z)]$

$+K_4[d(Fx_n,z)+d(Gx_n,z)]+K_5\ Min\ \{d(Fx_n,z)d(Gx_n,z)\}+a_{n+1}$

Case-I when $Min\ \{d(Fx_n,z)d(Gx_n,z)\}=d(Fx_n,z)$

$\le K_1u(x_n,w)+K_2d(Fx_n,z)+K_3[d(Fx_n,z)+d(z,Gx_n)]+d(G_w,z)+K_4[d(Fx_n,z)+d(Gx_n,z)]$

$+K_5\{d(Fx_n,z)\}$

$(1-K_3)d(G_w,z)\le K_1u(x_n,w)+(K_1+K_3+K_4+K_5)a_n+(K_3+K_4+1)a_{n+1}$

$$d(G_w,z)\le\frac{K_1}{1-K_3)}u(x_n,w)+\frac{(K_1+K_3+K_4+K_5)}{1-K_3}a_n+\frac{(K_3+K_4+1)}{1-K_3}a_{n+1}$$

$d(G_w,z)\le R_1u(x_n,w)+R_2a_n+R_3a_{n+1}$

$u(x_n,w)\in\{d(Fx_n,F_w),\frac{1}{2}\ [d(Fx_n,Gx_n)+d(F_w,G_w)]+\frac{1}{2}[d(Fx_n,G_w)+d(F_w,Gx_n)]$

At least one of three cases holds for all n, consider only the case of $u(x_n,w)=\frac{1}{2}[d(Fx_n,Gx_n)+d(F_w,G_w)]$ because the other two cases have shown that the proof of theorem it is satisfied

$d(G_w,z)\le\frac{R}{2}[d(Fx_n,Gx_n)+d(F_w,G_w)]+R_2a_n+R_3a_{n+1}$

$\le\frac{R}{2}[d(Fx_n,z)+d(Gx_n,z)+d(F_w,z)+d\ (z,G_w)]\ +R_2a_n+R_3a_{n+1}$

$\le\frac{R}{2}[a_n+a_{n+1}]+\frac{R}{2}d(G_w,z)+R_2a_n+R_3a_{n+1}$

$d(G_w,z)\le\frac{R}{2}d(G_w,z)+\left(\frac{R}{2}+1\right)a_n+\left(\frac{R}{2}+R_3\right)a_{n+1}$

This is $d(G_w,z)\le 4a_n$

Since $4a_n\ \le 0\ then\ G_w=z$ hence z is a point of coincidence of F and G the uniqueness of z as in the proof of theorem 1.1 also if F and G are weakly compatible then it is obvious that z is unique common fixed point of G and F by [1.1]

Theorem (1.3) Let X be an vector metric space with E is Archimedean suppose the mapping $F,G{:}X\to X$ satisfies the following conditions

1. For all $x\ y\ \in X$
   $d(Gx,Gy)\le b.d(Fx,Gx)+c.d(Fy,Gy)+ed(Fx,Gy)+fd(Fy,Gx)$
   $+gd(Fx,Fy)+hd(Fx,Fy)+i[d(Fx,Gx)+d(Fy,Gy)]$

$+j[d(Fx,Gy)+d(Fy,Gx)]$
$+R\ Min\ \{d(Fx,Gy).d(Fy,Gx)\}$
Where b,c,d,e,f,g,h,i,j and R are nonnegative and b+c+d+e+g+h+i+j+R<1

2. $G(X)\subseteq F(X)$
3. F(x) or G(x) is E-complete subspace of X then F and G have a unique point of coincidence in X moreover if F and G are weakly compatible then have a unique common fixed point in X

Proof:-Let us define the sequence $\{x_n\}$ and $\{y_n\}$ as in the proof of theorem (1.1) we have to show that

$d(y_n,y_{n+1})\le kd(y_{n-1},y_n)$for some $k\in[0,1]$ and all n consider $Fx_{n+1}=Gx_n=y_n$ for all n then.

$d(y_n,y_{n+1})\le(b+g+h+i+e+j)d(y_{n-1},y_n)+(c+i+e+j)d(y_n,y_{n+1})$

and

$d(y_{n+1},y_n)\le(b+i+j+f)d(y_n,y_{n+1})+(c+g+h+i+f+j)d(y_{n-1},y_n)$

Hence

$[2-(b+2i+2j+c+e)]d(y_n,y_{n+1})\le(b+2g+2i+2h+e+j+c)d(y_{n-1},y_n)$

$$d(y_ny_{n+1})\le\frac{b+2g+2h+2i+e+j+c)}{[2-(b+c+e+2i+2j)]}d(y_{n-1},y_n)$$

If we choose $K_1=\frac{(b+e+j+c+2g+2h+2i)}{[2-(b+c+e+2i+2j)]}$

Then

$K_1\in[0,1]$

In the proof of theorem (1.1) we illustrate that $\{y_n\}$ is an E couchy sequence, then there exist $Z\in F(X)$ $w,\in X$ and (a_n) in E such that $F_w=Z,\ d(Fx_n,Z)\le a_n$ $and\ a_n\downarrow 0$

Let us show that $Gw=Z$ we have $d(Gw,z)\le d(Gw,Gx_n)+d(Gx_n,z)$

$d(Gw,z)\le(b+f+i+j)d(Gw,z)+(c+f+g+h+i+j)d(Fx_n,z)+(c+e+i+j+1)d(Gx_n,z)$
$+R\ Min\{d(z,Gx_n)d(Fx_n,Gw)$

$$d(Gw,z)\le(b+f+i+j+R)d(Gw,z)+(c+f+g+h+i+j+R)a_n$$
$$+(c+f+g+h+i+j+R)a_{n+1}$$
$$\le(b+f+i+j+R)d(Gw,z)+(2c+2f+2g+2h+2i+j+R)a_n$$
$$d(Gw,z)\le\frac{(2c+2f+2g+2h+2i+j+R)}{1-(b+f+i+j+R)}a_n.$$

For all n. then $d(Gw,z)=0$ $i.e.Gw=z.$ Hence Z is a point of coincidence of F and G. Then uniqueness of z is easily seen. Also if F and G are weakly compatible, then if is obvious that z is unique common fixed point of G and F by [1.1].

Acknowledgement: Author [**Rks**] , thankful to Ishak Altun and Cuneyt Cevik for motivation by their results for extension.

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